Developing an Online Learning Environment to Support Previously Disadvantaged Schools in South Africa

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Abstract

The use of information and communication technologies in education is not a new field. Many online learning environments exist, but often these are either too generic, or too specific to the education systems of other countries. As a result, they do not satisfy the requirements of the schools and the curriculum in South Africa. There is, therefore, a need for an online learning environment that is developed specifically for the South African context. In particular, previously disadvantaged schools have highly specific needs, due to a lack of learning resources and poor computer literacy. The aim of this research was to identify the specific requirements of South African schools and to develop a prototype online learning environment that demonstrates the ability to sustainably satisfy these requirements. The process of gathering requirements included a survey of literature in the field of e-learning and discussions with 12 South African teachers. The prototype was evaluated through user studies involving 86 learners and 22 teachers. Learners were asked to rate the components of the prototype and certain aspects of their use. Out of a maximum of 4, the prototype scored an average rating of 3.24 in this evaluation, indicating a remarkably positive response from the learners. 85% of the learners who used the prototype stated that they would like to use it to study for their examinations. Learners enjoyed using the prototype, found it easy to use and found that it had a positive impact on their learning. The results demonstrated that the prototype is an intuitive, interactive application that offers a sustainable solution to South African teachers and learners, particularly in previously disadvantaged schools.

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Chapter 1

Introduction

1.1 Background

Many previously disadvantaged schools in South Africa are faced with a shortage of qualified educators and quality teaching materials [21]. Computers and networks are being deployed in some schools, however, providing an opportunity to use Information and Communication Technologies (ICTs) to assist learners and teachers. At present, the use of this infrastructure is limited due to a lack of electronic information that is aimed at South African learners or relevant to the South African school curriculum.

1.2 Problem Statement

The problem that this research aimed to address is the development of a sustainable online learning environment (OLE) that is relevant to South African learners. In particular, the development was focused on creating an OLE that is easy to use and that actively facilitates the learning process, despite the difficulties that arise from the low computer literacy levels of learners in most previously disadvantaged schools.

1.3 Research Goals

The primary aim of this research was to develop a prototype OLE that South African learners and teachers would find relevant and useful, an OLE that fits in with the South

African curriculum. It was a goal of this research to ensure that the development was informed by current e-learning pedagogy as well as by the needs of teachers and learners in the South African context. The low average computer literacy level of the learners in previously disadvantaged schools necessitated that the prototype be easy to use and structured in such a way that learning is actively facilitated. Another salient goal of the research was to ensure that the solution be sustainable. It was therefore important that it be possible for teachers to contribute material to the prototype, in an easy and effective way. In order to ensure sustainability further, it was also important to create a resource that learners would enjoy using. It was key that this enjoyability was not simply due to the novelty of e-learning to learners, but as a result of them seeing the resource as beneficial to their learning. The overarching goal of the research was to use the development of a prototype to investigate what is required from an OLE to be an effective learning tool in South Africa, particularly in previously disadvantaged schools.

1.4 Document Structure

This dissertation is organised as follows:

Chapter 2 provides background information around the area of the use of ICTs in education, particularly within the South African context. It moves on to define e-learning and discusses its benefits. The chapter then focuses on OLEs and explores some theoretical approaches to effective OLE design.

Chapter 3 describes the method in which this research has been approached. It discusses the decision to develop a prototype and describes the approach to its development. The methodology for gathering requirements for the prototype is then explored, followed by the methodology used in evaluating the prototype.

Chapter 4 details the design considerations taken in the development of the prototype and provides an overview of the application design. It moves on to explain the design motivation behind, and implementation of, each of the features of the prototype - with particular reference to the high level system requirements they aim to satisfy.

Chapter 5 presents the results obtained from the evaluation of the prototype. Both the quantitative and qualitative results are discussed in depth, in order to investigate whether the prototype succeeded in satisfying the requirements set out for its development.

Chapter 6 provides a brief summary, highlighting the conclusions that can be drawn from this research. It revisits the problem statement and discusses some possible extensions to this work.

Chapter 2

Related Work

2.1 Introduction

The primary aim of this chapter is to explore the literature surrounding the development of OLEs. In particular, the focus is on outlining approaches to design and pedagogy that have the potential to facilitate the successful implementation of an effective prototype OLE. This investigation begins by providing an overview of the context in which the use of ICTs for education occurs in South Africa. It moves on to define and explore the concept of e-learning. Once this background is established, the discussion concentrates on the development of OLEs. Firstly, a survey of prominent design theories and features is provided. Secondly, an investigation is undertaken into various techniques that may be used to improve learner engagement. Finally, a brief overview of methods of evaluating the success of OLEs is offered.

2.2 Current State of Information and Communication Technology Use for Education

Before any meaningful discussion of the use of OLEs can be undertaken, it is important to consider the current state of the use of computer technologies to aid teaching in South Africa. This section provides a brief outline of some of the problems currently facing education in South Africa and introduces the possibility of ICT use as part of the solution. It also provides some background on the current state of ICT use in South Africa and

legislation surrounding ICTs in education. From this discussion it will become apparent that the use of ICTs in education faces many difficulties in South African schools, but that there is an emerging confidence in ICT use among South African and world leaders.

2.2.1 State of Education in South Africa

The former South African Minister of Finance, Trevor Manuel, identified education as a development area of "particular priority" [26]. The national senior school pass rate for 2008 was only 62,5% [33]. Many South African schools do not have enough adequately qualified teachers [21] and, according to the 2007 Survey of ICT and Education in Africa, are "under-resourced, under-supplied, and over-crowded" [21]. These impeding factors result in learners not receiving adequate instruction, and not being up to the standard of their final year examinations.

2.2.2 ICT as a Possible Solution

The United Nations recognizes education as a fundamental way of addressing the issues facing developing countries [40]. Universal primary education by 2015 is one of the UN's Millennium Development Goals [40]. The former Secretary General of the UN, Kofi Annan, argued for the use of ICTs to "unlock the door to education" [40] and the South African government shares this sentiment. In the 2003 Department of Education (DoE) White Paper on e-education, the DoE argued that ICTs are a powerful tool that can be used to "overcome" the "capacity-related limitations" in the education sector [36, p. 1]. The white paper outlines a policy framework for e-education in South Africa and sets the ambitious goal of ensuring that all learners are ICT capable by 2013 [36]. It also serves as an acknowledgment from the government of the potential and importance of ICT use in education [36]. Former President Thabo Mbeki stated that ICT is a "critically important tool" in the struggle against "poverty ... under-development [and] ... marginalisation" [36, p. 3].

Province	Schools with computers used for teaching and learning
Eastern Cape	4.5%
Free State	12.6%
Gauteng	45.4%
KwaZulu-Natal	10.4%
Mpumalanga	12.4%
Northern Cape	43.3%
Limpopo	4.9%
North West	22.9%
Western Cape	56.8%
National	*26.5%*

Table 2.1: The percentages of schools with computers used for teaching and learning use in South Africa. [36]

2.2.3 State of ICT Use for Education in South Africa

In order to get a complete idea of the possibilities of ICT use in South African schools, it is important to consider the current state of ICT usage. The e-education white paper states that only about 6,4% of South Africans in 2003 had access to the Internet, compared to 72,7% of Americans. It also states that over 19 000 schools did not have any computers to use for teaching or learning [36]. Table 2.1 illustrates the percentages of schools, both nationally and in each province, that have computers which are for teaching and learning use.

It is interesting to note that the Eastern Cape has a particularly low figure, with only 4,5% of schools having computers to use for teaching and learning. Wagner identifies some of the obstacles to the spread of ICT use as: a shortage of staff with IT (Information Technology) skills, poor infrastructure ("including power, telecommunication access, and Internet service providers"), and curricula that do not have room for IT skills [41, p. 15]. He also stresses that it is vital that government policies support the use of ICTs in education [41].

2.2.4 Legislation

In any country, the state of the legislation surrounding a development issue will play a crucial role in the success of that development [5]. A recent series of international case studies and surveys revealed that successful ICT integration does not arise simply from the

presence of computer equipment, but that government policies and implementation plans, along with the necessary administrative and training support, are essential elements in making ICTs effective in an educational environment [41]. The South African government has launched several initiatives that aim to support the improvement of South African education using ICTs. The Presidential National Commission on the Information Society and Development (PNC on ISAD), launched in 2001, serves as an advisory body to the government regarding the best approaches to ICT use [36]. More recently, the Accelerated and Shared Growth Initiative for South Africa (ASGISA) was established. This initiative focuses on ensuring that communications infrastructure in the country is expanded and made more affordable, as well as on the development of critical IT skills [21].

The 2005 Electronic Communications Act makes provision for a minimum of 50% discount on electronic communication charges and equipment to "all public schools and all public further education and training institutions" [38, 21, p. 7]. Schools are still having difficulty obtaining this discount, though, meaning that the necessary legislative support is not being enforced [21]. In fact, many schools are unable to obtain suitable connections to the Internet, due to a lack of regional infrastructure and funding [21]. The government is making more funding available for the integration of ICT in education, though, which should have a positive impact on infrastructure expansion [21].

2.3 E-learning

The previous section provided a broad overview of the ICT infrastructure and legislation in place in South Africa. The discussion now moves on to explore the actual practice of using ICTs to aid education. An investigation into OLEs would not be complete without a background understanding of what online learning, or e-learning as it is commonly referred to in the literature, is and why it is something worth researching. This section aims to provide a broad definition of e-learning as well as an idea of the kinds of benefits that can be expected from its implementation. It also makes the fundamental point that an implementation of e-learning requires more than a simple transferral of traditional classroom pedagogies in order to be successful.

2.3.1 What is E-learning?

In order to be able to talk effectively about OLEs, it is crucial to define the concept of e-learning. Churton defines e-learning as "an approach to facilitate and enhance learning by means of personal computers, multimedia, and the Internet" [5, p. 7]. It is thus simply a process that uses computer technology to aid learning. The South African DoE explains e-learning in terms of three parallel processes. As the primary process, it involves "learning with" computers - using ICTs to convey, or facilitate the conveyance of, concepts [36, p. 13]. As secondary processes, learners (a) learn more "about ICTs" themselves, and (b) learn new learning methods "through" their use of computers [36, p. 13]. E-learning tends to promote an environment where communicating and collaborating is easier, which enables learners to engage with content more actively and creatively [36]. E-learning also has a propensity for allowing the combination of structured content and flexible learning; as well as allowing for the management of individual learning [36]. One of the DoE's goals is to establish a community of "e-schools", which can be broadly defined as schools (with access to reliable ICT infrastructure and useful learning resources) where learners use ICTs to aid them in their learning, and teachers use them to aid in the teaching process [36].

An important concept that needs to be defined is that of "integrated e-learning". Jochems, Merriënboer and Koper define integrated e-learning as a supplement to "more conventional methods" of teaching [22]. The focus of integrated e-learning is not on replacing traditional methods of instruction, but on e-learning as "just one of the methods" involved in "providing optimal learning arrangements by the use of a variety of methods" [22]. At this point, it is also important to distinguish between synchronous and asynchronous e-learning. The term synchronous e-learning describes scenarios where "students and instructors engage each other at the same time," often from different locations [42]. "Telephone calls, VoIP, live text chat, videoconferencing, and LVCs [Live Virtual Classrooms]" can all be described as synchronous e-learning technologies [16, p. 28]. Asynchronous e-learning, on the other hand, refers to scenarios where "students and instructors are engaged in 'anytime-anyplace' learning" [42]. In asynchronous e-learning, learners are able to access learning material whenever it is most convenient for them to do so [42]. Asynchronous e-learning is therefore better suited to integrated e-learning. For the purposes of this discussion, the focus will be on integrated asynchronous e-learning.

2.3.2 Benefits of E-learning

One might ask exactly why e-learning is something worth investigating. There are several benefits to using computers to supplement learning. Firstly, e-learning enables a "learner-centered" teaching approach [5, p. 9]. Because learning happens asynchronously, learners are not constrained by the traditional classroom practice of everyone learning content in the same time period [5]. This means that learners are able to work through content, to some extent, at their own pace [5]. Secondly, e-learning has room for the successful practice of more individual learning approaches and individual needs, meaning that learners are able to engage with content in a manner they feel more comfortable with [5, 36]. Computer networks also make collaboration and discussion easier, which teaches learners how to express their ideas, and learn from one another [36]. Another salient benefit of e-learning is the exploratory approach required to find content on computer networks. Using ICTs encourages learners to be more "active" in their learning: they are required to take responsibility for their own learning, they need to engage with the content more carefully, and they need to develop analytical skills in order to discern whether information is useful [5, 36]. E-learning also exposes learners to a "wider range" of sources, learning environments and learning styles [30]. In terms of e-learning's impact on pedagogy, it has been demonstrated that, with proper teacher training, adopting e-learning forces teachers to revise teaching strategies and rework content, often with the result that learning becomes more relevant and accessible to learners [41]. E-learning also offers a powerful means of "connecting learners and teachers to each other" as well as to ideas from a broader range of sources [36, p. 7]. A final prominent benefit of e-learning is that learners and teachers both acquire essential "21st Century skills" [41, p. 2]. Churton contends that e-learning not only teaches content, but also skill in the use of computer technology, which is an increasingly important modern ability [5]. Kozma takes this idea a step further by contending that the use of computers also introduces learners to other vital modern skills such as "information management, communication, working in teams, entrepreneurialism, global awareness, civic engagement, and problem solving" [41, p. 14]. In short, learning how to use ICTs does not merely provide learners with ICT skills, but equips them with the building blocks of a modern skill-set and perspective.

2.3.3 E-learning Strategies

It is important to recognize that there are differences between e-learning environments and the traditional classroom environment; and that, with this, comes the need for new strategies for teaching. Churton is adamant that conventional teaching strategies "will not

be successful" in e-learning [5, p. 2]. He stresses the importance of both "educational and instructional strategies" [5, p. 3]. Essentially, he argues for the importance of the strategy employed in incorporating e-learning into teaching, as well as the strategy actually used during e-learning [5]. It is not necessarily the content itself that needs to be adapted, but the way in which it is presented [5]. Teachers need to adapt their teaching methods in order to be able to effectively monitor the learners in their class. In an e-learning classroom environment, teachers do not always have the usual "visual cues" that inform them that learners are confused, so it is important to find ways of incorporating measurement of the learner progress in e-learning strategies [5, p. 9]. Another important pedagogical consideration is how to make learners' transition to e-learning as smooth as possible. It is important that students feel comfortable when being introduced to computers and e-learning so that they are not discouraged [5]. To achieve this, e-learning should be aimed at the "needs of the students", and should fit in with their "preferred learning styles" [5, p. 9]. It may also be useful to provide mechanisms for learners to use to communicate with their teacher and one another using computer networks, so that they can ask for help and learn from each other [5]. If this is done correctly, learners will feel motivated to use e-learning, and explore its possibilities [5].

2.4 Online Learning Environments

An online learning environment is a completely web based "co-ordinated collection of learning materials" and activities [24, 42]. Essentially, OLEs act as a platform where integrated asynchronous e-learning can take place. This section aims to provide some synthesis of the literature on what facilitates the development of successful OLEs. This is achieved by exploring different design considerations, investigating ways in which online content design can improve learner engagement, and outlining some approaches to the evaluation of OLEs.

2.4.1 Design Considerations

Holmes and Gardner define instructional design as "a branch of knowledge concerned with research and theory about learning and teaching strategies, particularly in an e-learning environment" [20, p. 93]. It is important that research into OLEs is informed by at least a broad understanding of the major e-learning theories, the specific learning theories which are most relevant, and the design features that fit into those theories.

2.4.1.1 Learning Theories

As Churton argues, it is essential that the design of e-learning software is informed by learning theory [5]. It is thus important to include a survey of different learning theories used in e-learning. There are many different accounts of how learning works and how it should be approached. Before giving an overview of some of the major learning theories, it would be beneficial to convey a disclaimer from Terry Mayes. He stresses the importance to recognize that different learning theories are not disjoint ways of looking at the same learning, but compatible ways of looking at different learning activities within their particular contexts [10]. The different theories are not necessarily exclusive, but rather differ in the areas in which they place emphasis [10]. Dyke, Conole, Ravenscroft and de Freitas [10] identify a list of the major e-learning theories. Table 2.2 provides a brief explanation of the principle tenets of some of these theories. This list is not exhaustive, but provides an idea of the major schools of thought on ways to approach e-learning.

2.4.1.2 Constructivist Design

Within the context of previously disadvantaged schools, where many teachers do not have extensive experience in the use of ICTs [21], an OLE would need to facilitate and support a learner-centred approach. Of the theories outlined in Table 2.2, the constructivist theories bear most relevance to this context, as they focus on "learner-centred and activity-oriented cognitive processes" for the creation of knowledge [10, p. 90], which Dyke *et al.* contends are all "typical features of the constructivist paradigm" [10, p. 90]. Coomey and Stephen support this conclusion by arguing that constructivist features such as a task-based focus and learner-centred conduct are required in contexts where "tasks and ... learning goals are specified *but* learners have control over how they work" [7, p. 43]. Because of its focus on the role of collaboration in knowledge creation, constructivist theories also fit well with emerging Web 2.0 technologies, such as "blogs, wikis and ... social networking sites like MySpace ... and Facebook" [27, p. 664].

The central premise from which constructivism follows is that "students create their own knowledge from their experiences and from interaction with their environment and other people" [20, p. 90]. According to the pioneering constructivist psychologist, Piaget, children learn by incorporating unexpected responses and new information into their existing understanding [10]. In constructivist learning, the individualized construction of knowledge is encouraged over rote learning [20]. As can be seen in Table 2.2, constructivist

Learning Theory	Focus
Behaviourist	Learning through *modification of behaviour* using stimuli. Based on the theories of behavioural psychologists like Skinner, these theories view behavioural modification as the outcome of learning. They emphasize the use of positive and negative reinforcement and association to bring about learning [10].
Cognitive	Learning through *reflective incorporation* of new information into existing knowledge structures. This theory emphasizes instructional design around the learner's cognitive processing and existing knowledge structures [10].
Cognitive Constructivism	Learning through enquiry-led *active individual engagement* in a learning environment. Cognitive Constructivists see knowledge as learner-constructed, and so emphasize the importance of tasks that allow learners to approach them in their own way - which aids them in the discovery of new information through exploration [10].
Social Constructivism	Learning through cementing individual knowledge by *communicating* knowledge to others and understanding it in relation to *communal knowledge*. This school of thought emphasizes the importance of learners' collaboration with each other and with experts. It sees communication as a vital learning process that helps learners clarify and contextualize what they have learnt and identify possible gaps in their understanding [10].
Experiential	Learning through *applying* information in solving problems and examining case studies. Experiential theorists believe experience to be the best way of establishing new information. They emphasize the use of real world problems, that relate to the learners' experience to allow them to learn new information by applying it [10].
Activity-based	Learning through mediating between the learner's "developmental stage" in an *activity* and that of society at large. These theories are based on the work of Vygotsky and originate from the idea that the context of an activity determines how learners interpret the results of that activity [10, p. 87].

