THE E-LEARNING DOME: A COMPREHENSIVE E-LEARNING ENVIRONMENT DEVELOPMENT MODEL

by

MAGDALENA MARIA MANESCHIJN

submitted in part fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

in the subject of

INFORMATION SYSTEMS

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: MRS A J VAN DER MERWE

JUNE 2005

I declare that *The E-Learning Dome: a comprehensive E-learning Environment Development Model* is my own work and that all the sources that I have used or quoted have been indicated and acknowledges by means of complete references.

____

MM Maneschijn

The E-Learning Dome: a comprehensive E-learning Environment Development Model

By MM Maneschijn

Degree: Master of Science

Subject: Information Technology

Supervisor: Ms AJ van der Merwe

Summary

The purpose of this study is to investigate the weaknesses of current e-learning environment development models and to establish a comprehensive e-learning environment development model (EEDM). In the literature study I established the components of a comprehensive EEDM by looking at five existing models. The main concern in all of the models is the lack of configuration management, which lead to the investigation of other characteristics that an EEDM should have to be described as a comprehensive model. I then used these characteristics to establish the E-learning Dome – a comprehensive EEDM. The E-learning Dome consists of three layers, namely the Infrastructure layer, E-learning administration layer and the Course development layer. The Quality Dome encompasses the combination of these three layers. Through the use of case studies to test the feasibility of the E-learning Dome I concluded that the E-learning Dome is successful as a comprehensive EEDM.

Dedication

I dedicate this dissertation to my incredible husband and best friend Anton. Also to my parents who installed in me my love for all things academic.

Acknowledgement

Firstly, a big thank you to my supervisor, Mrs AJ van der Merwe for her inspiration when I needed it most.

Thank you also to Prof E Cloete for all her assistance and wise words.

I also want to thank Anton and Leria for their endless understanding and support throughout my studies.

To Dr S Buys, thank you for time off when needed.

Abstract

The purpose of this study is to investigate the weaknesses of current e-learning environment development models and to establish a comprehensive e-learning environment development model (EEDM). In the literature study I established the components of a comprehensive EEDM by looking at five existing models. The main concern in all of the models is the lack of configuration management, which lead to the investigation of other characteristics that an EEDM should have to be described as a comprehensive model. I then used these characteristics to establish the E-learning Dome – a comprehensive EEDM. The E-learning Dome consists of three layers, namely the Infrastructure layer, E-learning administration layer and the Content Development layer. The Quality Dome encompasses the combination of these three layers. Through the use of case studies to test the feasibility of the E-learning Dome I concluded that the E-learning Dome is successful as a comprehensive EEDM.

TABLE OF CONTENTS

List of Figures

List of Tables

Abbreviations

DDLM	Demand Driven Learning Model
EEDM	E-learning Environment Development Model
EESM	Electronic Education System Model
ODLIS	Open and Distance Learning Information System
WWW	World Wide Web
ALN	Asynchronous Learning Network
LAN	Local Area Network
EED	E-learning Environment Developer

Preface

In publishing their research findings, scientists use different presentation styles to present their work as accurately and objectively as possible. Traditionally, the recommended style for such writings has been very formal where the third person passive voice is used, and the scientist does not use the term "I" to identify himself or herself.

In modern times, however, the tendency has been to use a more informal style of writing, with some degree of familiarity, but without degrading the scientific basis of the work. In this thesis, I preferred to use the more informal approach to ensure that the reading effort in itself is not strenuous, but rather encourages the reader to concentrate on the technical content.

In addressing gender distinctions, I used the applicable gender when referring to a specific person. In other cases, a reference to one gender also includes reference to the other gender.

1. Orientation to the study

1.1 Introduction

The purpose of this study was to investigate the weaknesses of current e-learning environment development models and to establish a comprehensive e-learning environment development model (EEDM).

For the purpose of the study I formulated the following definitions from a number of definitions available. E-learning is the delivery of a learning, training or education program by electronic means. E-learning involves the use of a computer or electronic device (e.g. a mobile phone) in some way to provide training, educational or learning material. A model is a schematic description of a system, theory, or phenomenon that accounts for its known or inferred properties and may be used for further study of its characteristics. Development models are models used to determine the best techniques for applying a new process. An EEDM is defined for the purpose of this study as a scientifically generated framework for guiding the developer of an e-learning environment in the process of designing, developing and implementing such an e-learning environment.

My personal experiences as an information technology lecturer exposed me to the ever increasing utilisation of e-learning as a useful educational tool. An Internet search for a comprehensive and standard development tool for e-learning courses indicated that such a tool was not readily available. This prompted me to pursue the development of such a tool, or development model, in a formal way.

My hypothesis is that *the current e-learning environment development models are not sufficient to support an e-learning environment and that a comprehensive e-learning environment development model can be established.*

In section 1.2, the background of this study is given followed by the problem statement in section 1.3. The strategy towards the solution is briefly discussed in section 1.4 followed by the scope of the study in section 1.5. Section 1.6 concludes with a summary.

1.2 Background to the study

E-learning evolved from traditional distance education which, in its original form, means using paper correspondence through a postal service, or what is now called *snail mail*, as the study medium (Moore, Winograd & Lange, 2001). As new technologies developed over time, distance education adapted to new methods of correspondence, including media such as audiotape, videotape, radio and television broadcasting, and satellite transmissions (Moore, et al., 2001; Goggin, Finkelberg & Morrow, 1997).

Today the Internet, the World Wide Web (WWW), and microcomputers are directing the current generation of distance learning, while virtual reality, artificial intelligence, and knowledge systems may be next (Kerka, 1996). The developments in virtual reality, artificial intelligence and knowledge systems can be included successfully in an e-learning environment to enhance the capabilities of such an environment. Cloete and Kotze (2002) state that e-learning is a combination of learning services, technologies and products, which provides a coherent institutional environment for instruction on the Internet.

Ismail (2002) indicates that the great majority of institutions have only begun to search for ways to establish e-learning courses. Many of the reported e-learning implementations are activities that were based on intuition and available technologies, rather than on a scientific foundation. Cloete (2001) identifies the scientific model as a framework for designing and implementing e-learning classrooms. An EEDM should be used to ensure that e-learning environments are properly designed and maintained, as well as to ensure that the institution provides e-learners with a quality learning experience and service (Holt & Segrave, 2003). This will also ensure that the components of the e-learning environment are reusable (Brusilovsky & Nijhavan, 2002).

There are a number of EEDMs available (Johnson & Aragon, 2002; Stevens-Long & Crowell, 2002; Cloete, 2001). Five of these EEDM models were selected as test studies in this study. The following models were selected because they are the most referenced in the literature and all use a scientific approach towards the modelling of an e-learning development environment:

- The Electronic Education System Model (Cloete, 2001)
- EcoSystem model (Ismail, 2002)
- E-education framework (Motiwalla, 2000)

- The Demand Driven Learning Model (MacDonald, et al., 2001)
- Open and Distance Learning Information System (Bouras, et al., 2000)

Cloete (2001) proposed the *Electronic Education System Model* (EESM). The EESM is a layered model that consists of the *instructional layer*, the *educational middleware layer*, the *electronic paradigm layer*, the *physical layer*, and an *evaluation plane*. Ismail (2002) recognised the need to move from creating and delivering large inflexible training courses, towards producing database-driven learning objects that can be reused, searched, and modified independently. He described the *EcoSystem model* as a conceptual model representing the information flow, and interfaces between various modules, and the interaction between main processes in the e-learning environment. The *E-education framework* presented by Motiwalla (2000) uses e-commerce frameworks that are used by many corporations to enhance their businesses. It is used as a guide to plan the effective delivery of course materials, as a tool for interaction between role players, and as a guide for the design and implementation of an e-learning environment. The *Demand Driven Learning Model* (DDLM), presented by MacDonald, et al. (2001), was developed as a collaborative effort between academics and experts from private and public industries. The model consists of three main constructs: a) *superior structure*, b) *consumer demands*, and c) *learner outcomes*, and is founded in consumer demands for quality content, delivery, and service that results in desired learner outcomes. Bouras, et al. (2000) developed the *Open and Distance Learning Information System* (ODLIS) model to address the management of data in web-based applications, and the difficulty of integrating the different technologies and tools that support educational activities.

1.3 Problem statement

The main concern in all of the models is the lack of configuration management, which lead to the investigation of other characteristics that an EEDM should have to be described as a comprehensive model. For the purpose of this study, I define a comprehensive model as a model that should at least include the following characteristics, (identified in section 2):

- facilitate the effective management of an e-learning course development project,
- recognise the existence of the various constituent components and elements of an e-learning course and should facilitate their generic grouping,
- provide for a modular approach in the selection of the components for an e-learning course,

- ensure subject independence,
- ensure the best possible performance of the e-learning course,
- facilitate effective quality control of the e-learning course development project, and of the implemented e-learning course,
- facilitate system fault reporting, and
- facilitate configuration management of the e-learning course components and elements, both during development and operation.

Not one of the models includes all of these characteristics, which is the drive in this study, the investigation of the feasibility of a proposed comprehensive EEDM.

1.4 Research questions

Cloete (2001) specifically identifies the shortage of scientific EEDMs, and finds that designers of e-learning environments repeat the same mistakes, whilst being frustrated by the seemingly difficult and complicated process of establishing e-learning environments. The main focus of this study is to identify the characteristics that a comprehensive EEDM should adhere to, propose a comprehensive EEDM and investigate the feasibility of the proposed EEDM.

The questions that relate to the focus of the study include:

- What are the requirements of a development model?
- What is lacking in current development models?
- What is the structure of a comprehensive EEDM?
- How feasible is the implementation of the proposed EEDM?