Table 2.2: Outline of major learning theories

learning theory consists of two separate complimentary sub-theories: cognitive constructivism and social constructivism [10]. This is because construction takes place both in individual and social contexts; with new information not just being assimilated individually, but also challenged, contextualized and enforced through social interaction and exposure to the views of others [20]. Collaboration is encouraged in constructivist learning, as it provides exposure to different interpretations and articulations of the same information - which helps the learner to better understand their own views [20].

2.4.1.3 Design Features of Online Learning Environments

In their review of 100 journal articles and research reports from the field of OLEs, Coomey and Stephenson identify certain categories of design features that were considered as necessary to successful online learning by most of the research reviewed [7]. In this paper they coined the "DISC" framework, consisting of four such features, within which most considerations in the design of OLEs can be categorized [7, p. 38]. The four design features they identify are: Dialogue, Involvement, Support and Control [7]. Exploring online learning design considerations under these headings will result in a comprehensive overview of the different components and approaches that may be included in the design of OLEs.

Dialogue According to constructivist learning theories, collaboration plays a central role in knowledge creation [20]. Vygotsky argues that learners "develop critical reasoning skills through internalizing the process and content of dialogical argumentation" [10, p. 95]. Including components that facilitate and encourage learners to discuss their learning with others will ensure that they achieve an understanding that is mediated by, and clarified through, the understanding of others [7, 20]. Some examples of components that may help achieve this include "e-mail, bulletin boards, 'real-time' chat, asynchronous chat [and] group discussion" [7, p. 38]. Coomey and Stephenson argue, however, that getting learners involved in such discussion can be difficult, and so the use of collaboration components needs to be "carefully structured" into the learning environment (both online and in the classroom) [7, p. 39]. They suggest that it may be useful to set discussion topics and time allocations for discussions; and even to have moderators in discussion groups that guide the discussion [7]. They also suggest that asynchronous discussion tools, such as forums, allow "active participation", as well as time "for in-depth reflection and thoughtful responses" [7, p. 39].

Involvement Involvement centres on "active engagement with material" [7, p. 39]. Chan and Repman coin the useful term "flow", to refer to "a state of total absorption by the student in online learning activities" [7, p. 39]. In order to achieve "flow", the learning environment needs to give control over content exploration to the learner, and should actively challenge the learner [7, p. 39]. It also needs to hold the learner's attention, specifically by providing "clear feedback" to the learner as they interact with the system [7, p. 39]. Dyke *et al.* emphasizes the importance of "activity" and "interaction" to learning [10, p. 84]. Holmes and Gardner argue that learner involvement can be supported by requiring "creative responses" from the learner and through "tasks requiring the searching for and analyzing of information" [20, p. 105]. He also stresses the importance of dialogue as a part of keeping learners engaged with material [20]. Holmes and Gardner contend that constructivist learning models will only really work if learners see themselves as "producers" of information, rather than mere "consumers" [20, p. 94]. Web 2.0 technologies like blogs may be useful in facilitating this paradigm shift [27]. Links to multimedia can also raise learners' interest levels and facilitate involvement through more exciting media than plain text [39].

Support Perhaps the most difficult feature of an OLE is support [7]. Support refers to mechanisms that guide learners' interaction with content, and helps them when they become confused or unsure [7]. Learners are often frustrated by a lack of support online, particularly if they are accustomed to a traditional classroom environment [7]. To prevent this, it may be advisable to maintain "periodic face-to-face contact" in addition to online supervision [7, p. 39]. It is also essential that learners' queries via email and other online support mechanisms are responded to timeously, so that they do not feel like their learning is without support [7]. The same holds for feedback on assessment and group discussions, as assessment offers guidance to the learners on which learning areas require attention [7]. Possible online support mechanisms include email, discussion groups and links to external experts [39]. In situations where there is a of lack teacher support, it may also be useful to encourage learners to form online "working groups" [7, p. 40]. This will make learners feel like part of a learning community, and ensure that they have somewhere to go with their queries, even before seeking help from teachers [7].

Control The primary factor that differentiates e-learning from conventional teaching, is that it offers the opportunity for learning to be learner-managed [7]. Stephenson argues that e-learning is causing a shift in pedagogy "towards giving learners greater responsibility for managing their own learning" [39, p. 219]. Coomey and Stephenson define control

as the "extent to which learners have control of key learning activities and the extent to which they are encouraged to exercise that control" [7, p. 40]. This control includes how long learners take to complete tasks, which tasks they complete and in which order, what material to study and which sources to use [7]. Holmes and Gardner argue that control over content encourages responsibility, exploration and curiosity [20]. Learners often have difficulty exercising this control over directing their own learning, however, particularly if they see the OLE as a different instantiation of traditional classroom learning [39]. They feel that learning requires direct teaching, and become unsettled when the teaching component of learning is not as obvious as in classroom learning [7]. To overcome these feelings, it is important that teachers act as coaches, who guide learners through this new way of learning and help them feel comfortable using it [7]. This is of particular importance in the case of learners with limited ICT experience, where learners may have difficulty with the exploratory nature of e-learning and deciding how to direct their own learning [7]. It is also important that learners' control over their learning is structured in such a way that it takes their other activities into account - otherwise some learners may not know when to stop their exploration and spend too much of their time on a particular task or concept [7]. The inclusion of a course structure, and perhaps structuring online content accordingly, will help guide learner activities [7]. Stephenson makes the important observation that the amount of control learners have exists on a continuum with the amount of control teachers have; and thus the extent to which e-learning is learner-managed depends on how OLE designers "choose to manage (or constrain) the potential" of the available technologies [39, p. 221].

2.4.2 Learner Engagement

Modern learning theories promote "learning as transforming knowledge" over "learning as reproducing knowledge" [1, p. 157]. Cairncross and Mannion argue that this "deep learning" requires "active involvement on the part of [the] learner" in order to be effective [1, p. 157]. By virtue of the fact that e-learning is so learner-centred, it requires a significant level of learner responsibility in order to work effectively [5]. It is therefore essential that learners are sufficiently motivated to take responsibility for their learning [5]. According to Churton, Jafari argues that "sites such as MySpace, You-tube, and e-bay are 'sticky' " and manage to "lure individuals back to the site on a repeated basis" [5, p. 5]. Churton contends that it is necessary to create a similar level of engagement in OLEs in order to motivate learners to use them repeatedly [5]. Johnson and Aragon argue that OLEs "must be able to gain and maintain students' attention by providing

an environment that is interactive and participative" [23, p. 4]. This section deals with different ways of encouraging learner engagement in an OLE.

2.4.2.1 Multimedia

Cook, White, Sharples, Sclater, and Davis define multimedia as "the orchestrated combination of text, graphic art, sound, animation and video elements" [6, p. 59]. Johnson and Aragon argue that what they call "The MTV Generation" prefers visual content over traditional learning materials [23, p. 4]. They assert that there is "no excuse for not incorporating multimedia into technology-based learning systems" [23, p. 4]. According to Waterhouse, the use of "multimedia resources in e-learning can dramatically improve student responses" to content [42, p. 110]. She argues that multimedia, including images, animations, videos and audio clips will help learners to understand information by appealing to their dominant senses [42]. Johnson and Aragon found that that graphic images, photographs, and videos enhance student motivation [23]. Incorporating multimedia can "increase enjoyment" and learner engagement [1, p. 159]. At the very least, multimedia can act as a means to "motivate a learner into using" an OLE and so initiate engagement with other material [1, p. 159].

It is important that the multimedia design of an OLE takes individual preferences into account [1]. Some learners learn better when they are able to approach content holistically - they begin by learning broad concepts and then learn the detail by fitting it into those broad concepts [1]. Other learners prefer the more conventional method of simply moving through material sequentially and building up a broad overview once they have covered the material [1]. Both of these approaches can be catered for by giving the learner more control over their learning, by allowing them to navigate freely between sections of multimedia content [1]. This can also be achieved using a "hierarchical-based menu system" where learners can either follow the set order or an alternative order that better suits their learning needs and preferences [1, p. 160]. Cairncross and Mannion make a distinction between learners who require assistance in structuring their approach to content and learners who prefer to control their own learning structure and navigation [1]. Content therefore needs to be structured clearly enough to orientate learners who need structure, as well as flexible enough for learners who want to exercise more control [1]. Multimedia can be used to present the same information in different ways, thereby providing learners the opportunity to engage with material in the way they find most useful and comfortable [1, 42]. This duplication also aids in the transfer of information "from short-term memory to long term memory" [1, p. 158].

Cairncross and Mannion point out the importance of taking human cognitive limitations into account when using multimedia, in order to prevent "divided attention and disorientation" [1, p. 158]. It is salient to keep in mind that some types of multimedia content (and combinations of these) are better suited to certain types of content [1]. The inclusion of multimedia content does have the potential to distract from other learning materials [1]. Cairncross and Mannion argue that simply providing repositories of links to multimedia content is not effective, as learners become overwhelmed and unproductive [1]. Instead, multimedia should be closely linked with other learning materials, perhaps using a "narrative-like structure" [1, p. 159]. The use of hyperlinks can enrich the learning experience, though, if they are structured in such a way that they link from positions in content with similar themes [1, 6].

In addition to the ability to navigate through media in a way that suits learners, it is essential that they are able to engage in interactive activities with learning material [1]. The use of animations can allow learners to engage with simulations of real world scenarios and explore "alternative courses of action", without being inhibited by the fear of incorrect actions [1, p. 159]. Multimedia also allows for role-playing, which offers another useful way for learners to test out new knowledge in realistic scenarios [1]. An essential consideration when designing interactive learning activities is to ensure that they "cognitively engage the learner" and "cause them to think about the material that is presented" and how it applies to real world scenarios [1, p. 161].

2.4.2.2 Assessment

Before undertaking any discussion of assessment, it is important to make the distinction between summative and formative assessment. Summative assessment refers to assessment, usually in the form of examinations, which determines whether a learner has achieved the required outcomes for a course or qualification [35]. Formative assessment, on the other hand, which is what this discussion focuses on, refers to assessment that is used to evaluate learner progress, provide feedback to learners and assist them in achieving learning outcomes [35].

A major benefit that the web has for education is the ability to integrate assessment with learning material [35]. Through designing an OLE that provides "automated feedback" to the learner, while they are learning, it is possible to create a much more engaging and interactive way of learning [35, p. 148]. If this feedback is "based on the input of the learner", it enables them to incorporate it into their current understanding and get a sense

of how well they understand the content [35, p. 148]. Hartog, Draaijer and Hofstee call this type of content "activating learning material" and argue that it "forces the student to actively engage with the learning material by making selections and decisions" [18, p. 1]. Instant feedback on learner responses to content is an effective way of encouraging learners to learn from their mistakes, as the feedback is received before any misunderstandings can be internalized [42]. Behaviourist theories of learning state that providing feedback indicating that a learner has understood a section can act as a form of extrinsic motivation [20]. Automated feedback can therefore help boost learners' confidence as they progress, by confirming their understanding of the content [35].

There are several limitations to electronic assessment, mainly due to the limits to what computers are able to mark [35]. Some teachers consider electronic assessment to be "inappropriate for assessing ... 'higher order' learning outcomes" [35, p. 150]. These limitations should not discourage the use of electronic assessment, however, as it can still be a useful way of administering simple assessment of learners' progress for self-assessment [42]. By closely linking questions to the points in the learning material where they appear, it will be possible to provide learners with a useful sense of their progress while they work through material [42]. In addition, there are techniques that try to improve the efficacy of the standard multiple choice questions normally used in electronic assessment [35]. These include negative marking and asking learners to specify how confident they are of their responses [35]. It is possible to mark electronically the use of one word or short phrase questions [35]. It is even possible, using "natural language processing techniques" to mark sentence-length responses [35, p. 150]. Hartog, van Boxel, Hofstee, Latour, Rietveld, Verstralen and Gorissen include "drag-and-drop", "fill-in-the-blank" and "hot spot" in the list of computer-assessable question types [18, p. 10]. Administering assessment using computers has the added benefit of being able to perform useful analysis of learner results easily - thereby providing both learners and teachers with a meaningful indication of both individual and class performance [35]. Electronic assessment also "offers consistency in marking", which is useful for performing comparative analysis [35, p. 155].

2.4.2.3 Online Discussion

One of the major trends that characterizes Web 2.0 is the shift from seeing the Internet as "read-only" to seeing it as "read/write" [3, p. 245]. The web is no longer just a way of getting information; it is now also a way for individuals to share information with others [3]. By incorporating this information-sharing culture and technology in OLEs, it is possible to turn learning into a more collaborative process and encourage learners to

share information with one another [3]. Waterhouse contends that enabling this kind of communication in an OLE has several advantages [42].

First of all, online discussions make it easier for learners to communicate [42]. Online communication provides learners with a method of communication that is instantly available and easily accessible from the content that they wish to discuss [42]. Online communication is convenient [42]. As a result of discussions taking place online, learners can take part from wherever they happen to be [42]. The absence of geographical constraints means that learners can exchange ideas with other, geographically distant learners that they would ordinarily not be able to contact [7, 42]. The asynchronous nature of online communication media such as forums and email, means that learners are also able to contribute to discussions at any time [42]. Online communication also has the benefit of removing the anxiety experienced by some learners in traditional face-to-face discussions [42]. Shy students will often be more inclined to participate in online discussion, largely due to the fact that asynchronous discussion offers them the opportunity to reflect on ideas in their own time, and edit their responses before posting them [42]. Despite the benefits of asynchronous online communication, synchronous communication is still a useful way of exchanging ideas - and this can be facilitated through online chat [42].

Secondly, electronic discussion makes it easier for learners to think about ideas [42]. Dyke *et al.* argue that reflecting on, and thinking about, what has been learnt is central to the learning process [10]. The asynchronous nature of forums allows learners to take time to reflect on what others have said before replying [10, 42]. Waterhouse argues that this leads to "more thoughtful responses" [42, p. 123]. She also argues that electronic discussions encourage learners to take pride in what they say, due to the fact that it will appear in writing for their peers to see [42]. In addition, online discussions tend to be more "detailed and involved" because of the nature of written communication and the fact that they are not constrained to scheduled time in class [42, p. 123].

Thirdly, electronic discussion fosters a sense of a learning community [42]. An interesting feature of online communication is that physical characteristics such as "gender, age, race, and disability" are largely obscured; creating an environment that is safer from discrimination on these grounds [42, p. 123]. Waterhouse contends that learners who communicate online "build a sense of community" and find it easier to communicate their ideas within such an online learning community [42, p. 124]. Learners also gain valuable interaction skills, particularly relating to the respectful exchange of ideas [42]. Graham, Cagiltay, Lim, Craner and Duffy argue that online discussion allows learners to "challenge the ideas of the instructor, of other students, or those presented in the readings or other

course materials," which enriches their own understanding of concepts [15, p. 6].

A final benefit of electronic discussion is that it is automatically recorded. Quite simply, this creates a knowledge base for future learners [42]. Because forums are archived, electronic discussion results in an easily accessible record of a wealth of opinions, thoughts and ideas around a variety of discussion topics [42]. Learners can use these forums to see what others have thought and use this insight to guide their own learning [42]. Recorded discussions also enable teachers, tutors and course administrators to monitor what learners are learning and how well they are engaging with the content [42].

Blogs are another method of electronic communication, which are focused on the sharing aspect of Web 2.0 [3]. A blog, or web-log, as defined by Carliner and Shank, is "a series of chronologically arranged (most recent at the top) online journal entries that is frequently updated by its author" [3, p. 259]. Dyke *et al.* identify "thinking and reflection" as "core elements of learning" [10, p. 89]. Johnson and Aragon argue that an online journal can "promote continuous reflection throughout the course" [23, p. 7]. By teaching learners to blog, it not only encourages them to take more ownership of the ideas they are learning about, but also facilitates "idea sharing and interaction" with their peers [25, 27, p. 666]. Lin, Yueh, Liu, Murakami, Kakusho and Minoh found that blogging elicits "personal authority " in learners over what they say and provides a good representation of learners' progress [25, p. 3].

2.4.2.4 Activity Based Learning

Dyke *et al.* identify learning from "experience and activity" as one of the "three core elements of learning" [10, p. 84]. Johnson and Aragon argue that "project-based learning and cooperative learning are common techniques for engaging students in activities that involve considerable amounts of creativity, decision-making, and problem solving" [23, p. 6]. Activity theory places emphasis on the idea that humans learn based on their interactions [10]. A well designed OLE will facilitate interaction that stimulates "decision-making, problem-solving and hypothesis-testing" [20, p. 105]. Activity based learning focuses on learners cementing their understanding of ideas by applying their understanding in activities such as simulations and case studies that mirror real world scenarios [10, 23]. According to Cairncross and Mannion, "understanding occurs best through performing tasks" where "new knowledge" is applied [1, p. 157]. Kolb's learning cycle emphasizes "learning by doing" and consists of four distinct stages: "experience, reflection, abstraction and experimentation," with activities playing a large role in the experimentation stage

[10, p. 90]. Holmes and Gardner present "problem-based learning", "online simulations and gaming" and "WebQuests" as activities that facilitate the conceptualization of newly acquired information [20, p. 109]. In problem-based learning, learners are required to practise analytical and creative thinking to come up with solutions to real world problems or dilemmas [20]. Online simulations are useful in the way that they model real-life scenarios for learners to interact with [20]. Although games are often not as realistic, they are useful in increasing learner motivation as they tend to be fun and competitive [20]. WebQuests involve assigning learners a topic to research on the Internet and aim to aid the development of critical reading, analysis and synthesis skills [20].

2.4.2.5 User Interface

Nam and Smith-Jackson argue that the success of an OLE is dependent on whether it "effectively facilitate[s] learner interactions" [30, p. 26]. User interface design is particularly important in the field of education because a more intuitive user interface will allow learners to focus quickly and easily on learning material, rather than spending time learning how to use the web site [30]. Nam and Smith-Jackson also stress the importance of taking the needs of learners into account throughout the user interface design process, in order to ensure that the user interface facilitates a learner-centred approach [30]. Hamid argues that good user interface design is crucial because it gives the learner "a sense of control" [17, p. 313]. Graham *et al.* provide a framework for evaluating user interface design, which is outlined in Table 2.3 [15]. As discussed by Hamid, Nielsen identifies five traits of effective user interface design, which will be useful to keep in mind while exploring Graham *et al.*'s framework:

- ease of learning
- efficiency of use
- memorability
- error frequency
- user satisfaction [17]

Principle	Description
Consistency of web page layout and design	• Improves the learnability of the environment • Makes it easier to access information in the environment • Allows the use of knowledge gained in one area of the environment to be transferred to another [15]
Clear organization and presentation of information	• Complicated or busy interfaces prevent learners from achieving the tasks they set out to complete • Organising information into clear categories makes information more meaningful and makes navigation more efficient • Avoid presenting too much information to the learner at one time in order to prevent cognitive overload and confusion [15]
Consistent and easy-to-use web site navigation	• Make sure learners always know where they are within the structure of the environment • The use of "standard navigational bars, icons, and links ... on each page" allows users to recover quickly from navigational errors • The use of hyperlinks can improve the efficiency of access to information • The use of consistent navigational tools improves the memorability of the environment [15]
Aesthetically pleasing design and graphics	• Poor aesthetic design hinders learner engagement • Graphics "should be kept simple" and relevant so that they do not distract or confuse the learner • The user interface should be designed so that learners are able to comfortably engage with it for extended periods of time [15, p. 14]

Table 2.3: Graham *et al.*'s user interface evaluation framework.