1.5 Solution approach

In addressing the research questions, I first consulted the theory on how to establish the requirements and evaluation criteria for an e-learning model. After this activity the new e-learning model was developed and evaluated, using case studies. Lastly conclusions were drawn from these case studies. The study included the following steps in completing the research:

1. A technical survey was conducted to identify existing models and solutions for distance learning over the Internet, and specifically those models and solutions that are based on a scientific framework. The library was used as main source for journal articles. A valuable resource that was used during the study is the electronic journal facilities available from the library, which was used to conduct searches on the e-journals available. Internet resources were only used in cases where the information was validated and where the work was of high quality. Numerous textbooks of importance in the field of educational models were also consulted for theoretical background.
2. At the stage of doing this research, there was not a list of criteria available for the evaluation of e-learning models. Before it was possible to comment on the feasibility of the model, a nominal level of measurement was identified. This measurement tool included the mapping of each characteristics to a *yes* or *no* value for a characteristic, if the model focused on, has, or lack the characteristic (Leedy, 1993). The results of the survey were used to establish typical requirements, as well as generally accepted evaluation criteria for EEDMs. This was accomplished by the analysis and comparison of the models and by looking at the requirements for development models in other disciplines such as Engineering.
3. Based on the lacks identified in answering Research Question 1 and 2, a new model (the E-learning Dome) was suggested. This model specifically focused on the problem areas not addressed by the existing models identified in section 2.2. On each level of the model, a list of characteristics was defined that described the model. This list of characteristics was used in comparison use case studies, to show how the case studies adhere to the set of characteristics.
4. Each component of the E-learning Dome was compared to a number of case studies to establish which characteristics of which components were addressed by each of the case studies.
5. From the comparisons done in Chapter 4 it was determined that there are sufficient successful implementations of the different components of the E-learning to prove that the E-learning Dome is a useful, comprehensive, and complete model to develop an e-learning environment.

1.6 Scope

The e-learning model that was developed was mainly an interpretive study where existing models used by Cloete (2001), Ismail (2002), Motiwalla (2000), MacDonald, et al. (2001), and Bouras, et al. (2000) were used as the point of departure. For this study, the components that could be included in an EEDM were discussed using the characteristics derived from these models. The implementation of an EEDM model is beyond the scope of a Master study, and should be considered for future research. For this study, the case studies were used to investigate the feasibility of the different components of the comprehensive EEDM.

With regard to the role players in the environment, there are four major role players in an e-learning environment: the learner, the facilitator, the developer, and the administrator (Feldman, 2001). By its nature, the EEDM is a development tool for use specifically by the *developer* of the e-learning environment. In addition, the EEDM is used as a framework to *guide* the developer in the development of an e-learning environment. Thus, the scope of the model developed in this study was limited to identifying the responsibilities and development steps associated with the *developer* of the e-learning environment. However, where necessary, links and interfacing with the other role players are addressed as appropriate.

The dissertation is divided into five separate chapters. The first chapter gives a brief background to this study by introducing the models that will be analysed in Chapter 2. It includes the research problem, the solution strategy, and the scope of the study. The goal of Chapter 2 is to establish and give the theoretical background on the theory related to EEDMs. It includes the identification of a set of requirements and evaluation criteria for EEDMs. The chapter reports on the results of the technical survey, lists the typical requirements for an EEDM, and identifies acceptable evaluation criteria for such a model. In Chapter 3 the details of the EEDM, called the E-learning Dome developed in this study, is described. Chapter 4 reports on the results of testing the e-learning model developed in this study by means of comparison to selective case studies. Chapter 5 summarises this study, its findings, and its results, and makes appropriate recommendations for further work in this field of study. Figure 1 gives a layout of this dissertation.

Report Road Map

CHAPTER 1
ORIENTATION TO THE STUDY
1.1 Introduction
1.2 Background to the study
1.3 Problem statement
1.4 Research questions
1.5 Solution approach
1.6 Scope
1.7 Summary

CHAPTER 2
THEORETICAL FRAMEWORK
2.1 Introduction
2.2 Requirements for e-learning environment development models
2.3 The basic structure of an e-learning environment development model
2.4 Overview of existing e-learning models
2.5 Characteristics included in each of the models
2.6 Summary

CHAPTER 3
THE E-LEARNING DOME: AN E-LEARNING ENVIRONMENT DEVELOPMENT MODEL
3.1 Introduction
3.2 Research methodology
3.3 The criteria to be used for the evaluation of e-learning models
3.4 Role players in the e-learning environment
3.5 The E-learning Dome
3.5 Summary

CHAPTER 4
IMPLEMENTATION OF THE E-LEARNING DOME THROUGH SELECTED CASE STUDIES
4.1 Introduction
4.2 Determining the feasibility of the general requirements of the E-learning Dome
4.3 Determining the feasibility of the infrastructure layer
4.4 Determining the feasibility of the administrative layer
4.5 Determining the feasibility of thecourse development layer
4.6 Determining the feasibility of the quality dome
4.7 Summary of findings for each case study
4.8 Summary

CHAPTER 5
CONCLUSIONS
5.1 Introduction
5.2 Research summary
5.3 Scientific reflection
5.4 Further research
5.5 Concluding remarks

Figure 1: Layout of dissertation

1.7 Summary

Chapter 1 provides the background to the study. The research problem was defined and the research questions related to the study identified. A proposed strategy to address the issues in this study was given, as well as the scope of the study.

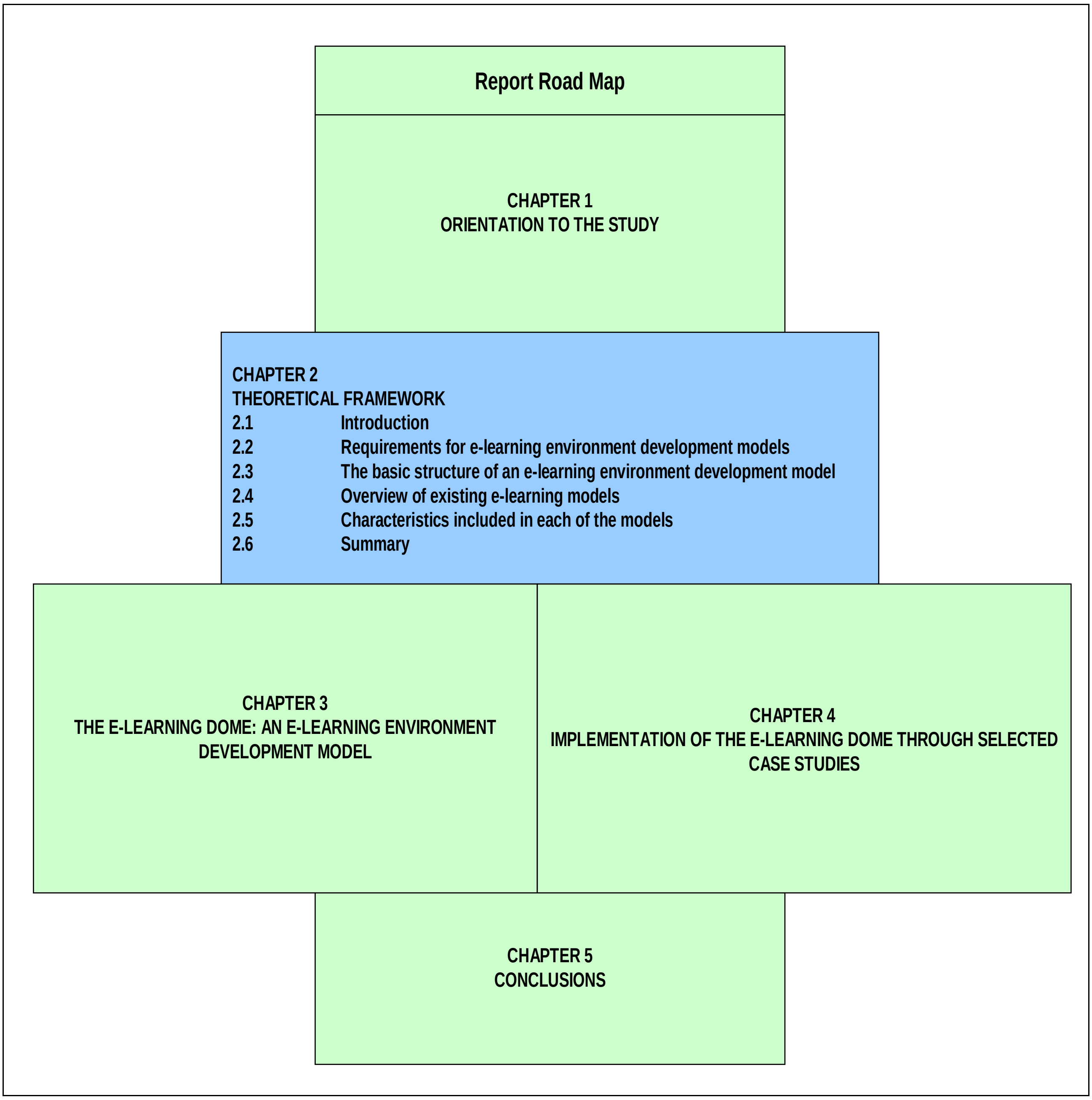

Figure 2: Layout of Chapter 2

2.Theoretical framework

2.1 Introduction

The theoretical framework refers to the theory already written in the literature. For this study it is necessary to investigate the nature of the existing EEDMs. To ensure that all e-learning environments using EEDMs are on the same standard and provide a complete service to the learner and the institution using the e-learning environment, a comprehensive EEDM is necessary. In this chapter I give an overview on the literature study conducted to establish which EEDMs exist and what the requirements are for a comprehensive EEDM. Using these requirements the existing EEDMs are investigated to indicate the shortcomings experienced by them.

This chapter focuses on the first two research questions identified in Chapter 1 as context questions. The questions were defined as:

- What are the requirements for a development model?
- What are the shortcomings in current development models?

In section 2.2 I focus on the requirements for the development model and in section 2.3 the basic structure of an EEDM is discussed. In section 2.4 the different models are considered followed by a discussion on the different EEDMs and the characteristics that they adhere to (and also what lacks in current development models).

2.2 Requirements for e-learning environment development models

In this section, the requirements for a successful EEDM are established. To identify the requirements, I looked at a number of existing e-learning environments, existing models and at the requirements for development systems from other disciplines such as engineering. After careful consideration and thorough comparison of a number of articles, best practices from each of the environments were used to formulate eight requirements that should be considered in the development of a comprehensive EEDM. These eight requirements are given in Table 1 with the relevant references.