2.4.3 Evaluating Online Learning Environments

In addition to considering the design of OLEs, it is also salient to investigate ways of evaluating their success. Oliver, Harvey, Conole and Jones argue that evaluation can "contribute to research" and provide "feedback for a changing teaching and learning practice" [32, p. 203]. Oliver *et al.* suggest an "input/output efficiency" based evaluation approach [32, p. 204]. Table 2.4 provides an overview of some of the major evaluation techniques discussed by Oliver *et al.*

Evaluation technique	Description
Experimental methods	Experimental evaluation follows the model of a traditional experiment. In order to test a hypothesis, a controlled environment is set up and the effect of a few variables on that environment is monitored. The outcome of the experiment is evaluated using quantitative measures such as data collection and statistics. Experimental evaluation often aims to measure improvements or differences between scenarios [32].
Illuminative evaluation	Illuminative evaluation places great importance on the contexts that influence what is being evaluated and takes a "more open-ended, exploratory approach to evaluation". Researchers try to remain as impartial as possible and consider all possibilities that surface during the evaluation equally [32, p. 206].
Systems approaches	Systems approaches are directly "linked to learning outcomes". Rather than evaluating the process of learning, these approaches focus on whether certain predetermined expected results are met [32, p. 206].
Action research	Action research focuses on evaluation as a collaborative process between researchers and research subjects. It places great importance on the interests of research subjects and is often redirected to pursue these interests. Action research is therefore subjective in nature and tends to focus more on facilitating change than just evaluating performance [32].
Responsive evaluation approach	The responsive approach aims to monitor the current situation and take practical steps, informed by the thoughts of research subjects, to bring about changes in the situation. There is a focus on producing research that will be considered useful by research subjects [32].

Table 2.4: Outline of major approaches to evaluation.

Waterhouse discusses two types of feedback that can be used to evaluate OLEs: Student Feedback and Peer Evaluation [42]. Student Feedback can be obtained using anonymous student surveys, which can be administered online [42]. Such surveys aim to determine whether the learners found the course valuable, whether they felt that their individual

needs were met, whether they felt the course was interactive enough and whether the course was appropriately administered [42]. They can also be used to evaluate the infrastructure of the web site; including whether particular components were effective and easy to use, whether the site was well structured and whether content was relevant and up to date [42]. Anonymous student surveys contain some questions that need to be answered with a rating from one to five, ranging from "strongly disagree" to "strongly agree" [42]. Web-based applications are also able to "systematically collect continuous feedback from users" in the form of usage statistics, which provides course administrators with easily accessible details on learner performance [30, p. 24]. Peer Evaluation involves formal or informal reviews by colleagues from within the organisation or colleagues from other organisations in the field [42].

2.5 Conclusion

This chapter has provided a survey of the literature in the field of e-learning. Through an exploration of the literature that deals with the state of ICT use for education in South Africa, it has become apparent that there are many constraints and obstacles that need to be kept in mind when developing an OLE for use in South Africa. Fortunately, the literature also points to an increase in support for ICT use in education and highlights several initiatives driven by the South African government to facilitate the implementation of e-learning in schools. By reviewing the literature surrounding e-learning, the concept has been broadly defined and briefly justified as a beneficial approach to learning. The need for innovative teaching approaches for the effective implementation of e-learning has also been outlined. The discussion narrowed in focus to explore literature that suggests approaches for the effective design, pedagogy and implementation of OLEs. This included an outline of major e-learning theories and the presentation of a framework aimed at categorizing design features required in OLEs. The discussion also included an investigation into design and implementation techniques that can be used to improve learner engagement when using OLEs. Lastly, this chapter outlined literature suggesting approaches and techniques for the evaluation of OLEs. The next chapter explains the research methodology in order to clarify the scope of this research and the approach taken.

Chapter 3

Methodology

3.1 Introduction

This chapter provides an explanation of the approach taken to the research. It discusses the reasoning behind the decision to develop a prototype OLE and describes the approach taken in the development of the prototype. It outlines the process of gathering requirements for the prototype and provides an overview of the approach taken to evaluate the prototype.

3.2 Developing a Prototype

From the outset of this research, it was decided that the best approach to investigate the application of e-learning in previously disadvantaged schools in South Africa would be to develop, and evaluate the success of, a prototype OLE. By taking this approach, it has been possible to gain experience in the full life-cycle of an OLE, including gathering requirements, development, use and evaluation. This provided the opportunity to take current e-learning pedagogy, combined with the requirements for e-learning as seen by teachers, and apply it in the development of a new OLE. These same requirements were then used as criteria against which learners and teachers could evaluate the success of the prototype.

3.3 Scope of the Prototype

Although this research is relevant to learning areas across the school curriculum, it was necessary, due to practical considerations, to narrow the scope of the prototype to be developed. Narrowing the scope of the prototype ensured that there would be enough time to develop and evaluate a functional prototype with a useful depth of features [31]. For this research it was decided to develop a vertical prototype, which can be defined as "a limited part of the full system" that can "be tested in depth under realistic circumstances with real user tasks" [31, p. 95]. This focus also ensured that the amount of learning material required could be sourced and prepared in the time available. It also made it possible for user studies to test the full functionality and content of the prototype.

It was decided to focus the prototype on Grade 12 English Poetry. The decision to focus on Grade 12 was made due to the fact that it is a level at which there are standardized examinations across schools. There is also standardization concerning the texts that are taught. Focusing on Grade 12 ensured that the content available on the prototype would be applicable to the schools involved in the user study. Having the learners in any user studies using the same learning material also ensures the integrity and usefulness of the results of such user studies. The decision to use English as the subject to be covered has several advantages:

1. The principal investigator has experience with, and a Bachelor level qualification in, the subject.
2. It is a subject that all Grade 12 learners at each of the schools involved are enrolled for. This ensures a large group of potential users in each school and provides a level of consistency between schools.
3. English is the second language of most of the learners at previously disadvantaged schools in South Africa. It is therefore a challenging subject and offers a worthwhile test of the prototype's functionality.

The decision to focus on poetry as a learning area was largely due to the principal investigator's interest in the subject. In addition, poetry was seen as a subject with potential for interesting approaches to interactive learning.

3.4 The Grade 12 English Curriculum

It was necessary to ensure that the poems included in the prototype were in the prescribed list of poems set out in the national curriculum. The list of English Prescribed Work Titles for Grade 12 in 2009 (see Appendix B.2) was obtained from the DoE's website [37]. The content of the list was confirmed by the English teachers at the schools involved. It is worth mentioning that the curriculum for Grade 12 English as a language includes English Home Language and English First Additional Language. English First Additional Language is aimed at schools where most learners are not first language English speakers. Some schools where learners are not first language English speakers do, however, teach English Home Language instead of English First Additional Language, mainly because it is believed to better equip learners for work or tertiary education.

3.5 Obtaining Copyright permission

In order to be able to display the text of the poems on the prototype, it was necessary to ensure that copyright permission was obtained for each of the poems. Several of the poems in the Grade 12 English curriculum are in the public domain, as their copyright has expired. For those poems in the curriculum that do not fall within the public domain, letters and emails were sent out to the appropriate poets and copyright holders. Copyright permission was obtained from some authors to include their poems in the prototype (see Appendix E). No poems under copyright were included in the prototype without the permission of their authors. The poems included in the prototype are:

- "To Autumn" (John Keats)
- "An Irish Airman Foresees His Death" (William Butler Yeats)
- "Ozymandias" (Percy Bysshe Shelley)
- "Preludes" (T.S. Eliot)
- "Sonnet 104" (William Shakespeare)
- "you cannot know the fears i have" (Shabbir Banoobhai)
- "The World Is Too Much With Us" (William Wordsworth)

- "The Night Train" (Fhazel Johennesse).

With the exception of the Banoobhai and Johennesse poems, the texts of these poems are available online on the Project Gutenberg website [34] as well as on Wikisource [43].

3.6 Content for the Prototype

An obvious requirement for the prototype was to contain lessons on the included poems. It was decided to approach postgraduate students in the Rhodes University English Department to prepare lesson content for the prototype (see Appendix E). This allowed the principal investigator to focus on the development of the prototype and also ensured that the lessons varied in length, focus and style. Each contributor was asked to pick a poem that they felt competent and comfortable with and prepare a lesson on that poem (see Appendix E). They were instructed to divide the lesson into logical sections and to prepare a few questions on the content of each of these sections. They were also asked to prepare responses to possible answers to each of these questions.

3.7 Gathering Requirements

It was crucial for the development of the prototype to be rooted in requirements that are not only in agreement with prominent e-learning strategies, but that also directly reflect the needs of the teachers and learners that will be using it. Before any development began, attention was focused on understanding the requirements for the proposed system. In order to gain a holistic understanding of the requirements, a survey of the literature was performed. In addition, two individual interviews were held; as well as a focus group with Eastern Cape teachers from previously disadvantaged and former model C schools.

3.7.1 Survey of Literature

The first step in gathering requirements for the prototype OLE was to perform a survey of the literature in the field of e-learning (see Chapter 2). It was vital that the design of the prototype be informed by current writing about e-learning pedagogy. The approach taken for the literature survey was to begin broadly, by reading around the topic of ICT use

in education in general, and particularly in South Africa. The focus of the survey then narrowed to literature that explores e-learning strategies; including both theory based pedagogies, as well as strategies formulated on the basis of results from practical explorations. Specific attention was paid to literature that aims to outline specific requirements for OLEs and specific features that are common to successful OLEs.

3.7.2 Interviews and a Focus Group

In order to identify what the expectations of teachers in South African schools are from an OLE, two teachers were interviewed: one from a previously disadvantaged school and one from a well established private school. In addition, a focus group was held with another ten teachers (from a mixture of previously disadvantaged and previous model C schools). All participants involved in an interview or focus group were asked for their consent to use their responses in this research anonymously. They were provided with an information sheet describing the purpose of the research and the procedure of the interview/focus group and each participant signed a consent form. Appendix A contains examples of the information sheets and consent forms used in this research. All information and consent forms, along with summaries of the interviews and focus group, are available on the electronic appendix CD-ROM. The contents of the CD-ROM can be found as Appendix E. Permission to conduct interviews, focus groups and user studies was also obtained from the Computer Science Departmental Human Research Ethics Committee.

Interview Procedure It was decided to conduct semi-formal interviews, so that the teachers' responses were not restricted, while still having a good idea of what topics should be explored in the interviews [2]. The interviews were one-on-one with the principal investigator and lasted for approximately 30 minutes each. An interview schedule was prepared (Appendix B.1) before the interviews and both interviews were directed by the principal investigator using the same interview schedule. The interviews were each divided into two broad areas of discussion: 1) The teacher's *experience* of the use of computers in teaching; 2) The teacher's *expectations* of the use of computers in teaching. The first area of discussion (experience) was aimed at gaining an understanding of what the teachers have noted as the advantages and disadvantages of e-learning. The second area (expectations) was aimed at gaining an understanding of the requirements the teachers have of an OLE.

Focus Group Procedure The focus group was conducted in a more informal manner than the one-on-one interviews [2]. After providing the focus group with some background information about the research, the principal investigator led the discussion using a set of questions (Appendix B.2), although these questions served primarily as a means to prompt open conversation [2]. Again, the main outcome set for the discussion was to determine the teachers' experience and expectations of the use computer technology in teaching.

The teachers' responses were captured through shorthand notes taken by the principal investigator during the interviews and the focus group. Due to time constraints, no member checking was done. An important outcome set for these discussions was to gain an understanding of what aspects of computers teachers found to be useful, and what they found had a negative impact on learning. The goal was to find out what features the teachers would like an OLE to offer; and to use these features to shape the requirements specification for the prototype.

3.8 Evaluating the Prototype

Once the prototype was developed, it was evaluated to test whether it fulfilled the requirements of the system. This evaluation was done in the form of two user studies. The first user study involved learners and evaluated the interactive learning component of the prototype. The second user study involved teachers and evaluated the lesson contribution component of the prototype.

3.8.1 User Study - Learners

The best way to test the functionality of the prototype was to have learners use the prototype and evaluate it themselves. Performing this kind of user study ensured that the results of the study would be based on practical, realistic results. The user study involved 86 grade 12 learners from three different schools in Grahamstown, in South Africa's Eastern Cape. A detailed description of the different groups of learners involved is provided in Table 3.1. The computer literacy level of the learners was determined qualitatively, by asking teachers to describe their learners' level of computer literacy. Learners were asked to use the prototype for approximately thirty minutes. They were asked to explore its contents and complete some of its lessons. Thereafter, they were

	Type of school	English curriculum	Computer literacy level	Number of learners in study
School A	Previously disadvantaged	First Additional Language	Low	46
School B	Previously disadvantaged	Home Language	Low	16
School C	Private	Home Language	Excellent	24

Table 3.1: Information about schools involved in user study

asked to fill out a one page evaluation form, designed to capture their experience of using the website (Appendix C). The evaluation form consists of fifteen Likert scale questions and four free response questions [2]. For the first fifteen questions, learners were asked to rank their response to each of fifteen statements as "Strongly disagree", "Disagree", "Agree" or "Strongly Agree" (see section 2.4.3). No "Neutral" option was provided, in order to ensure that learners committed to either a positive or negative response to each statement [2]. These questions provided a way to perform quantitative analysis of the learners' experience of using the prototype. The fifteen statements were designed in such a way that each statement evaluated a separate component of the website (the site in general, multimedia, lessons, or the questions in the lessons); as well as an evaluation of a particular aspect of the component's use (ease of use, enjoyability or impact on learning). As a result, the set of each responses to the questions can be used to gain insight into each of the components of the website, as well as on each aspect of the use of the website. The four free response questions were aimed at obtaining a qualitative measurement of the learners' experience of using the prototype. These questions ensured that it was possible to identify specific strengths and weaknesses of the prototype.

All learners involved in the user study were provided with an information sheet describing the purpose of the research and the procedure of the user study. Each participant was required to have their parent or legal guardian sign a consent form, giving consent for the learner to be involved in the user study. The teachers of each of the classes involved were also provided with an information sheet and required to sign a consent form.

3.8.2 User Study - Teachers

It was also decided that it would be useful to see how teachers would evaluate the prototype. A user study was therefore held with 22 teachers. The teachers involved all teach in the Eastern Cape in either previously disadvantaged or former Model C schools. The group was provided with a brief introduction to the research and research methodology. They were then asked to use the "Learn" page of the prototype (the page containing the learning materials for learners) for approximately twenty minutes. They were then asked to fill out the same evaluation form as the learners. This allowed for the comparison of the experience of teachers and learners. The group was then provided with a short demonstration of the "Contribute" page (the page that allows teachers to create their own interactive lessons). After this, they were required to use the "Contribute" page to create their own short interactive lessons, on a subject area of their choice. They were then asked to write down what they liked and disliked about the process of creating lessons using the prototype.

All teachers involved in the user study were provided with an information sheet describing the purpose of the research and the procedure of the user study. Each participant was required to sign a consent form, giving their consent to be involved in the user study.

3.8.3 Approach to Data Analysis

In order to gain a broad understanding of the experience of those involved in the user studies, and to be able to compare different sub-groups and aspects, some quantitative analysis was necessary. What follows is a description of the approach to the data analysis performed on the responses on the Likert scale evaluation form.

For each of the fifteen statements, the responses on the Likert scale were quantified in order to be able to perform useful statistical analysis on the responses [2]. This quantification, as summarised in Table 3.2, was done on a scale of 1 to 4. A score of 4 represents the most positive response to the statement, which, in the case of most of the statements, was "Strongly agree". There were, however, three negatively worded statements - statements where agreement indicated a negative evaluation of the prototype. For example, the statement "It took a long time to get used to how the website works". In the case of such statements, the quantification was inverted, so that the most positive evaluation of the website (namely "Strongly disagree") resulted in a score of 4, in order to ensure consistency with the results from the positively worded questions.

	Strongly disagree	Disagree	Agree	Strongly agree
Positively worded statement	1	2	3	4
Negatively worded statement	4	3	2	1

Table 3.2: Quantification of Likert responses

Each statement, as mentioned earlier, evaluates not only a component of the prototype, but also an aspect of its use. For example, the statement, "The pictures on the site were easy to use", provides a score that can be used to evaluate the multimedia component of the prototype. This same score can also be used to evaluate an aspect of the use of the prototype - whether it was easy to use or not. In the same way, the statement "The website helped me to understand the poems better", evaluates not only the website in general (as a component of the site), but also whether the website as a whole had a positive impact on learning (as an aspect of website use). The four components of the website evaluated were 1) the website in general, 2) the multimedia on the site, 3) the lessons and 4) the questions and their responses. The three aspects of website use that were evaluated were 1) ease of use, 2) enjoyability and 3) the impact of the website on learning.

The way in which each question provides an evaluation on both a component and an aspect of its use, combined with the quantification of the responses to the statements, allowed for some simple data analysis and comparison to be done. The average score and mode for each question was calculated for each school. In addition the average scores and modes of the questions that pertain to particular components and aspects of use were also calculated. From this information, averages were calculated across all schools and across previously disadvantaged schools. Comparisons could then be made between schools, between components and between aspects of use.

3.9 Conclusion

This chapter has presented the methodology employed in this research. It has described the decision to develop a prototype OLE and the preparatory steps taken for this development. It has presented the approach taken to gathering requirements for the prototype, through a literature survey and discussions with South African teachers. Finally, it has outlined the methodology for evaluating the success of the prototype, including the specifics of the user studies and subsequent data analysis that was performed. The next chapter provides a detailed discussion of the considerations taken during the design phase

and explains the implementation of features alongside the requirements isolated for the prototype.

Chapter 4

Design and Implementation

4.1 Introduction

Developing the prototype OLE was a crucial aspect of this research. This chapter outlines the considerations taken in the design phase and provides details of the prototype's implementation. The system architecture is presented, firstly through an explanation of the technology related decisions that were taken and, secondly, through a model providing an overview of the application design. The discussion then focuses on each of the broad system requirements in turn, explaining the design considerations behind, and implementation of, each of the features that satisfy these requirements.

4.2 Technology Choices

When developing an application, it is important to have a system architecture that complements the goals of the system. This section outlines the major design considerations taken while deciding on the kind of system to be developed. It then discusses the Google Web Toolkit and the reasons why it stood out as a framework that would simplify and enrich the development of the prototype. Some discussion is then provided on the approach taken to the various aspects of handling the data in the system.

4.2.1 Broad Approach

The first major design consideration was the decision to develop a new system from scratch, rather than adapting or using existing Learning Management Software (LMS), such as Moodle [28]. The first reason for this was that the process of development would provide useful insights into the evaluation of an OLE. The opportunity to take a system right through from design to evaluation allowed for results that could be meaningfully linked to the requirements of the system. In addition, this allowed the prototype to be developed to the requirements of those learners and teachers it will be used by. This ensured that development could focus on the core functionality required. The evaluation included teachers who were not part of the process of gathering requirements, though, which ensured that the prototype was not limited to the needs of specific individuals. LMSs such as Moodle are designed with a generic audience in mind. Developing a new system allowed for it to be focused directly on the needs of those teaching and learning in South African schools. The system was designed to be used by any schools in South Africa, but there was a particular focus on ensuring that it serviced the needs of previously disadvantaged schools (needs that are not directly taken into account in existing LMSs). The second reason for developing a new system was that existing LMSs like Moodle are extensive tools designed to manage online courses or support taught courses. Christian Dalsgaard contends that "a common idea behind LMS is that e-learning is organized and managed within an integrated system" [8]. They offer a great deal of administrative, assessment and communication tools. Although these tools are useful, there simply would not have been enough time in this research to evaluate a system that included all of this functionality. In addition, this functionality introduces complexity that would increase the learning curve of the system to such an extent that the time available for user studies would not have been sufficient for learners and teachers to use and evaluate the core learning functionality. LMSs also require extensive course integration and administrative preparation from teachers, which would not have been logistically feasible. Lastly, most LMSs are designed using PHP or HTML, making them static systems that require constant page refreshes while navigating through content. Developing a new system allowed for the use of technologies that enable a more fluid user interface design.

The second major design decision was to develop a web site as opposed to a standard desktop application. There were several strong motivating factors for this decision:

1. A web site is easily accessible from any location (provided that Internet access is available).

2. A web site has the potential to be expanded to include mobile access, which would increase the reach of the content on the site.

3. The only software required to access a web site is a web browser, which are pre-installed on most computers. This avoids most installation issues usually associated with desktop applications.

4. Having an online system centralizes information. This ensures that the latest version of the web site is always available to everyone using it. It also ensures that any learning material contributed is instantly available.

Another important consideration was what kind of web site to develop. It was decided to develop a full web application, rather than a static HTML or PHP site. Using a web application development framework provided more powerful functionality, particularly for communication between the client and server; as well as with the system's data layer. Employing AJAX avoids full page refreshes and so provides for a more fluid user interface, similar to the desktop applications that many users are accustomed to. It also conserves bandwidth, which is of particular importance to schools in South Africa (and other developing countries) where bandwidth is expensive.

4.2.2 The Google Web Toolkit

The Google Web Toolkit (GWT) [14] is a powerful web application framework. GWT is set apart from other frameworks by the way that the development process works. All the development for the client side user interface (UI) is done in Java, making developing a web page similar to using the javax.swing library to create the UI for a regular desktop application. This Java code is then cross-compiled into plain JavaScript and HTML [9]. The result is a WAR (web application archive) that can be deployed on any web container and appears to web browsers as an ordinary AJAX web page. This means that the users of GWT sites do not need to install any additional plugins or runtime environments (not even the Java Runtime Environment). Because the application is compiled into plain HTML and JavaScript, it can be styled using CSS (Cascading Style Sheets), making styling the site easy and portable. The GWT development team claims that the framework "automatically works across all major browsers", thereby freeing developers from having to spend time eliminating browser quirks [12]. The prototype has been tested in Internet Explorer, Mozilla Firefox, Opera and Safari, with only a few issues arising. Developing the UI in Java means that one can use all the built in error checking and debugging tools

Feature	Advantages
Design web pages in Java	This allows the developer to use their Java development experience and avoids all the quirks and problems associated with html and JavaScript.
Debugging	Java coding in any IDE - complete with error and syntax checking and the ability to debug code at runtime (step through code as it runs and inspect variables).
Better integration	Coding the whole client side in Java means that integrating the client side into the application domain is much easier. It also simplifies integration with the data access layer
Client-Server communication	GWT RPC makes talking to the server almost as simple as an ordinary method call. It also makes it possible to "move all of your UI logic to the client" [11].
Widget library	GWT offers a wide variety of (customizable) HTML UI components that make developing a rich user interface easy.
JavaScript event handling	Means no browser refreshes, a more fluid UI and the ability to constantly communicate with the server.

Table 4.1: Useful GWT Features

available in popular Java IDEs. Eclipse, in particular, has an excellent GWT plugin and is recommended by the GWT development team [12]. The plugin provides an easy to use "New Web Application Wizard" and makes it easy to maintain and expand the structure and classes of GWT applications [13]. Some of the most useful GWT features are listed in Table 4.1, along with brief explanations of their advantages.

4.2.3 Data Handling

As an OLE is, in its simplest form, a collection of learning materials that is made available online, it was essential that the data involved in the prototype was handled in an efficient way. This section describes some of the data handling techniques employed in the development of the prototype, how those techniques work and why they were used.

MySQL

Choosing MySQL [29] as the Relational Database Management System for the prototype was motivated by a few simple factors. Firstly, MySQL is widely used in Java EE applications. Secondly, MySQL is free software. In addition, the MySQL connector for Java is available for free.

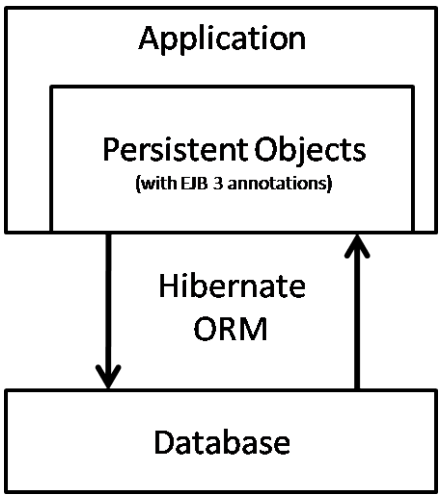


Figure 4.1: Object Relational Mapping with Hibernate

Hibernate

Hibernate [19] is an Object Relational Mapping (ORM) tool for Java. Its primary function is object persistence - taking Java objects and saving them to, and retrieving them from, relational databases. Hibernate takes care of all the mapping between Plain Old Java Objects (POJOs) and the relational database. For the developer, this provides a useful level of abstraction over the database used in the application. The developer does not have to concern themselves with designing the database structure, writing stored procedures or SQL queries - they can simply work with their POJOs and delegate all of the low level work to Hibernate. See Figure 4.1 for an illustration of how Hibernate fits into the architecture of an application.

The way that Hibernate translates between the two ways of seeing your domain objects is based on metadata supplied by the developer. This metadata can be supplied in two ways. The first (and originally only) method of providing metadata is through XML files. If using this technique, the developer is required to write an XML file, providing information on how data should be mapped, for each Java class they want to be persisted. The second method of providing metadata, and the one used in the development of this prototype (due mostly to its simplicity) is through the use of annotations. Hibernate has its own set of powerful annotations, but in the case of this prototype it was sufficient to use the EJB 3 (Enterprise Java Beans) annotations, which are also supported by Hibernate. Annotations are a way of providing metadata directly in the Java classes you want to provide persistence mapping information for. Figure 4.2 presents a simplified version of one of the domain classes of the prototype.

```
@Entity
@Table(name="poems")
public class Poem implements Serializable{

        @Id
        @GeneratedValue(strategy = GenerationType.AUTO)
        @Column(name = "id", updatable = false, nullable = false)
        private Long id = null;

        @Version
        @Column(name = "version")
        private int version = 0;

        @Column(name="poemName")
        private String name;

        @Column(name="poemAuthor")
        private String author;

        @Column(name="poemLines", length = 65000)
        private String[] lines;

        //more properties

        //constructor public Poem(){ }

        //more methods
}
```

Figure 4.2: Example of a domain class, annotated for persistence

```
//poemName is a String variable that holds
//the name of the poem to search for
Query query = session.createQuery
                        ("from Poem p where p.name=:searchName");
query.setString("searchName",poemName);
```

Figure 4.3: Querying using Hibernate

The lines of code beginning with "@" are annotations from the javax.persistence library and provide metadata about how this class of objects should be mapped when persisted to a relational database. The `@Entity` annotation indicates that this class describes an entity that is to be persisted. The `@Table` and `@Column` annotations provide specific names for the table to be created and its columns, but are not required as Hibernate uses its default naming conventions in their absence. Other properties can also be specified using annotations, such as the maximum length of text for a field or whether a field is nullable. The no-arguments constructor is the only requirement for a persistent class. This constructor is used by Hibernate in the mapping process. If no metadata is supplied for a specific aspect of an object, Hibernate resorts to its default behaviour - which, in many cases, provides a sufficient understanding of the system.

The code for actually persisting objects to the database is simple. The connection with the database is managed using a `Session` object. To begin a new transaction with the database, one simple calls the `beginTransaction()` method of the `Session` object, which returns a `Transaction` object to work with. Persisting an object, say "`myObject`", is done through a simple method call: `session.save(myObject);`. Through the Transaction object, Hibernate allows the developer the ability to roll back transactions in the case of an exception, which is vital to database integrity, particularly when saving and retrieving data sent over the Internet. Another useful feature of Hibernate is Hibernate Query Language (HQL). HQL is a SQL like language, used for database queries, that abstracts the querying process and refers to objects and their properties, rather than tables and their columns. This greatly simplifies the process of writing a query to search for and retrieve a `Poem` object (with a particular name) from the database. This process, using HQL, is shown in Figure 4.3.

Hibernate was used in the development of the prototype, because it makes object persistence considerably easier and more accessible.

Remote Procedure Calls

The Google Web Toolkit provides a powerful, easy-to-implement framework for client-server communication - the GWT Remote Procedure Call (RPC) mechanism. In the event that client side needs to communicate with the server, RPC allows that communication to be almost as simple as an ordinary method call. The code on the server that is executed through RPC "is often referred to as a service" and so an RPC call can be seen as "invoking a service" [11]. It is important to note that this term "service" is not related to general web services [11]. An overview of the RPC architecture is illustrated in Figure 4.4. The first step in creating a service is creating an interface on the client that outlines the methods available. A class is then created on the server side which implements the methods outlined in the service interface. Because AJAX is inherently asynchronous in nature, it is necessary to provide the scaffolding necessary to be able to call the service's methods asynchronously. This is done by creating a second interface on the client side, which provides an asynchronous outline for each of the methods outlined in the standard interface already created. The methods in this interface all have a `void` return type. The return value is instead managed by having an `AsyncCallback` object as a parameter to the method, which employs Java Generics to specify the return type. At the point in the client side code where a particular method needs to be called, an `AsyncCallback` object is created and sent as a parameter in a method call to an instance of the service. The `AsyncCallback` object is required to implement `onSuccess` and `onFailure` methods. The `onSuccess` method has the result of the RPC as a parameter and it is at this point that the result can be used. The created `AsyncCallback` object is sent to the service and the `onSuccess` method will be run when the result returns from the server asynchronously.

Data Transfer Objects

An important part of being able to send objects across RPC is that they are serializable. When a class is annotated as a persistent entity, Hibernate enhances objects of that class so that they can be persisted [4]. Using Hibernate actually results in the bytecode for persistent objects being rewritten, resulting in them no longer being serializable [4]. There are several possible ways around this problem, including using external libraries such as Dozer and Gilead [4]. In the development of the prototype, it was decided to avoid the overhead of these libraries and employ a much simpler solution - the use of Data Transfer Objects (DTOs). A DTO is simply a non-annotated lightweight version of an annotated domain class [4]. This solves the serialization problem and has the added advantage of

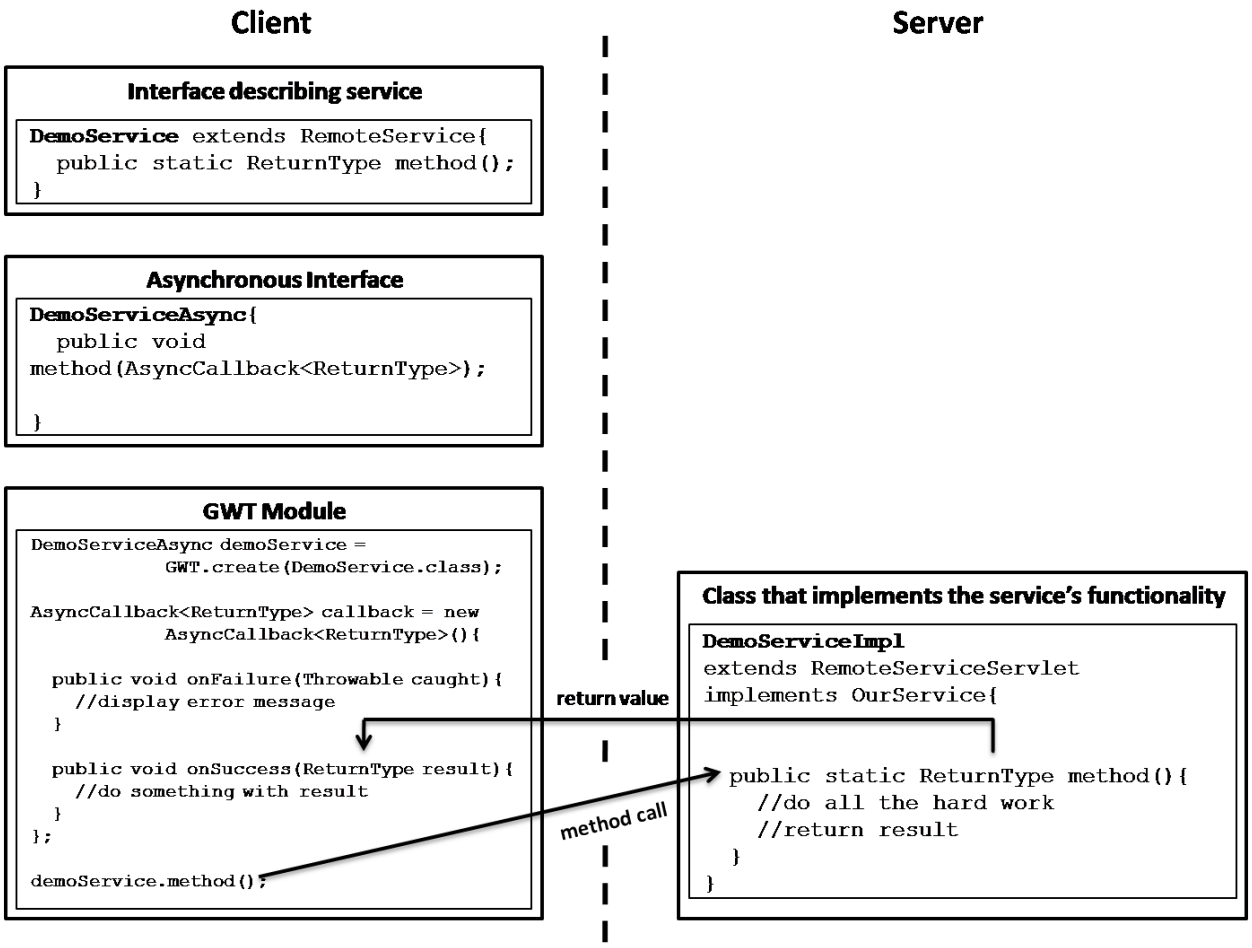


Figure 4.4: GWT Remote Procedure Call

providing a distinction between objects used on the client side (the DTO) and those used on the server side for persistence. It does, unfortunately, introduce the extra coding needed to convert between the two types of objects.

4.3 Overview of Application Design

Before discussing the design of individual components and specific functionality and explaining how they were implemented to meet requirements, it is important to provide an overview of the application design. Figure 4.5 is a UML (Unified Modelling Language) diagram describing the core components of the prototype and the relationships between them. The client side consists of two user interface classes, `PoemGuide` and `Contribute`, which each implement the GWT `EntryPoint` interface. Each of these GWT modules is hosted in an HTML page of the same name. These classes use the `HibernateServiceAsync` interface to access the functionality provided by the server. Due to the fact that Hibernate Entities cannot be serialized, a DTO exists for each of the domain classes. These domain classes are on the server side, and are persisted using Hibernate. All database transactions occur in the `HibernateServiceImpl` on the server side, which is the implementation of the functionality described in `HibernateService`. The final server side class is `HibernateUtil`, which contains the required Hibernate initialization and allows access to the current Hibernate session.

4.4 Requirement Specification and the Implementation of Features

The process of gathering requirements from current literature and discussions with teachers identified three primary system requirements: intuitiveness, interactivity and sustainability. This section highlights the reasons for the inclusion of each requirement and explores the design and implementation of each of the features that were developed to satisfy these requirements. For each feature, the design considerations behind it are explained and its implementation is described.