Table 1: References to each requirement

		Ismail (2002)	Johnson & DeSpain (2001)	Cloete & Van der Merwe (2001)	MacDonald, et al. (2001)	Psaromiligkos & Retalis (2002)	Cloete & Schremmer (2000)	McGraw (2001)	Daugherty & Funke (1998)	Govindasamy (2002)	Polyson, Saltzberg & Godwin-Jones (1996)	Harwood & Miller (2001)	Berge (1999)	Macpherson (2002)	Hicks (2000)	Anido, et al. (2001)	Cloete & Kotze (2002)	Luca & McMahon (2000)	Deming (1994)	Gustafson (2002)	Nichols (2002)	Garvin (1988)	IEEE 1987	IEEE 1990a	IEEE 1990b
1	Project Management	✓																							
2	Elements of e-learning	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									
3	Modular system											✓													
4	Subject Independence	✓																							
5	Performance				✓		✓					✓					✓	✓							
6	Quality assurance				✓		✓	✓											✓	✓	✓	✓			
7	System fault reporting																			✓					
8	Configuration management					✓																	✓	✓	✓

In section 2.2.1 – 2.2.8 the requirements to show its relevance to the development of a comprehensive EEDM.

2.2.1 Requirement 1: Project management

According to Ismail (2002) many e-learning projects do not realise their full potential, because they fail to adequately meet basic instruction goals and objectives, therefore an e-learning environment model should include a project management component to assist the institution with collecting, organising, managing, maintaining, reusing, and targeting instructional content.

2.2.2 Requirement 2: Elements of e-learning

Issues such as the integration of additional hardware, equality and quality of the hardware, accessibility to students, maintenance, support costs and personnel issues, infrastructure, and the transmission costs are according to Johnson and DeSpain (2001) requirements which should be considered when implementing a distance learning initiative. Cloete and Van der Merwe (2001) state that issues that need to be addressed by an e-learning environment include:

- guidance and assistance in course design and development for the e-learning environment,

- support for multiple facilitators,
- assessment and feedback structures, capabilities and technology,
- configurability, manageability and usability of an e-learning environment from different perspectives, and
- course content issues: format, exportability, and adaptation to and from other formats.

According to MacDonald, et al. (2001) key elements for an effective e-learning environment design include: curriculum, pedagogy, technology, support, and interaction.

According to Psaromiligkos and Retalis (2002) e-learning environments are complex systems and incorporate a variety of organisational, administrative, instructional and technological components. According to Cloete and Schremmer (2000), the e-learning environment consists of many components that can be categorised into one of three categories. The first category is the communication technology category, the second is the virtual support system component category, and the third is the instructional issue category.

From the previous statements the following elements to facilitate an articulated model were extracted, which is believed to provide for quality e-learning environments: content, pedagogy, technology, support, interaction, and continuous evaluation. In the following paragraphs, a closer look will be taken at each element and the importance of each will be argued.

The first element is *content*, which concerns the subject matter that will be presented in the e-learning environment. Ismail (2002) states that e-learning content will expand beyond its current concentration on Information Technology and certification programs. This means that the e-learning application should be able to handle a magnitude of different subject matters, for example: Mathematics, Programming Languages, Philosophy, Science, etc. According to McGraw (2001) an e-learning model should address the creation of content that makes learning compelling, engaging and relevant to target audience needs. This means that content should be updated regularly and should be maintained constantly.

The second element, *pedagogy,* includes the teaching methods that are used by the facilitator of the e-learning environments. MacDonald, et al. (2001) states that the use of new education technology have asserted that effective instruction with technology should be driven by sound pedagogical principles, involve critical thinking, and provide a real community to learners. According to Govindasamy (2002) most of the pedagogical principles that apply to the traditional classroom delivery method also apply to e-learning, but should be extended to accommodate and provide for the rapid changes in technology. Although available pedagogical theories are recognised and accepted, the focus of this study is not the pedagogical theories.

The third element is *technology*, which includes the hardware and telecommunication devices needed to develop and run an e-learning environment. McGraw (2001) states that an e-learning model should address a standard driven technology architecture that can link to existing systems and be accessed efficiently, while according to MacDonald, et al. (2001) the increasing quality and availability of technology, e-learning has become rapid, effective, flexible, and convenient. This indicates that technology should be recognised as an important aspect of an e-learning strategy. In order to deliver effective e-learning programs, educators need to become proactive in the development and use of technology in the teaching process and that an appropriate model would acknowledge and maximise technology to inform the teaching-learning transaction (MacDonald, et al., 2001).

The fourth element, *support*, covers the action *behind the scenes* to help an e-learning environment run effectively. Lack of technical support is often seen as a barrier to designing, developing, and delivering web-based learning (Daugherty & Funke, 1998). Support should be provided to facilitators as well as learners (Govindasamy, 2002; McGraw, 2001). Polyson, Saltzberg and Godwin-Jones (1996) states that there will be technical problems to resolve and it is therefore critical that both instructors and learners have technical support available to them. Harwood and Miller (2001) agree with this by saying that technical support in the form of online help materials and other documentation should be provided to instructors and learners. Once e-learning is ‘up and running’ there is a continued need for technical support and should therefore not end with implementation. Each potential benefit of web-based learning depends on skilful development coupled with immediate, knowledgeable maintenance (MacDonald, et al., 2001).

The fifth element is *interaction.* Berge (1999) defines interaction as the two-way communication among two or more people within a learning context, with the purpose of either task/instructional completion or social relationship-building, that includes a means for instructor and learner to receive feedback and for adaptation to occur based upon information and activities with which the participants are engaged. To use this definition in an e-learning environment it should be adjusted to include the interaction between the learner and the e-learning environment and with each other. Not only does computer-mediated communication and the World Wide Web allow significantly faster interaction between learner and instructor and among learners (Berge, 1999), it also provides for the immediacy and range of interaction comparable with face-to-face learning by means of whiteboards, chat rooms, newsgroups and the like (MacDonald, et al., 2001). Macpherson (2002) agrees with this statement, but found that most students only access e-learning courses to download material in order to read it offline. This shows that students will manipulate the e-learning environment to meet their own needs.