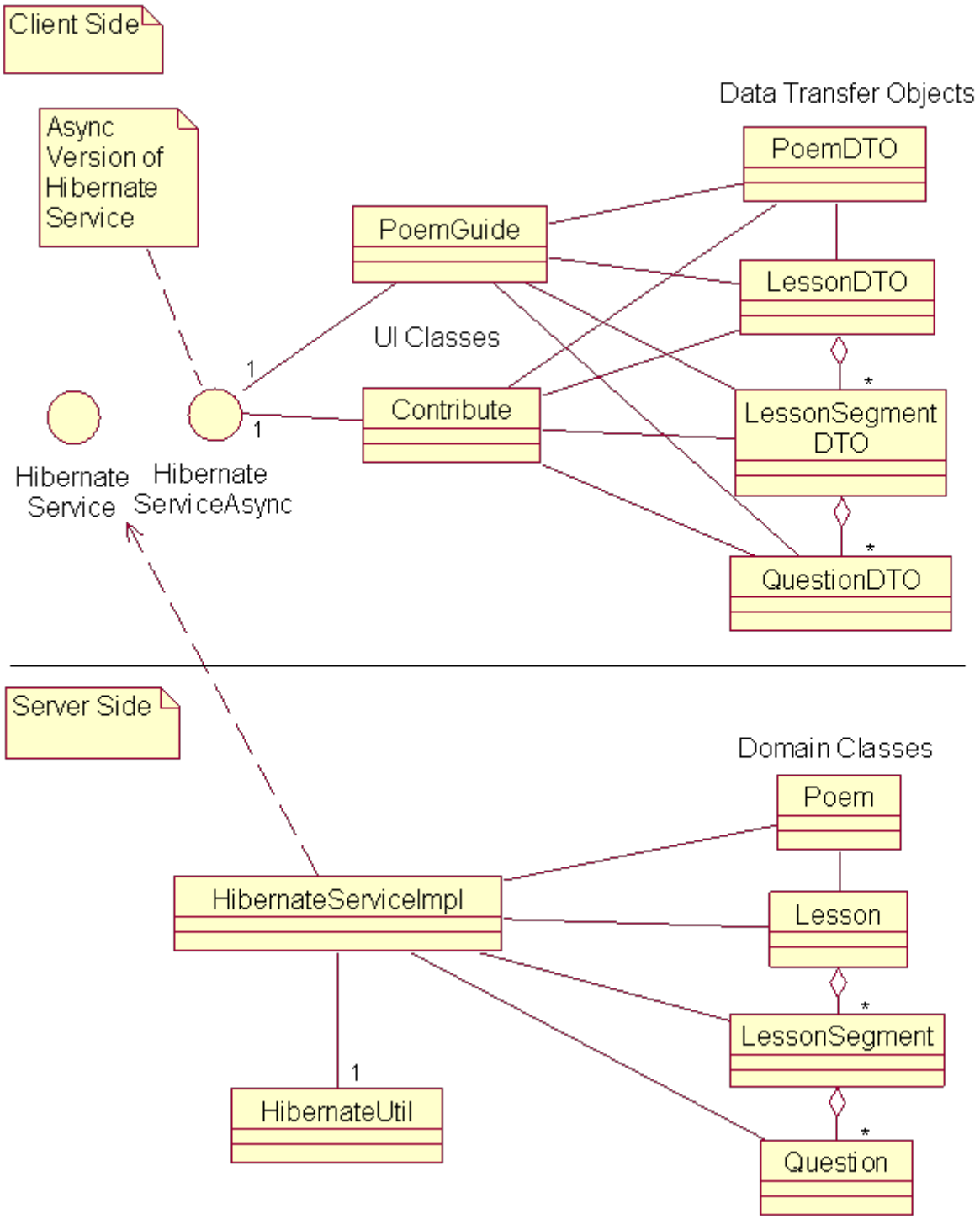


Figure 4.5: UML Diagram Describing Application Design

4.4.1 Intuitiveness

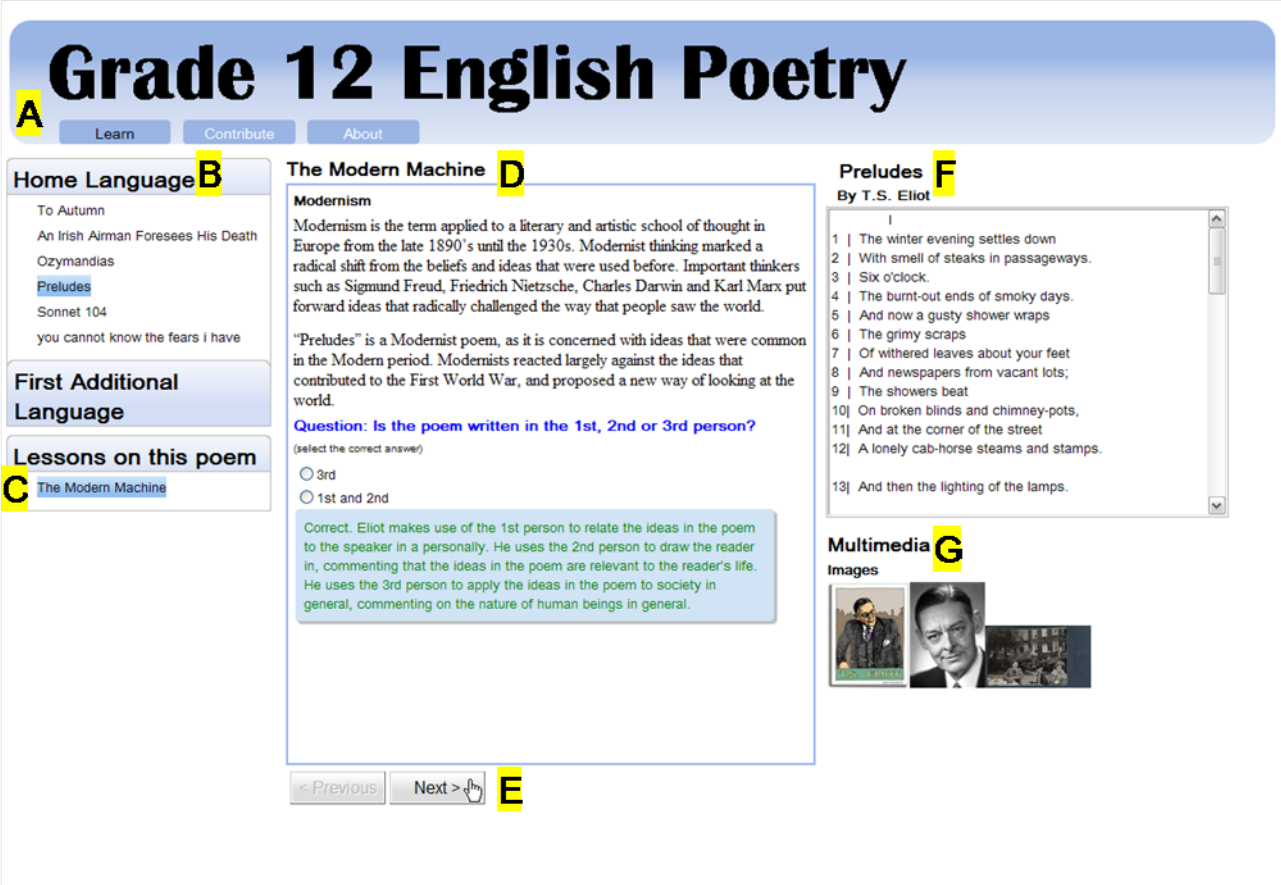
It is a reality that learners in previously disadvantaged schools in South Africa generally have little experience using computers. This makes ease-of-use an essential requirement for any application aimed at such learners. One teacher interviewed stressed that school learners will only keep using a website if they find it simple and easy to use (see Appendix E). It was therefore decided to approach intuitiveness as a core system requirement in the development of the prototype. The focus on intuitiveness was centered on two main system design aspects: the user interface and the structure of content on the website.

User Interface

For a visual overview of the user interface, see Figure 4.6. It is critical, when attempting to design a system that is easy to use; and that the user interface is simple and intuitive. From the literature survey, it was clear that the success of an e-learning site hinges on its usability and that an intuitive interface allows users to learn more and start learning faster (see section 2.4.2.5). Using Graham *et al.*'s [15] user interface evaluation framework (see section 2.4.2.5), it was ensured that:

- The page layout remains consistent, irrespective of the user's position on the site
- The organisation of information is clear and simple
- Navigation is kept minimal and easily accessible
- The site's aesthetic design is minimalistic and straightforward

The GWT was a useful tool in the creation of an intuitive user interface, because GWT widgets (user interface components like labels, buttons, tables etc.) are written in HTML. Using these widgets gave the prototype a look and feel that is consistent with other websites - providing users with a familiar look and feel. In addition, GWT enabled the development of JavaScript events by coding Java event handlers. The end product of this cross-compilation was a fluid user interface, similar to most desktop applications. Because click events were handled by asynchronous JavaScript instead of static hyperlinks, the learner does not have to wait for any page refreshes - which usually slow down and fragment the experience and frustrate users. As a result, learning can become more immersive. The immediate responses to specific events also means that learners can be



- A - General static site navigation
- B - Poem navigation panel (find a poem)
- C - Lesson navigation panel (find a lesson)
- D - Lesson content panel (contains the content of the current segment of a lesson and all its interactive questions)
- E - Segment navigation buttons (navigate between parts of a lesson)
- F - Poem box (contains the text of the current poem)
- G - Multimedia panel (contains all multimedia related to the current poem)

Figure 4.6: Overview of User Interface

assisted as they learn and can easily understand where the additional information fits into the context of what they are learning. The prototype was also designed in such a way that user interaction is almost entirely mouse-based. This point-and-click method of interaction keeps communication simple and facilitates an exploratory approach to learning. The click based interaction with immediate feedback also helps the learner feel in control of their learning experience, which builds confidence.

A modular design approach was employed when designing the user interface. This means that the various components that make up the learning environment are self-contained and clearly separate from other components. In other words, it is clear to the user that the text of the poem itself, the lesson content and the navigation panels are all separate components - and it is clear where they begin and end. This makes it easier for the user to learn the layout of the site and the functionality of each section of the page. Importantly, it helps prevent cognitive overload, by allowing the user to focus on a particular component. It does not, however, cause confusion as they are still aware of the other components, where they are and what state they are in. The page has been designed in such a way that all of the components fit on the screen at once. As a result, the learner does not need to scroll around the page using the web browser's scroll bars. Instead, each component on the screen was designed to have its own fixed size and scroll bar. This means that learners scroll within individual components, rather than scrolling through an entire web page that displays the full content of all of its sections at once. This ensures that the learner can see all the different components of the web site at once, thus maintaining a good understanding of the structure of the page and the relationships between components. At the same time, it ensures that learners can focus on a particular component, and specifically on the content they are currently interested in within that component. This is another way that the prototype's UI design helps prevent cognitive overload. The prototype was designed for use with 17 inch monitors, but using the full screen mode on the web browser makes the site usable on smaller monitors as well.

Structure

From the interviews held (see Appendix E), it was clear that most online learning resources are perceived as cluttered and that their structure makes it difficult to find relevant information. From the discussions with teachers, it was determined that the prototype needed be structured in a simple, transparent way; and that navigating through the site's content needed to be made easy. On the suggestion of one teacher, it was decided that the actual text of each poem would be visible on the site, which set it aside from

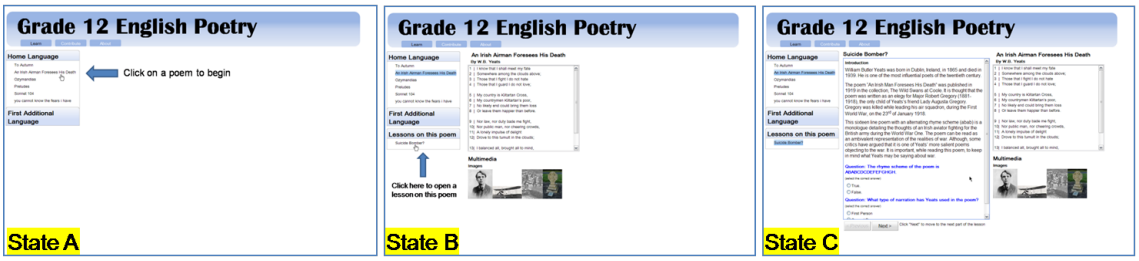


Figure 4.7: Master-Detail Layout

most websites that aim to teach poetry. Most teachers felt it was important to have a practical structure and that content navigation should be simple. The primary means of navigation for the learner are the poem and lesson navigation panels (points B & C in Figure 4.6). They are conveniently placed on the left of the screen and remain visible throughout use. The poem navigation panel allows the learner to select either "Home Language" or "First Additional Language" and then shows only the relevant poems. The lesson segment navigation buttons (point E in Figure 4.6) allow the learner to move easily between the different parts of each lesson and informs them when they have reached the end or beginning of a lesson.

In designing the structure of the prototype, it was decided to employ a master-detail layout (see Figure 4.7). Effectively, this means that the relationship between different components is made clear and that details are displayed only when requested. On loading the website, the learner is faced with a very simple screen, containing only the poem navigation box (State A in Figure 4.7). This makes knowing where to start considerably easier than it would have been if all the information on a particular poem was already displayed. Only once the learner clicks on a poem, is the poem and its associated multimedia displayed, along with the available lessons on the poem (State B in Figure 4.7). The lesson panel is only displayed when a learner clicks on a particular lesson (State C in Figure 4.7). At this stage, the poem and multimedia panels are shifted to the right and the lesson panel moves into the centre of the screen. This is to make it easier for the learner to focus on the lesson, while still having the same additional information available in the periphery of the screen. The master-detail layout makes it easier for learners to understand the structure of the site and prevents them from being overwhelmed and confused by a cognitive overload. Employing a master-detail layout means that learners understand at which points certain information becomes available, allowing them to have a better grasp of what the information is for and where it is situated on the screen.

In order to create an effective OLE, it is vital that the actual content on the site is structured in a meaningful and useful way. For the prototype, it was decided to structure

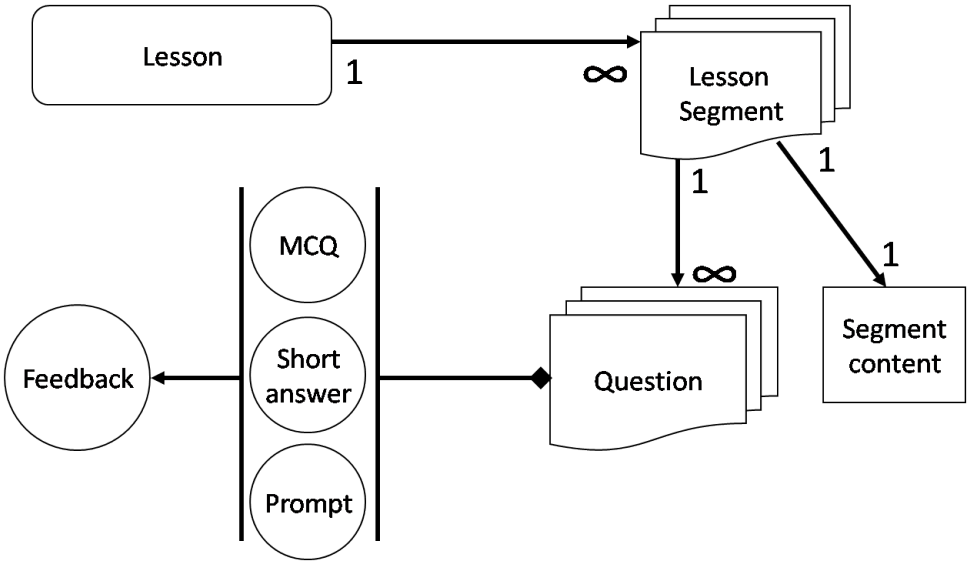


Figure 4.8: Lesson Structure

the site around the concept of lessons. A lesson is a broad term used to describe any text content with interactive questions that aims to teach the learner something on an aspect of (in this case) a poem. Figure 4.8 illustrates the structure of a lesson. To ensure that lessons have a modular structure and separate content into logical categories, each lesson consists of (any number of) lesson segments. A lesson segment will usually cover a particular aspect and is what is displayed in the lesson content panel (see point D in Figure 4.6). Each lesson segment consists of two components. The first is the content of the lessons segment, and is plain HTML. The second component that a lesson segment consists of is (any number of) questions. A question can be of one of three types: multiple choice question, short answer question, or prompt question. Each question is required to provide feedback to the user based on their input. The form that this feedback takes depends on the question type. The multiple choice question consists of a question and any number of possible answers. Only one of these possible answers is correct. For each incorrect option, there is a response intended for the learner, which explains why the option is incorrect. The correct answer also supplies a response to the learner, justifying why it is the correct answer. Multiple choice questions can be used as true or false questions as well. The short answer question consists of a question and a short (preferably single word) answer. Feedback is provided as to why the answer is correct. In addition, feedback can be provided for obvious pitfalls (likely incorrect answers) explaining why they are incorrect. Prompt questions consist simply of a question (intended to make the learner think about a particular aspect) and a response providing some discussion, insight or answer to the prompt. Figure 4.9 shows an example of a lesson segment with one question of each type.

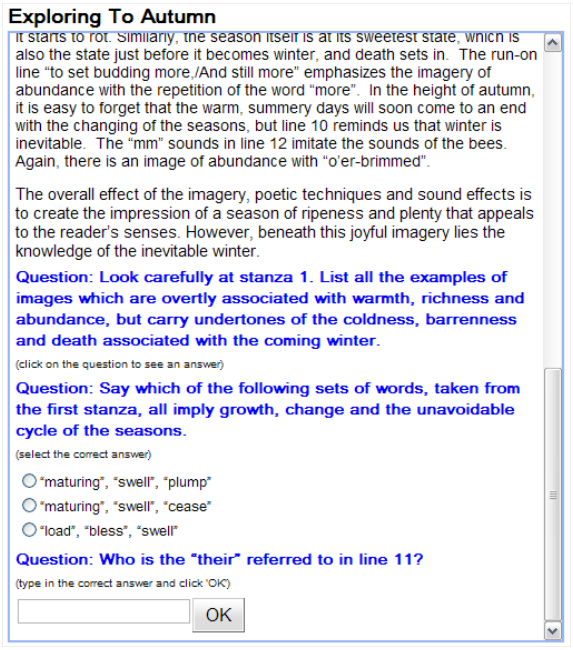


Figure 4.9: Example of the different question types

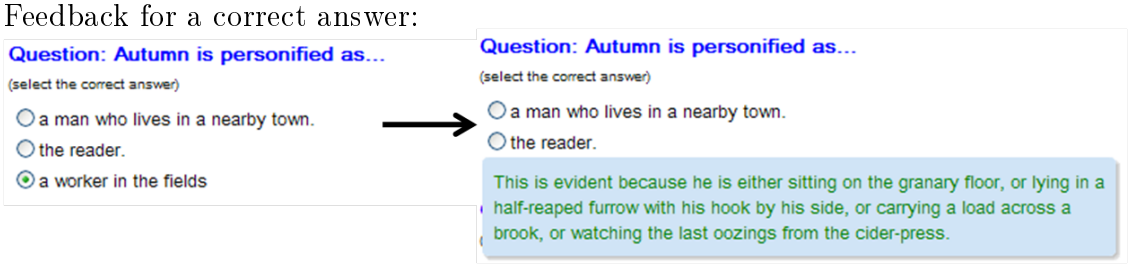
4.4.2 Interactivity

From the survey of literature (see sections 2.4.1.3 and 2.4.2.4) and the discussion with teachers, the importance of interactivity was apparent. It was clear that, for an OLE to be truly successful, it would have to offer the learner an active, immersive engagement with its content. The two main features of the prototype that address this broad requirement are questions with interactive feedback and multimedia.

Interactive Questions

Questions are an integral part of the lesson structure explained in 4.4.1 above. According to current literature on e-learning, it is essential that an OLE integrates formative assessment with learning material (see section 2.4.2.2). Asking learners questions as they learn helps cement their understanding of content and catches and corrects misconceptions they may have early on. Thanks to GWT AJAX, the lesson structure described earlier is implemented in such a way that the learner immediately receives feedback on their answer. Figure 4.10 shows examples of such feedback. The feedback pops onto the screen immediately, at the location of the answer that the learner provided. This ensures that the feedback is relevant to the learner's position in the learning material. Responses to correct answers are displayed in green text and responses to incorrect answers in red - adding a

Feedback for a correct answer:



Feedback for an incorrect answer:

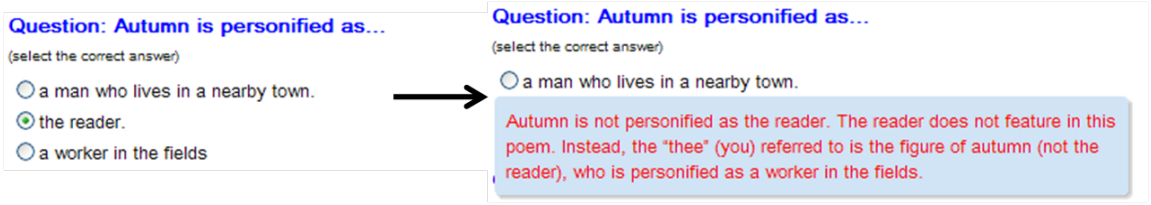


Figure 4.10: Immediate feedback

visual element to the feedback. One of the teachers interviewed stressed the importance of making learning interesting for learners. These kinds of interactive questions keep the learner's attention and provide useful information. The fact that the questions are a type of formative assessment (as opposed to summative assessment - see section 2.4.2.2) means that learners are not afraid to click on different answers to see what the responses will be. This adds to a sense of exploration, which makes learning more interesting.