Closely associated with the perceived advantages of e-learning is the lack of systematic evaluation (Macpherson, 2002). Therefore, the last element is *continuous evaluation.* With basic evaluation processes focusing on the number of hits on e-learning environments, computer-based tests and reduced costs, the holistic evaluation required to measure real institutional impact is significantly lacking (Macpherson, 2002). A common problem with evaluation is the fact that most evaluation processes in an e-learning model focuses only on easy-to-collect quantitative data. However, according to Hicks (2000) the investment is significant in time, cost, and effort, but there is also a need to evaluate validity, viability, reliability, and learner satisfaction to provide feedback to designers and to assist in e-learning strategy development. This is echoed by Anido, et al. (2001) when they state that as in every other software development process, feedback from users is necessary to tune up the best possible platform.

2.2.3 Requirement 3: Modular system

Modularity is one of the key features of e-learning models, according to Harwood and Miller (2001). Modularity suggests that each e-learning environment can be divided into separate modules that can operate essentially independently, but when used in conjunction with other modules constitute the complete e-learning environment.

2.2.4 Requirement 4: Subject independence

The model should include generic characteristics to enable development of e-learning environments over the widest possible spectrum of subject material. Thus, the content developer should be able to use the model to develop a learning environment for a *variety of subject matter*, whether it is theory-based (for example history) or practical-based (for example a software programming course). Ismail (2002) states that the focus of e-learning content will move away from Information Technology and will move from creating and delivering large inflexible training courses toward producing database-driven learning objects that can be re-used, searched, and modified independent of their delivery media.

2.2.5 Requirement 5: Performance

The evaluation process should provide data on defensibility, flexibility, interactivity, convenience, and collaboration (MacDonald, et al., 2001), which can be analysed to determine the performance of the e-learning environment. According to Cloete and Schremmer (2000) an e-learning environment that display efficiency, simplicity, and quality will attract the most students and will be more likely to survive the competition. Harwood and Miller (2001) highlight accessibility, interoperability, communication/collaboration, flexibility, usability, robustness, and ease of use as key performance elements. The following elements where chosen to use as performance measurements to be used in the criteria to evaluate the models:

- *Collaboration*: MacDonald, et al. (2001) feels that full collaboration of teachers and technical professionals has been suggested as a means (even a necessity) for achieving a high-quality e-learning environment. Collaboration takes place by means of, for example, bulletin boards, e-mail, chat, and file sharing.
- *Usability*: According to Cloete and Kotze (2002) usability in an e-learning environment is concerned with interface aesthetics and consistency. Harwood and Miller (2001) agree with this and add that the interface should not only be consistent, but also intuitive.
- *Accessibility*: Harwood and Miller (2001) suggest that an e-learning environment should be accessible from all platforms.
- *Flexibility*: Flexibility refers to how adaptable the e-learning environment is for making changes needed to satisfy technical, instructional and stakeholder needs. For example, a flexible e-learning environment can be programmed to satisfy a wide scope of design specifications, and is well suited for integration with existing legacy systems (Luca & McMahon, 2000).
- *Interoperability*: The ability to be customised by adding features, supports the presentation and integration of learning objects, and connect with other environments (Harwood & Miller 2001).
- *Robustness*: Robustness implies system stability and an ability to withstand difficult conditions. According to Luca and McMahon (2000), for an e-learning environment to work, it should be robust enough to accommodate the number of learners enrolled, while still being cost effective

to the organisation. It is also important that the e-learning environment supports the instructional aims of the project, and that it accommodates the skills and capabilities inherent in the implementing organisation. Factors that may influence the robustness of the e-learning environment include technical issues, instructional and content issues, and user issues, all of which should be addressed in the development of the e-learning environment.

2.2.6 Requirement 6: Quality assurance

Successful implementations of e-learning environments depend on the perceived quality of the system (Cloete & Schremmer, 2000), and although it is difficult to define, its importance is generally valued (Garvin, 1988). It is important to note that quality is not just about zero defects; improving the performance and style of an e-learning environment are important factors (Deming, 1994). McGraw (2001) states that a standard-driven technology architecture, which can link to existing systems and can be accessed efficiently, should be included in an e-learning model. According to MacDonald, et al. (2001) consumers in all learning programs demand high-quality content, high-quality delivery, and high-quality service. An important part of achieving this demand for quality is to plan for quality, that is, to plan those activities that will help to achieve quality (Gustafson, 2002). Another way to assure that the quality of the finished e-learning environment is to ensure that the processes used to create it is of a high quality (Nichols, 2002). It is clear to see that quality consists of many different elements. For e-learning environments, the following should be addressed (based on Garvin, 1988): performance, features, reliability, conformance, durability, serviceability, aesthetics, and perceived quality.

2.2.7 Requirement 7: System fault reporting

An e-learning model should provide a capability to *report system faults* for analysis and corrective action purposes. A fault is usually defined as external behaviour that is different from what is specified in the requirements (Gustafson, 2002).