Multimedia

All of the teachers involved in the focus group and interviews agreed that the ability to include multimedia is a strength of e-learning and that multimedia can have a positive impact on learning. Through the survey of literature it was found that Multimedia is effective because it appeals to learners' dominant senses and is perceived as a more enjoyable medium than plain text (see section 2.4.2.1). Figure 4.11 shows the interaction of a learner with an image. The image clicked on in Figure 4.11 provides the learner with visual information that helps them better understand this poem by Shabbir Banoobhai, in which the speaker talks to their unborn child. All of the images included on the website are in the public domain and were sourced from Wikimedia Commons, a database of freely usable media items [44].

Images are not the only type of multimedia that can be employed. It is also possible to include sound, video and animations. Videos may, in a subject such as history, provide useful, interesting footage of notable events. In science, animations can be used to demonstrate experiments that cannot be performed in some schools due to a lack of equipment

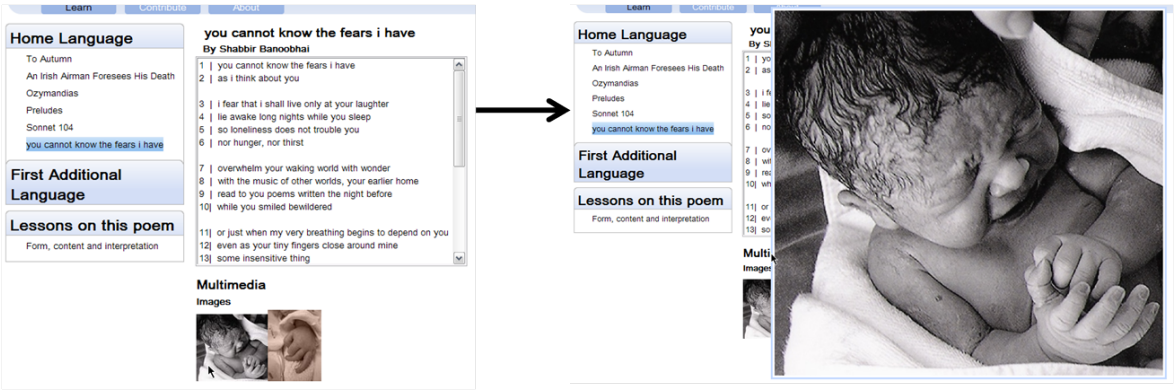


Figure 4.11: A learner clicks on an image to view the full sized version

and facilities. An idea for the prototype was to include sound clips of people reading the poems on the site. The functionality unfortunately had to be excluded because the computer laboratories where the learners would be using the site were not equipped with headphones. Having an audio representation of the poems would have aided learners' understanding of the structure and rhythm of the poems, and would have been particularly helpful to second language English speakers.

4.4.3 Sustainability

In order to be considered an effective solution, the prototype had to have the potential to be sustainable. A contribution module was thus created that allows teachers to create their own interactive lessons. In addition, it was important for the prototype to be enjoyable enough for learners to keep using it.

Content contribution

The content on the prototype would quickly become outdated and useless if it remained static. It was therefore important to create some sort of functionality that ensured that the prototype remained dynamic and relevant. In order to facilitate this, it was decided to create the "Contribute" page, which contains a GWT module that allows teachers to contribute lessons to the site. The module allows teachers (or other contributors) to create lessons, complete with interactive questions, without having to understand the mechanisms behind how they work. Essentially, a contributor simply uses a form to enter their lesson content and add their questions (along with the required responses). Once submitted, this content is then immediately added to the website, making it instantly

available to all learners on the "Learn" page, with all of the same interactive functionality of the other lessons. This functionality was a key element in ensuring the sustainability of the prototype, as it ensures the potential for the site to be continually updated and enriched.

Figure 4.12 shows the different stages of creating a new lesson. First, the contributor selects the poem that the lesson is for and gives it an appropriate title (stage 1 in Figure 4.12). The contributor is then faced with a table that displays all the lesson segments added to the lesson so far (stage 2). (In Figure 4.12 a segment is already added, in order to illustrate this.) When the contributor clicks on the "Add lesson segment" button, a popup appears which guides the contributor through the creation of a new lesson segment. The first tab on the popup is the "Content" tab, which is where the contributor is required to provide a title for the lesson segment as well as the actual content of that segment (stage 3). The content is added in a RichTextArea, which allows the contributor to format the content - enabling them to emphasize text, change colours, create lists or even include images. When the segment is created, the content of this component is saved as HTML, which is later displayed on the "Learn" page just as it was created. This allows teachers to be creative and exciting in the way that they create and present lessons. Once the content is entered, the contributor moves onto the "Questions" tab, which facilitates the creation of questions for the current segment (stage 4). Figure 4.12 shows two questions that have already been created. It shows the contributor selecting to create a prompt question from the dropdown list. They then supply the question and the response to the question that will be provided to the user (stage 5). Once the contributor has added all the questions they want, they can move to the "Finalize" tab to submit the segment. Once all the segments are added to the lesson, the lesson can be submitted to the server, which persists it to the database. If the contributor were to navigate to the "Learn" page, they would find that their lesson has been added to the list of lessons for the appropriate poem.

Enjoyability

Another important aspect in creating a sustainable solution was to ensure that the prototype was something that learners find enjoyable to use - if learners do not enjoy using the site, they will simply not return to it (see section 2.4.2). It is crucial that this enjoyability is not simply due to the novelty of e-learning, however. There are several of the features described already that were aimed at creating a sustainably enjoyable user experience:

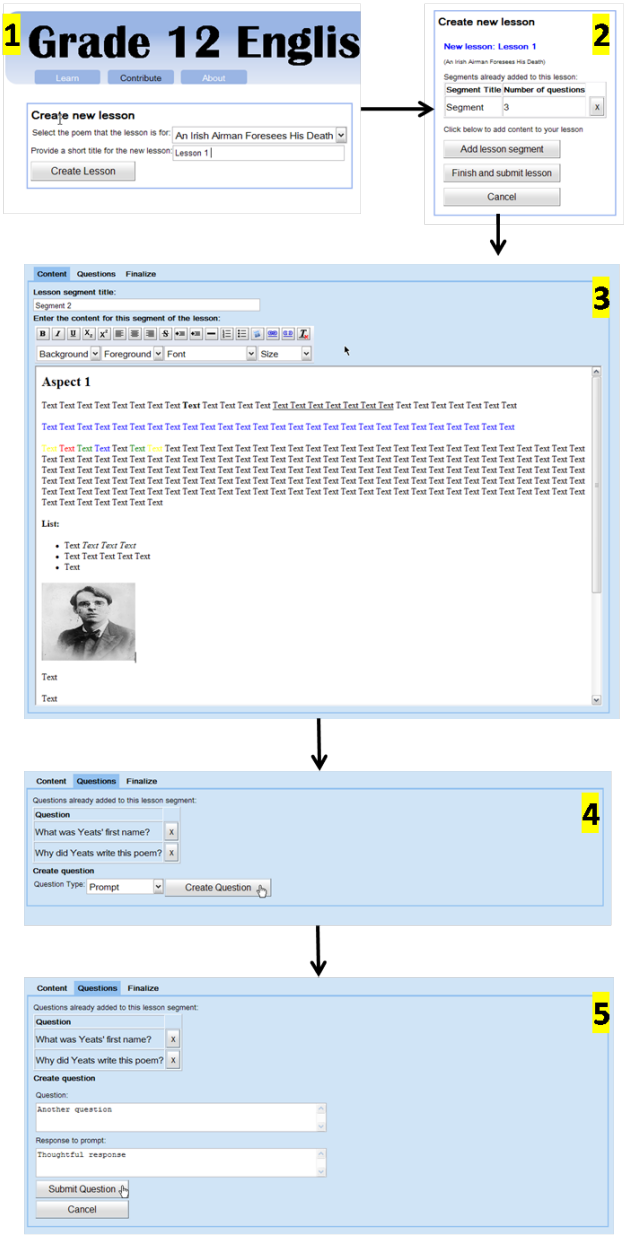


Figure 4.12: Creating a new lesson

- The simple page design and navigation process prevents users from giving up on the site because of frustration and confusion
- The site structure allows learners to control the way that they approach the learning material, creating a feeling of ownership
- The interactive questions help make the learning process more immersive
- The multimedia appeals to the dominant senses of learners and is more exciting than plain text
- The contributing process allows teachers to make lessons more exciting, by formatting lessons and adding images

4.5 Conclusion

This chapter has presented the design for the prototype OLE and some of the details of its implementation. It began by justifying the design decisions that were taken concerning the technological architecture of the prototype, including in-depth explanations of the more complex techniques and technologies. The chapter then moved on to provide a brief overview of the application design, supplemented by a UML diagram of the core components of the application. Lastly, the system requirements for the prototype were presented and discussed, alongside a detailed explanation of the implementation of the features that aim to satisfy the system requirements. After implementation, user studies of the prototype were conducted. The next chapter presents and discusses the findings from these user studies.

Chapter 5

Results

5.1 Introduction and Overview of Results

The evaluation of the prototype OLE yielded positive results, with many interesting features that provide insight into the process of developing such a system.

The quantitative analysis of the evaluation forms filled out by the learners showed that each of the components and aspects of website use evaluated averaged out, across all schools, to scores over 3 (see section 3.8.3). This indicates a positive response from the learners. Figures 5.1 and 5.2 show the results for each category as rated by the learners who used the prototype. The average score over all questions for all schools was 3.24/4 - a rating of 81.02%. A summary of the results is presented in tabular form in Appendix D. The qualitative feedback was also positive. One learner wrote that the prototype was "A better way to learn. Much more fun and more interesting".

This chapter explores these results in more depth and offers some interpretation of the interesting patterns and traits that arose from them. In order to be able to fairly determine the success of the prototype, it will be evaluated against the three high level requirements which it aimed to satisfy: intuitiveness, interactivity and sustainability.

5.2 Intuitiveness

Considering the low levels of computer literacy of the learners in most previously disadvantaged schools in South Africa, the prototype could only be considered effective if it

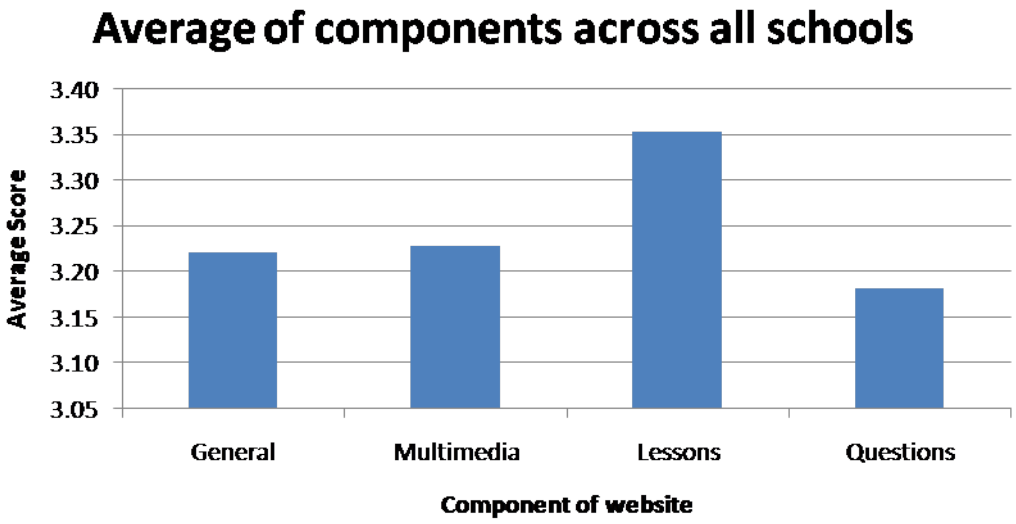


Figure 5.1: Overall average for each component of the prototype across all schools

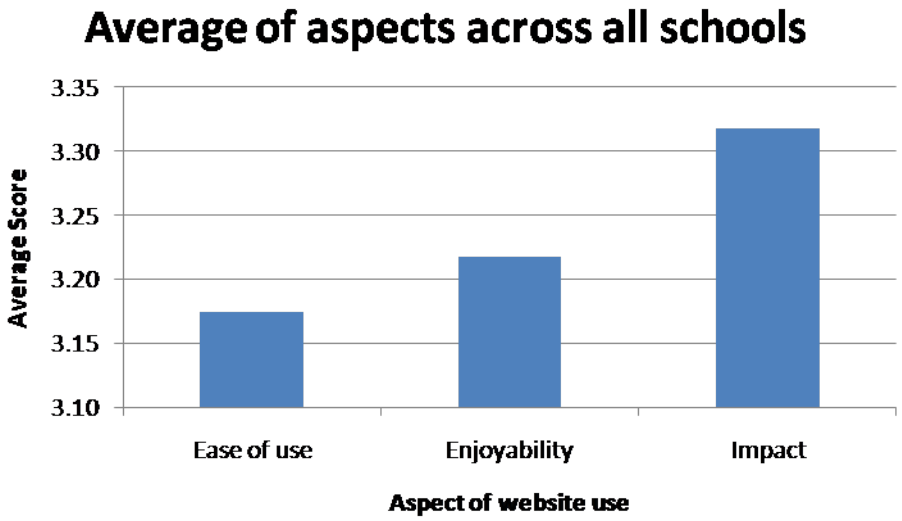


Figure 5.2: Overall average for each aspect of website across all schools

was intuitive. In order to test extensively the intuitiveness of the prototype, the learners involved in the user study were not given any instructions on how to use the website. They were assisted in navigating to the website URL, but, once there, they were left to explore the website on their own. The principal investigator encouraged the learners to click around and have fun. The outcome of this aspect of the user study was remarkably positive. In each class that participated, all of the learners managed to discover and use all the functionality of the website within ten minutes. In many cases, learners learnt more about how the website works by looking at their classmates' screens to see what they had discovered. The learners asked almost no questions about how to use the website. It should also be noted here that the website itself also contains a minimal number of instructions. From a technical perspective, everything ran reasonably smoothly. Once the website had been loaded, learners did not experience any delays or bugs. The "ease of use" aspect of the website use averaged out to 3.17/4 (see Figure 5.2) and the mode was 3 for each of the schools. This means that, on average, users agreed that the different components of the website were easy to use. One learner from School B stated in the free response questions on the evaluation form that the website was "very useful and easy to use". Another learner, from School A, in response to a question asking whether they would use the website to study for exams, said: "Yes! It is very very easy to understand."

Despite the positive overall results, it is necessary to take note of issues relating to ease of use. One aspect of the user interface that several of the learners struggled with was the lesson navigation box (see Figure 4.6). These learners repeatedly clicked on the heading of the panel, instead of on the name of the lesson in the panel. They were, however, eventually able to open the lesson. Another, rather similar, issue was with learners clicking to see a response to a prompt question. Learners would click on the instruction below the question, instead of on the question itself. A useful solution to this problem would be to change the cursor into a hand icon when the learner hovers their mouse over a clickable area of text. This would assist them in knowing exactly which parts of the lessons they are able to interact with. Some learners were also confused when they clicked on their browser's back button. The learners probably expected the back button to undo an action, but were instead navigated back to the browsers home page and needed assistance to return the to website URL.

An interesting aspect of the results relating to how intuitive the prototype was to use, is the difference in results between the two previously disadvantaged schools and the private school. Figure 5.3 compares the ease of use, enjoyability and impact on learning of the prototype between previously disadvantaged and private schools. It is salient to note that, although the learners at previously disadvantaged schools found the website easy to use,

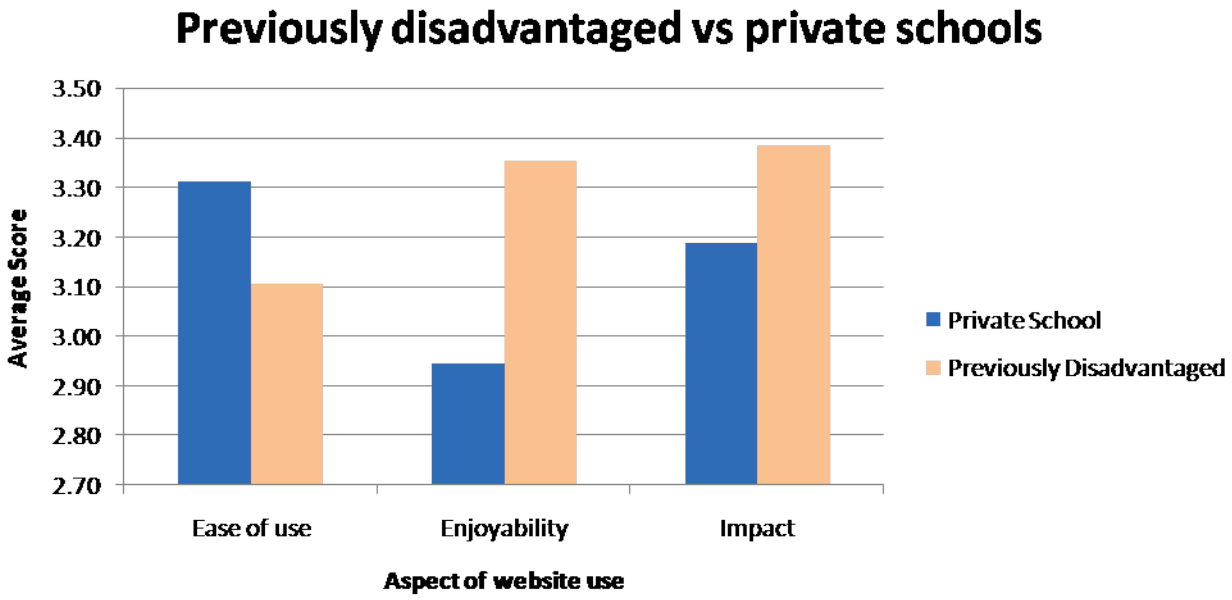


Figure 5.3: Differences between previously disadvantaged and private schools

the learners from the private school (who tend to be more computer literate) found the website easier to use. There were only three questions that had an average score of less than 3 from the previously disadvantaged schools. Each of these questions related to some aspect of ease of use. It is worth pointing out, though, that the lowest of these scores was 2.82, which is still a positive response. Some of the learners in previously disadvantaged schools found using the website to be daunting. A learner from School B stated that their least favourite part of using the website was "[t]rying to make the computer work. It was difficult and embarrassing when we made mistakes". It is therefore important that, no matter how easy a website is to use, learners with low computer literacy levels are treated sensitively and with encouragement.