2.2.8 Requirement 8: Configuration management

The model should facilitate proper *configuration management* of all its inherent elements. Configuration management is the discipline of managing the evolution of e-learning environments during all stages of maintenance. Configuration management constitutes a key element of the software engineering process and includes many activities that should be carried out consistently. Moreover, it involves many different individuals, such as users, managers and software engineers as well as many different products such as management plans, specifications (requirements, design, test), code (source and executable), user's manuals, etc. Configuration management has four co-ordinating functions (IEEE 1987, IEEE 1990a, and IEEE 1990b):

- *Configuration identification*: The definition of the software cycle products that will be under control, their baselines and how they will change.
- *Configuration Control*: The technical and administrative procedures in order to control the changes to products.
- *Configuration Audit*: The function that makes the current status of any software product visible to management.
- *Configuration Status Accounting*: The function that provides the development history of any software product, recording the activities of the previous SCM functions.

In large-scale software systems the management of these activities is an extremely difficult work, but essential for effective and reliable evolution of such software (Psaromiligkos & Retalis, 2002).

Based on the established requirements, I will now propose a recommended structure for an EEDM. This structure is used as the basis for the development of the new model.

2.3 The basic structure of an e-learning environment development model

A literature study was conducted in which a number of models were chosen for analysis and evaluation. The particular models were selected because they share certain characteristics and are comparable with each other. This was done to ensure that the model that is developed in this study is based on a scientific analysis of, and comparison with, similar existing models. These models were then analysed to identify the primary *building blocks* used commonly in e-learning development models and to establish the basic structure of an EEDM.

While conducting the literature study I discovered that a few e-learning models were similarly structured. Thus, a model is typically developed in response to the requirements of the environment in which it is being developed, and is usually based on the perceptions of the developer/researcher of what the *best* structure for the specific model should be. However, it was established that most models are *structured*, and that certain common structural features are prominent in most models, even though these features are not always clearly defined in the models.

The existing models that are used in this study were selected for their potential to contribute effectively towards reaching the required results. The five models that were selected are the *Electronic Education System Model*, the *EcoSystem*, the *E-education Framework*, the *Demand Driven Learning Model*, and the *Open and Distance Learning Information System* model.

The *Electronic Education System Model* (EESM) that was developed by Cloete (2001) to address the shortage of scientific models, is the only model I found in the literature study that incorporates all the structural elements. I chose to use this model as the basis for the identification of the basic structure for EEDMs.

For the purposes of this study, the basic structural elements, or *building blocks*, of an EEDM that were identified, are:

- the *Infrastructure Building Block*, which addresses the hardware and system software infrastructure of the e-learning environment;
- the *E-learning Tools Building Block*, which addresses the specific tools, mechanisms, services, media, and support software that are used to develop and present the e-learning environment;
- the *Administration Building Block*, which addresses all administrative matters related to developing, implementing, and managing an e-learning environment;
- the *Instructional Interfacing Building Block*, which addresses the incorporation of the instructional material into the e-learning environment, and the methods and procedures of enabling effective interaction between the e-learning environment and the e-learner; and
- the *Quality Assurance Building Block*, which addresses matters related to the continuous evaluation and quality control of the e-learning environment.

The five existing models that are the subject of this discussion are described in this chapter in relation to the EEDM *building blocks*, to establish their level of compliance with the building blocks. However, the models are also tested for their potential contributions towards the evaluation criteria for e-learning development models.

In the next section an overview of each of the chosen models is given and I show how each of the models compares to the building blocks established above.

2.4 Overview of existing e-learning models

According to Ismail (2002) the great majority of institutions have only begun to search for ways to build and maintain ongoing capabilities in e-learning. Many of the reported e-learning implementations are activities that were planned according to the institution's needs and available technologies, rather than being based on a sound scientific model or plan. This is largely due to a lack of availability of such models, or possibly the lack of wide publication of these models.

This lack can be explained by applying Moore's technology adoption curve (Moore, 1995) to the e-learning domain. The curve, as reproduced in Figure 3, shows that when e-learning was first introduced, most institutions made use of their own capabilities to develop e-learning environments. Few or no standards and development models were available. After this initial period, the chasm follows where one or two developers took the initiative to develop *de facto* standards. This chasm, or development period, is followed by a large increase in the number of users of the newly developed standards, while others will wait even longer for more *evidence* of widespread implementation of the e-learning standards. Lastly, the *laggards*, or latecomers, are pressured by amongst others, market forces, to adopt the e-learning standards.