There were some interesting results from the teachers' evaluation of the "Learn" page. They were asked to complete one of the interactive lessons on the website, and filled in the same evaluation form as the learners. Figure 5.4 shows the differences in rating of the aspects of website use between the teachers and learners. The graph shows that the teachers actually found the website harder to use than the learners did. This may point to the fact that that the structure and design of the "Learn" page is more effective for use by school learners than older users. The teachers did, however, rate ease-of-use positively, with an average score of 3.10. One teacher commented that it was "easy to click around and play" on the website.

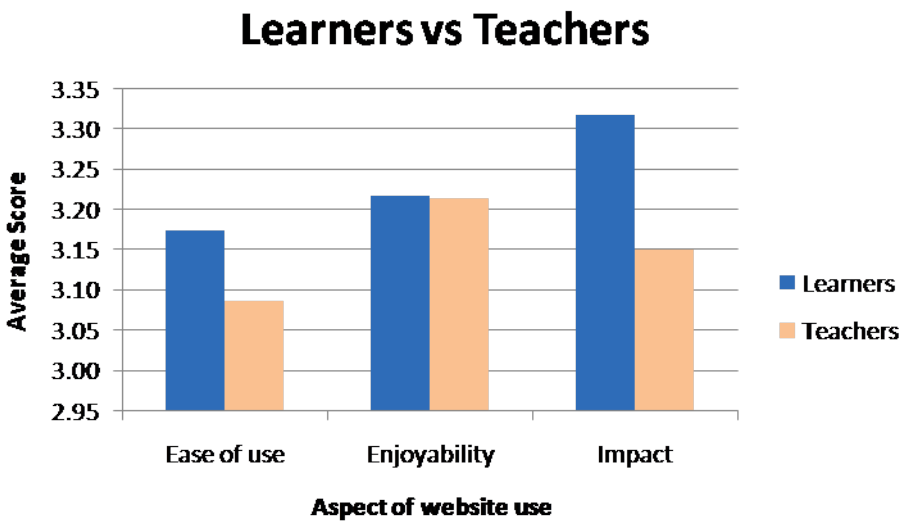


Figure 5.4: Differences between learners' and teachers' experiences of the website

The teachers were also asked to use and evaluate the "Contribute" page. They each created their own short interactive lesson and wrote down what they liked and disliked about the process. The user interface for the contribution process was not a primary focus of development and, as such, was not optimised for ease of use. Most of the teachers did, however, succeed to create their own lessons and were surprised at how easy the process made it to add content to the "Learn" page instantly. One teacher commented that the page had a "Very nice, friendly interface". With improvements in the layout of the form components, and the inclusion of some descriptions and instructions, the "Contribute" page could have an intuitive interface. The ordering and logic of the contribution process was followed without much difficulty by most teachers. One teacher commented that "This is a very simple process to contribute to a website like this".

5.3 Interactivity

The survey of literature around current e-learning pedagogies pointed to the importance of an interactive, immersive learning experience in maximising how much learners absorb from learning materials. The results from the evaluation of the prototype's interactive components were positive.

The average score for multimedia was 3.23 across all the schools and the mode for the questions relating to the website's multimedia was 3 for Schools A and C and 4 for School

B. An interesting aspect of the results is presented in Figure 5.5. From this graph it is clear that learners from the previously disadvantaged schools responded much more positively to the multimedia on the website than learners from the private school. One of the Likert scale questions in the evaluation form asked learners to rate the statement "The pictures helped me to understand the poems better". The average response score from the private school learners was 2.75, which stands in stark contrast with the scores of 3.18 and 3.38 from the two previously disadvantaged schools. This difference in response to the multimedia may be due to (probably a combination of) two main factors. Firstly, the learners from the private school have an excellent level of computer literacy and much more experience using the Internet. They have probably been exposed to large amounts of multimedia on the Internet, and no longer find its inclusion to be particularly novel or exciting. Secondly, learners from the private school had been exposed to multimedia by their teacher, who often uses images, audio and video to aid his teaching of poetry. The learners from the previously disadvantaged schools, however, are not presented with such learning resources. A learner from School A explained this while giving their reason for enjoying the multimedia on the website: "Well the book we are using with the poems has no pictures so I have to say the picture and how it helps to understand the poem better". The majority of the learners in the previously disadvantaged schools were visibly excited by the images on the website. In School A, learners were required to share computers due to the small size of the school's computer laboratory (2-3 learners per computer). The learners discussed the pictures with one another, and could be seen pointing out aspects of the images on the screen to their peers. One learner enjoyed the images so much that he used his cell phone's camera to take a photo of a portrait of William Wordsworth.

43.48% of the learners in School A cited the pictures as their favourite aspect of the website. This was not, however, merely because of the novelty of multimedia, but because of the impact that they had on the learners' understanding of the poems. A learner from School A said that "My favourite part it was when I was seeing the pictures, because they helped me a lot to understand exactly what it happening to the poem". Another learner in the same class said that "It was when I saw the pictures and realised what was the poem is all about". Poems, more often than not, attempt to convey imagery to the reader. In cases where the poem's language is not the first language of the reader, the conveyance of that imagery may be impeded. Images can therefore be useful in aiding the reader's understanding of the poem. One learner alluded to this advantage in their response: "My favourite was to see pictures of what you are reading about, because it is not that easy to make up your own image".

It was interesting to observe, during the user study with teachers, that the teachers did

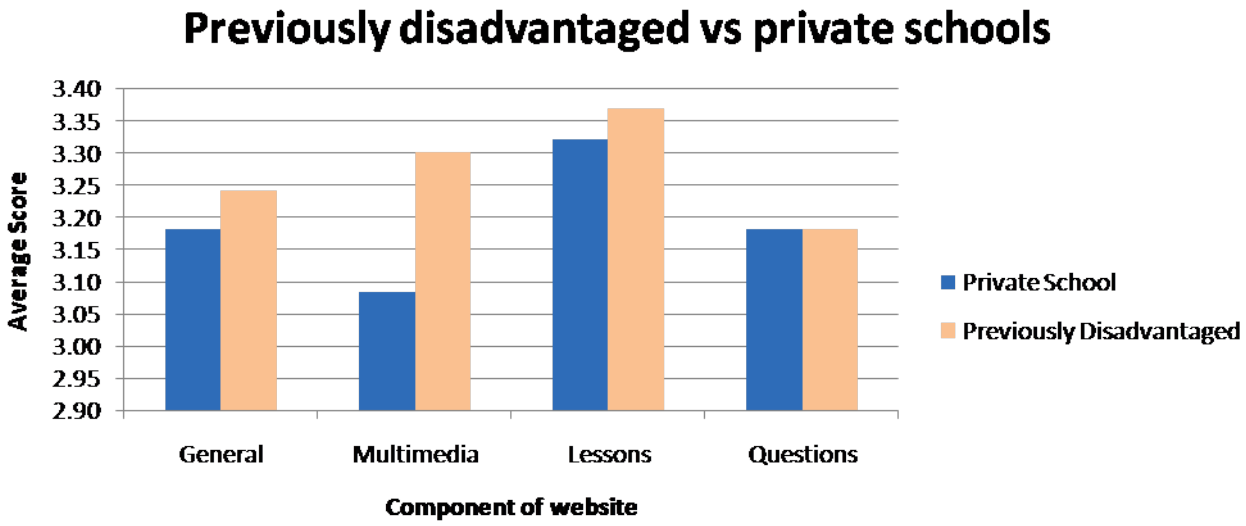


Figure 5.5: The difference in the average score for multimedia between previously disadvantaged and private schools

not demonstrate as much of an interest in the multimedia as the learners did. They did not click on many images; and didn't spend much time looking at the images that they did click on. This may confirm the idea that modern learners have a more dominant visual sense - making multimedia an effective way of conveying ideas to them. The teachers were, however, enthusiastic about the fact that the prototype allowed them to create their own lessons - and, in particular, that it allowed them to use different colours and fonts, and to include multimedia. One teacher said that "increasing font and put on different colours was fun and I wish I could do it all the time". Another teacher commented that the way that lesson content was captured on the website meant that "You can be very creative".

The other components of the prototype aimed at interactivity were also well received. The average score for the lessons across all schools was 3.35 and the mode was 3 for Schools A and C, and 4 for School B. The interactive questions and their feedback received an average rating of 3.18 and the mode was 3 for each school. During the user studies at the previously disadvantaged schools, one could see that the interactive nature of the questions kept the learners engaged with the lessons. Learners took the time to answer the questions and read the, often involved, responses. At School B in particular, learners were observed answering questions incorrectly, reading the response - and trying again until they got the right answers. 50% of learners in School B cited the questions as their favourite part of the website. There were several positive responses from learners about the questions in the free response section of the evaluation form. A learner from School A said that their favourite part of the website was "the part that when answer it you are

wrong it will correct you so that you so that you can understand". A learner from School B said that "giving answers ... helped me understand the poems better". Another learner from School A specifically points out that the *responses* to the questions were what they appreciated most: "My favourite part of the website was the explanation in the questions. Because it is clear". The questions give learners an idea of their learning progress or, as a learner from School A said, they "made me to know where I am standing on poems".

In addition, the questions made learning more immersive and so kept learners interested in lessons. One learner pointed out that they enjoyed having to "answer some questions based on the website" because "it was challenging, and I like challenges". It is important to note the important role that interactivity plays in creating a truly absorbing learning experience. It was interesting to note that, surprisingly, the fact that learners at School A had to share computers actually added to the interactivity and immersion of the experience. The group dynamic created a sense of exploration and the discussion between members added a useful element of interactivity. It may also have aided learners who might have been inhibited by their low level of computer literacy by providing some security through group confidence. A few learners in School A, once they had completed the lessons on the poems in their syllabus, moved on to the English Home Language poems, which they had not seen before. One learner stated that their "favourite part was to see a new poem which I had not done". This comments positively on the immersive nature of the website and indicates that it fosters a sense of exploration.

Learners also appreciated the lessons that provided some historical context to the poems. Often this kind of context allows learners to understand better why a poem was written and, through a closer understanding of the poet's intent, understand the poem better. One learner wrote that their favourite lesson was on the poem "The Night Train because it tells us about background of poets of Soweto". Another learner explained that they enjoyed learning about "the backgrounds of poets, because it makes it easier to see why the person wrote the poem what has espired the poet to write about the specific poem". By having lessons that make the poet's situation and intention more apparent to learners, it may therefore be possible to make poems more tangible - and make them easier to interact with on a direct level.

5.4 Sustainability

It would be pointless to have an OLE, even if it contained excellent learning material, if learners do not use (and keep using) it. It is therefore essential that using the website is

something that learners enjoy. Whether the efforts made to make the website enjoyable - including the easy-to-use-interface, the multimedia and the interactive components - have succeeded can really only be evaluated by the learners themselves. Fortunately the learners' response was positive. The average rating for the enjoyability aspect across all schools was 3.22. The mode for Schools A and C was 3. School B enjoyed the site the most with a mode of 4. One learner from School B wrote: "I loved everything about the site. I had fun while learning". Another learner, when asked if they would use the website to study for exams, wrote: "Definitely yes. It is much more fun to study in the website than having to crack your mind with many papers". The average responses from Schools A and B to the statement "I had fun using the website" were 3.14 and 3.47. The private school's response, on the other hand, was considerably lower at 2.75. Figure 5.3 shows that the average ratings of the enjoyability aspect of the website was considerably lower from the private school learners than from the learners in the previously disadvantaged schools - 2.94 vs 3.35. This may be, as explored earlier, due to the fact that the private school learners, with their extensive use of the Internet, do not find online learning as novel or exciting as the learners from previously disadvantaged schools. One may ask whether the learners in previously disadvantaged schools may feel similarly once the novelty of online learning wears off, and argue that this poses a problem to the sustainability of the website. This is a valid concern, but the positive ratings of the "impact on learning" aspect of the website by these learners, coupled with the positive response from teachers who used the website, indicates that it is likely that it has strong potential for continued use.

In the same way that an OLE would not be used (or continually used) if it is not enjoyable, it would not be used if it did not have a useful impact on learning. The average rating for the questions on the impact of the website on learning was 3.32 across all schools. The mode was 3 for Schools A and C; and 4 for School B. It is clear, based on these figures, that learners found that the website had a positive impact on their learning - which was the primary goal at the outset of this research. Again, although smaller, there is a discrepancy between the private school and the previously disadvantaged schools. Figure 5.3 shows that the learners from previously disadvantaged schools felt that the website a greater impact on their learning than the private school learners felt. It is worth noting that the discrepancy may be exaggerated by the fact that, save one, none of the poems on the website were in the IEB (SA private school) curriculum. The discrepancy may also be due to the difference between the standards of learning materials and classroom resources in previously disadvantaged and private schools. This may point to OLEs as a sustainable solution to offer support to teaching in previously disadvantaged schools, where other learning materials and resources are limited. Some of the responses from

learners support the idea that the website had a positive impact in their learning. One learner from School B wrote that: "I didn't understand some poems, but now I do a bit". A learner from School A wrote: "I've learnt more things that I thought". Another learner from School A pointed out that they "could not understand the way questions are asked in the book" and so found the questions on the website more useful. A statistic that stands out from the quantitative analysis of the learner's responses is the fact that, for each of the previously disadvantaged schools, the statement that received the highest ranking was the same - "The website helped me to understand the poems better". School A rated this statement at 3.47, and School B rated it at 3.69. It is clear that the learners in these schools found that the prototype made a meaningful impact on their learning. Most of the learners from these schools indicated that they would use the website to study for exams if they could. This points to a sustainable solution, that learners would keep using, because it is enjoyable and has a useful impact on their learning. Only 18.6% of learners indicated that they would not use the website to study for exams. Of the learners from previously disadvantaged schools, 85.48% said that they would use the website.

There were two learners from School A who, in their feedback, expressed a concern that they would not be allowed to use their school's computer laboratories to access the website. One of these learners wrote, when asked whether they would use the website to study for exams: "no because the educators unable to give learners the permission". The other wrote: "No, I don't think our educators can allow us to do that, I would if they asked if we want to". This is problematic, because it indicates that either, a) the school or its educators will not allow access to online learning resources; or b) the learners perceive this as being the case, and so will not ask for permission to use online learning resources. It is therefore important, for the potential of OLEs to be realised, that there is a commitment from government, schools and teachers; as well as clarity around the issue of access to computer laboratories. Interestingly, teachers did not score the website's impact on learning as highly the learners themselves did. This can be seen in Figure 5.4. This may be due to a more critical attitude from teachers, but may also be due to a higher level of scepticism over technology's potential as a learning aid.

A crucial part of evaluating whether the prototype is sustainable, was to explore the results of the user study in which teachers were asked to use the "Contribute" page to create their own interactive lessons. After the demonstration of the lesson contribution functionality, the teachers were impressed and excited to try it out themselves. One teacher wrote that "The idea of creating your own lessons was fun". The teachers were instructed to create their own short lessons, with questions, on a learning area of their choice. (Most of the teachers were not Language teachers, and so it was prudent not to restrict their choice

of material to English poetry.) Despite the brevity of the demonstration (less than ten minutes) and the short amount of time they had to create their lessons (around fifteen minutes), many of the teachers were able to create their own lessons. Some of these lessons included the use of different font colours, hyperlinks and images; and all but one included questions with brief responses. Figure 5.6 shows two basic lessons created by teachers during the session.

One teacher described the website as "Overall a good tool for teachers" and pointed out that "Any learning area can be accommodated". Another described the contributing process as "interesting", "fun" and "helpful". The teachers involved in the user study seemed excited by how easy it is to create interactive lessons, and were impressed by the fact that "you can ... add on the lesson anytime". It bodes well for the sustainability of OLEs such as this prototype that teachers support its goals, find it easy to use, and become excited by its capabilities and potential. Several teachers gave suggestions of features that they would like to see in the website, such as the ability for learners to upload their own content and the ability to integrate slide shows into the site. This points to a keen interest in the project and support for what the prototype attempts to achieve.

5.5 Conclusion

From this investigation of the results from the evaluation of the prototype OLE, it is clear that the prototype has proved that the potential exists for such systems to be highly effective. By measuring the prototype's success against the three requirements that guided its design, it has been apparent that it achieves much of what it set out to do. The results show that the prototype is easy to use, even to those with poor computer literacy levels and very little experience with computers. The results indicate that the attempt to create an interactive learning experience has been successful and that both teachers and learners recognise the merits of interactive e-learning. It is also clear that the prototype demonstrates the potential for a sustainable solution. The results are not without their problematic areas, but these problems point to important challenges to e-learning, particularly in previously disadvantaged schools.

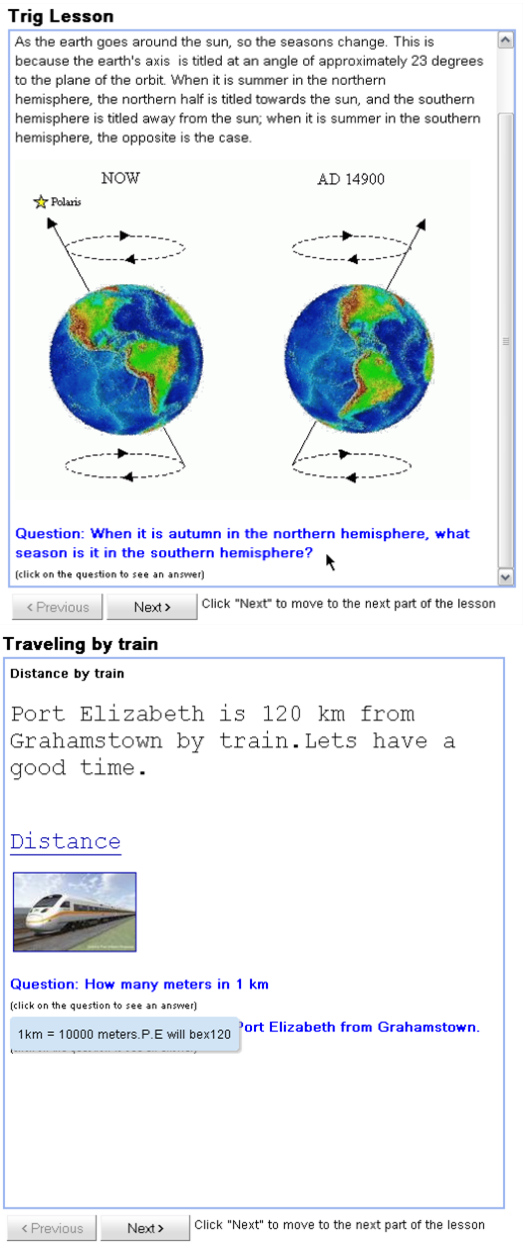


Figure 5.6: Lessons created by the teachers using the website for the first time

Chapter 6

Conclusion

6.1 Summary

This project has produced a working prototype of an online learning environment aimed at providing interactive learning material relevant to South African learners and teachers, in a way that is easy to use and sustainable. The prototype focuses on providing lessons for Grade 12 English poetry, but serves as a proof of concept for the use of such a system across the school curriculum. Before development began, a process of gathering requirements was undertaken. This included research into the current state of ICT use for Education in South Africa and the benefits of e-learning. Importantly, it included research into current theoretical perspectives on the design of OLEs. In addition to this research, the requirements for the system were based on the opinions and requirements of South African teachers, gathered through two interviews and a focus group. From this research, the three primary high level requirements for the system were identified as: intuitiveness, interactivity and sustainability. In order to ensure that the prototype was intuitive and interactive, it was designed using the Google Web Toolkit. Using the GWT made it possible to design a simple, fluid user interface and allowed for the graceful integration of multimedia and interactive questions into the system. In order to ensure sustainability, a contribution module was developed for the prototype, designed to allow teachers to create and instantly upload their own interactive lessons. In addition, the design and implementation of the prototype focused on creating an enjoyable user experience to ensure that learners would want to continue using it. The prototype was evaluated through user studies in three schools: two previously disadvantaged schools, and one private school. Learners were asked to use the prototype and fill out an evaluation form. The aim of the

evaluation was to determine whether, and to what extent, the prototype satisfies the requirements for the system. Teachers, from both previously disadvantaged and former model C schools, were also asked to use and evaluate the prototype, particularly the contribution functionality. The results from the evaluation process were positive. The data showed that the prototype was well received by both teachers and learners; and proved that there is great potential for the use of OLEs in South Africa, particularly in previously disadvantaged schools. The results also pointed to some interesting trends and variations between groups, which provided insight into the possible strengths and challenges of the use of OLEs.

6.2 Problem Statement Revisited

The problem this research set out to address was the development of a sustainable OLE that is relevant to South African learners. Through an investigation of current e-learning pedagogy and the requirements of South African teachers and learners, it was possible to create a design for a prototype that was both relevant to South African needs and optimised for effective e-learning. Through the use of the GWT, it was possible to create an implementation that is both easy to use and interactive. The prototype demonstrated the potential for the sustainability of such a system. The evaluation of the prototype yielded positive results that showed that learners found it easy and enjoyable to use; and that learners - particularly those in previously disadvantaged schools - found it to have a marked impact on their learning. The results also showed that teachers were impressed by the prototype, that they were able to contribute material of their own, and that they supported, in principle, the use of such a system in their teaching. The prototype has demonstrated that an OLE can be used effectively in the South African context, particularly in previously disadvantaged schools. The prototype shows promise for application across the school curriculum and being, if used nationally, a large, useful repository of interactive materials for a variety of learning areas.

6.3 Possible Extensions

The application developed in this research is simply a prototype for a much larger system with the potential for many additional features and implementations. A short list of possible extensions is provided below:

- A discussion module. The literature survey showed that collaboration is one of the key potential strengths of e-learning (see sections 2.4.1.3 and 2.4.2.3). A discussion module could be developed to include both forums (for asynchronous communication) and online chat (for synchronous communication). Unfortunately, due to the limited time available for this research, there would not have been sufficient time for a user study to test the functionality of such a module.

- A home page for each user. The widespread use of social networking sites such as Facebook indicates that modern users enjoy having their own virtual space. The prototype could be extended so that each teacher and learner has their own customisable home page. This home page could be developed to include the ability for learners to monitor their own progress through learning materials. It could also include a blog section where learners could express their opinions on what they are learning for their peers to read.

- A version of the prototype aimed at mobile phones. Mobile phone use is pervasive in South Africa, even among learners in previously disadvantaged schools. Mobile access could greatly increase the potential reach and impact of the system.

- The ability for learners to contribute material. In addition to the current contribution module, a module could be developed that allows learners to contribute their own study notes, essays and projects. Some measure to prevent plagiarism would have to be introduced in conjunction with such a module.

- A search function. In a larger version of the system, with a large amount of learning material, it would be useful for learners to be able to search the website to locate particular lessons or information.

References

[1] S. Cairncross and M. Mannion. Interactive multimedia and learning: Realizing the benefits. *Innovations in Education and Teaching International*, 38(2):156–164, 2001.

[2] P. Cairns and A. Cox, editors. *Research Methods for Human-Computer Interaction*. Cambridge, 2008.

[3] S. Carliner and P. Shank. *The e-learning handbook: Past promises, present challenges*. Pfeiffer, 2007.

[4] S. Chandel. Using gwt with hibernate. `http://code.google.com/webtoolkit/articles/using_gwt_with_hibernate.html`, [Last accessed: 2009/09/06].

[5] M.W. Churton. Pedagogical considerations for online (e-learning) teaching-learning. 2008. SEAMEO ICT Conference.

[6] J. Cook, S.A. White, M. Sharples, N. Sclater, and H.C. Davis. The design of learning technologies. *Contemporary Perspectives in E-learning Research: Themes, methods and impact on practice*, pages 55–68, 2006.

[7] M. Coomey and J. Stephenson. Online learning: it is all about dialogue, involvement, support and control-according to the research. *Teaching & Learning Online: New Pedagogies for New Technologies*, page 37, 2001.

[8] C. Dalsgaard. Social software: E-learning beyond learning management systems. `http://www.eurodl.org/materials/contrib/2006/Christian_Dalsgaard.htm`, [Last accessed: 2009/10/15].

[9] R. Dewsbury. *Google Web Toolkit Applications*. Prentice Hall, 2007.

[10] M. Dyke, G. Conole, A. Ravenscroft, and S. de Freitas. Learning theory and its application to e-learning. *Contemporary Perspectives in E-learning Research: Themes, methods and impact on practice*, pages 82–98, 2006.

[11] Google. Communicating with a server. `http://code.google.com/webtoolkit/doc/1.6/DevGuideServerCommunication.html`, [Last accessed: 2009/09/14].

[12] Google. Product overview. `http://code.google.com/webtoolkit/overview.html`, [Last accessed: 2009/09/14].

[13] Google. Google plugin for eclipse. `http://code.google.com/eclipse/`, [Last accessed: 2009/10/03].

[14] Google. Google web toolkit. `http://code.google.com/webtoolkit/`, [Last accessed: 2009/10/06].

[15] C. Graham, K. Cagiltay, B. Lim, J. Craner, and T.M. Duffy. Seven principles of effective teaching: A practical lens for evaluating online courses. *Technology Source*, 30(5):50–80, 2001.

[16] M.L. Halse. *The Development and Evaluation of a Custom-built Synchronous Online Learning Environment for Tertiary Education in South Africa*. Rhodes University, 2007.

[17] A.A. Hamid. e-learning is it the e or the learning that matters? *The Internet and Higher Education*, 4(3-4):311–316, 2001.

[18] R.J.M. Hartog, M. van Boxel, J. Hofstee, I. Latour, L. Rietveld, H Verstralen, and P. Gorissen. Guidelines for the design of digital closed questions for assessment and learning in higher education. *e-Journal of Instructional Science and Technology (e-JIST)*, 10(1), 2007.

[19] Hibernate. `www.hibernate.org`, [Last accessed: 2009/09/06].

[20] B. Holmes and J. Gardner. *E-learning: concepts and practice*. Sage, 2006.

[21] S. Isaacs. Ict in education in south africa. *Survey of ICT in Education in Africa*, 2(53), 2007.

[22] W. Jochems, J.J.G. van Merriënboer, and R. Koper. *Integrated e-learning: Implications for pedagogy, technology and organization*. Routledge/Falmer, 2003.

[23] S.D. Johnson and S.R. Aragon. An instructional strategy framework for online learning environments. *New Directions for Adult and Continuing Education*, 2003(100):31–43, 2003.

[24] A. Jolliffe, J. Ritter, and D. Stevens. *The online learning handbook: developing and using web-based learning*. Kogan Page Ltd, 2001.

[25] W.J. Lin, H.P. Yueh, Y.L. Liu, M. Murakami, K. Kakusho, and M. Minoh. Blog as a tool to develop e-learning experience in an international distance course. In *Proceedings of the Sixth IEEE International Conference on Advanced Learning Technologies*, pages 290–292. IEEE Computer Society Washington, DC, USA, 2006.

[26] T. Manuel. Address by minister of finance trevor a manuel, mp, to the national assembly on tabling the 2005 medium term budget policy statement and the 2005/06 adjustments appropriation bill. `http://www.info.gov.za/speeches/2005/05102514541001.htm`, [Last accessed: 2009/05/13].

[27] C. McLoughlin and M. Lee. Social software and participatory learning: Pedagogical choices with technology affordances in the web 2.0 era. In *ICT: Providing choices for learners and learning. Proceedings ascilite Singapore 2007*, 2007.

[28] Moodle. What is moodle? `http://moodle.org/about`, [Last accessed: 2009/10/10].

[29] MySQL. `http://www.mysql.com`, [Last accessed: 2009/09/25].

[30] C.S. Nam and T.L. Smith-Jackson. Web-based learning environment: A theory-based design process for development and evaluation. *Journal of Information Technology Education*, 6:23–43, 2007.

[31] J. Nielsen. *Usability Engineering*. Academic Press, 1993.

[32] M. Oliver, J. Harvey, G. Conole, and A. Jones. Evaluation. *Contemporary Perspectives in E-learning Research: Themes, methods and impact on practice*, pages 174–189, 2007.

[33] N. Pandor. Statement by mrs naledi pandor mp, minister of education, on the release of the 2008 national senior certificate examination results. `http://www.education.gov.za/dynamic/dynamic.aspx?pageid=306\&id=8276`, [Last accessed: 2009/05/13]. Department of Education of the Republic of South Africa.

[34] Project Gutenberg. `http://www.gutenberg.org`, [Last accessed: 2009/09/01].

[35] N. Sclater, G. Conole, W. Warburton, and J. Harvey. E-assessment. *Contemporary perspectives in e-learning research: themes, methods and impact on practice*, pages 147–159, 2007.

[36] South African Department of Education. Draft white paper on e-education: Transforming learning and teaching through ict, 2003.

[37] South African Department of Education. `http://www.education.gov.za`, [Last accessed: 2009/03/10].

[38] South African Government. Act no. 36 of 2005: Electronic communications act, 2005. Republic of South Africa Government Gazette Vol. 490, April 2006.

[39] J. Stephenson. Learner-managed learning-an emerging pedagogy for learning online. *Teaching & Learning Online: New Pedagogies for New Technologies*, page 219, 2001.

[40] United Nations News Centre. Information technology must be used to promote development, annan tells un forum. `http://www.un.org/apps/news/story.asp?NewsID=13961\&Cr=information\&Cr1=technology`, [Last accessed: 2009/05/13].

[41] D.A. Wagner, Bob Day, Tina James, Robert B. Kozma, Jonathan Miller, and Tim Unwin. *Monitoring and Evaluation of ICT in Education Projects: A Handbook for Developing Countries*. International Bank for Reconstruction and Development/-World Bank, 2005.

[42] S.A. Waterhouse. *The power of elearning: The essential guide for teaching in the digital age*. Pearson Education Canada., 2005.

[43] Wikimedia. Wikisource. `http://en.wikisource.org`, [Last accessed: 2009/08/30].

[44] Wikimedia. Wikimedia commons. `http://commons.wikimedia.org`, [Last accessed: 2009/09/14].

Appendix A

Ethics

A.1 Information sheet example

Computer Science Department Research

Developing a web-based learning environment to support previously disadvantaged schools in South Africa.

Researcher

Mr Rouan Wilsenach

BA

Tel: 046 603-8291

Many previously disadvantaged schools in South Africa are faced with a shortage of quality teaching materials. Computers and networks are being deployed in some schools, however, providing an opportunity to use Information and Communication Technologies (ICTs) to assist learners and teachers. By developing an online environment, that facilitates the sharing of educational information, it will be possible for teachers to prepare learning material and make it accessible to learners in several schools.

Essentially, the aim of this project is to research the best way to structure a web-based learning environment; develop a prototype using web application technologies; and to evaluate whether the prototype is a successful teaching aid.

In order to evaluate the success of the project, teachers will to contribute content in the particular learning area of English poetry, and classes from a few schools will test the application. Results will be obtained from the use of the prototype in order to have some indication of the efficacy of the application. With this end in mind, the resource will be developed in such a way that it is able to collect usage statistics and assess whether learners are benefiting from the resource.

You may choose not to be a part of the study at any time.

PROCEDURES AND DURATION:

You understand that you will be asked to complete the following experimental procedures as a subject of this research. The study will require approximately half an hour of time which you will be asked to:

1) Participate in a semi-formal interview on your personal experiences and expectations of the use of computers in teaching. The principal researcher will write shorthand notes of ideas that arise from the discussion. The interview will take no longer than 30 minutes. If you are uncomfortable, you may excuse yourself from the interview at any time.

VOLUNTARY PARTICIPATION: Participation in this study is voluntary, and you can refuse to be in the study or stop at any time. There will be no negative consequences if you decide not to participate or to stop.

CONFIDENTIALITY: In any publication or presentation of research results, participant identity will be kept confidential. All research material will be kept stored and locked on Rhodes University property in the Computer Science Department until completion of the study (30 November 2009).

A.2 Consent form example

CONSENT FORM

Project Title: Developing a web-based learning environment to support previously disadvantaged schools in South Africa.

Researcher: Mr Rouan Wilsenach

- I have received information about this research project.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project at any stage.
- I understand that participation in this focus group is done on a voluntary basis.
- To the best of my knowledge I have no physical impediments that will stop me from completing this study.
- I understand that while information gained during the study may be published, I will not be identified and my personal views will remain confidential.

Name of participant _____

Signed _____ **Date** _____

I have provided information about the research to the research participant and believe that he/she understands what is involved.

Researcher's signature and date _____

Appendix B

Interviews and Focus Group

B.1 Interview Schedule

A. Experience

1. How would you define an online learning environment?

2. Do you ever use computers to aid you in teaching?

3. If so, how?

4. Are there any particular resources or programs you have used?

5. What did you like and find useful about them?

6. What did you dislike? Were there aspects that you found counter-productive?

7. Do you consider computers to be a useful teaching tool?

8. What are your thoughts on the use of the Internet in education?

9. How would you describe your learners' level of skill and familiarity with computers?

B. Expectations

1. What aspects of teaching do you believe can be made easier using computer technology?

2. What aspects of teaching do you think computers may negatively affect?

3. If you could write a computer program for your learners to use, what would it teach them?

4. Do you have any thoughts on how it might teach them those things?

5. My idea is to develop a web site that facilitates the sharing of educational information. It will allow teachers to prepare lessons and make them accessible to learners in several schools. Learners will be able to use these lessons, and will be tested online to see whether they have learnt what they were meant to from the lessons. The learners will be able to track their own progress and take some responsibility for their own learning. What do you think of this basic model?

6. Do you have any thoughts on what the best way to structure a web site like this may be?

7. How would you evaluate whether the learners are gaining something from the web site?

8. The learning area I will focus my prototype on is English Literature, specifically Poetry. Do you have any ideas on how computers could be used to teach poetry effectively or differently?

B.2 Focus Group Discussion Points

A. Experience

1. Do you ever use computers to aid you in teaching? How?

2. Are there any particular resources or programs you have used?

3. What did you like and find useful about them?

4. What did you dislike? Were there aspects that you found counter-productive?

B. Expectations

1. What aspects of teaching do you believe can be made easier using computer technology?

2. What aspects of teaching do you think computers may negatively affect?

3. If you could write a computer program for learners to use, what would it teach them?

4. Do you have any thoughts on how it might teach them those things?

Appendix C

Evaluation Form

C.1 Likert scale statements

Evaluation Form - LearnOnline Grade 12 English Poetry

Questions	Responses			
	Strongly Disagree	Disagree	Agree	Strongly Agree
Mark your response with an X	☐	☐	X	☐
General				
The website was easy to use.	☐	☐	☐	☐
It took a long time to get used to how the website works	☐	☐	☐	☐
It was difficult to find my way around the website	☐	☐	☐	☐
I had fun using the website	☐	☐	☐	☐
The website was boring	☐	☐	☐	☐
The website helped me to understand the poems better	☐	☐	☐	☐
Multimedia				
The pictures on the site were easy to use	☐	☐	☐	☐
The pictures helped me to understand the poems better	☐	☐	☐	☐
The pictures made learning about the poems more interesting	☐	☐	☐	☐
Lessons				
The lessons on the site were easy to use	☐	☐	☐	☐
The lessons helped me to understand the poems better	☐	☐	☐	☐
The lessons made me think more about what the poems mean	☐	☐	☐	☐
Interactive Questions				
It was easy to answer the questions asked in the lessons	☐	☐	☐	☐
The questions helped me to understand the poems better	☐	☐	☐	☐
The questions made me think more about what the poems mean	☐	☐	☐	☐

C.2 Free response questions

What was your favourite part of the website? Why?

What was your least favourite part of the website? Why?

Which lesson helped you the most? Why?

Would you use the website to study for exams? Why/why not?

Appendix D

Results

D.1 Summary of Results in Tabular Form

	Average					
	School A	School B	School C	Prev Dis	Learners	Teachers
Ease of use	3.03	3.18	3.31	3.11	3.17	3.09
Enjoyability	3.20	3.51	2.94	3.35	3.22	3.21
Impact	3.25	3.52	3.19	3.38	3.32	3.15
General	3.10	3.38	3.18	3.24	3.22	3.25
Multimedia	3.25	3.35	3.08	3.30	3.23	3.08
Lessons	3.23	3.51	3.32	3.37	3.35	3.18
Questions	3.09	3.27	3.18	3.18	3.18	2.92

	Mode		
	School A	School B	School C
Ease of use	3	3	3
Enjoyability	3	4	3
Impact	3	4	3
General	3	4	3
Multimedia	3	4	3
Lessons	3	4	3
Questions	3	3	3

Appendix E

Contents of Electronic Appendix (CD-ROM)

1. List of English Prescribed Work Titles for Grade 12 in 2009.
2. Permission from Shabbir Banoobhai and Fhazel Johennesse to include their poems.
3. Request for, and instructions to, contributors.
4. Information sheets and consent forms for all interviews, focus groups and user studies.
5. Summaries of interviews and the focus group.
6. Evaluation form for user studies
7. Spreadsheet containing all results, as well as tables and graphs summarising the results.
8. The actual implementation - in the form of an Eclipse GWT project folder.
9. Copies of free software used in the development process.
10. The research website - which includes:
    (a) Project proposal
    (b) Literature review
    (c) Project poster

(d) Final seminar presentation

(e) PDF copy of this dissertation

(f) Development log

11. All available copies of electronic resources referenced in this dissertation.

12. SQL file that can be used to restore the full database with all content (mysqldump).

13. An electronic copy of this dissertation (PDF and LyX formats, with Bibtex reference file).