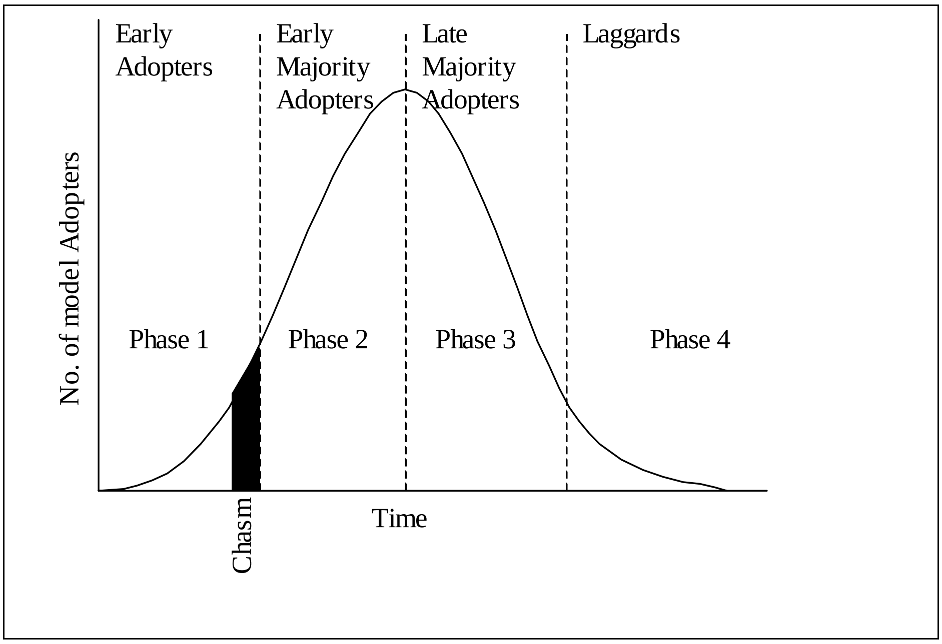

Figure 3: Adapted from Moore's Technology Adoption Curve (Moore, 1995)

2.4.1 Electronic Education System Model

Cloete (2001) proposes the *Electronic Education System Model* (EESM) to address the shortage of scientific models that can be used as framework to design and implement e-learning classrooms. Due to the apparent lack of such models, designers of e-learning classrooms repeat the same mistakes and are frustrated by the seemingly difficult and complicated process to develop and implement e-learning classrooms with a smaller chance of operational failure. This frustration often results in the perception that e-learning fails to be a successful learning delivery method.

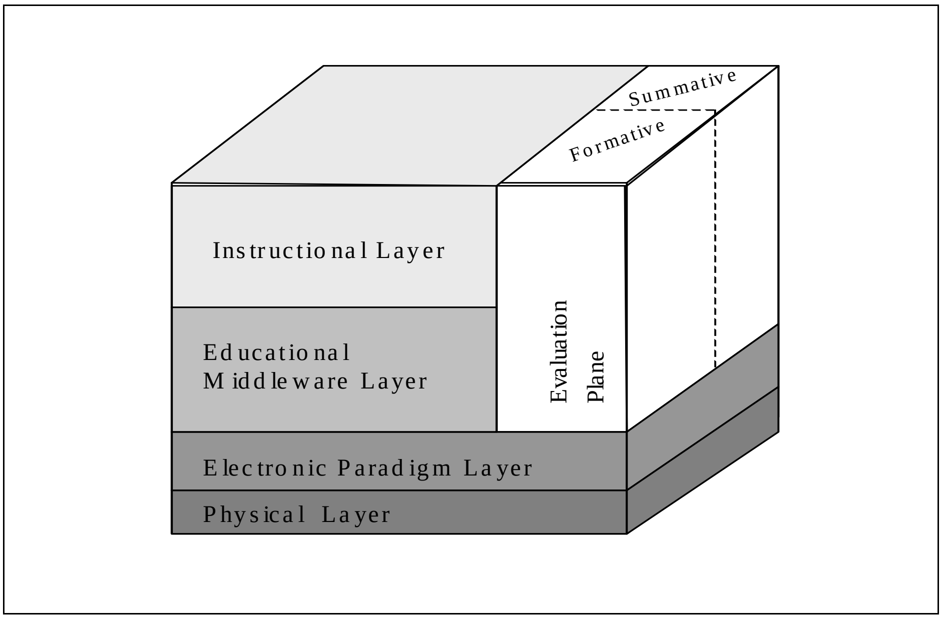

Figure 4: Electronic Education System Model (Cloete, 2001)

The EESM is a layered model that consists of four layers and an evaluation plane. Each of the layers can be viewed as a subsystem. The layers are the *instructional layer*, the *educational middleware layer*, the *electronic paradigm layer*, and the *physical layer*, and are presented graphically in Figure 4. In relation to the e-learning model building blocks, the four layers and evaluation plane correspond to the building blocks as given in Table 2.

Table 2: Comparing EEDM & EESM building blocks

EEDM Building Block	**EESM Layers and Plane**
Instructional Interfacing	- Instructional Layer
Administration	- Educational Middleware Layer
E-learning Tools	- Electronic Paradigm Layer
Infrastructure	- Physical Layer
Quality Assurance	- Evaluation Plane

Each layer offers specific services. These services, such as *course communications, course assessment*, and *course delivery* are depicted as objects. Each object offers different methods to meet its objectives. For example the *course communications* object can have methods such as e-mail, disk, phone, etc., and the *course delivery* object can have methods such as the Internet, CD, paper, et cetera. The model proposes a flow of work between objects on the same layer and also between objects on different levels, which is known as the *workflow structure.*

The instructional layer

The *instructional layer* serves as a window between the learner interacting with the e-learning system to gain knowledge, and the components that are needed to make up the learning situation. Objects that can be identified in this layer may include, for example, the *course communication*s object, which provides the means necessary for the communication between learners and their facilitator and for communication and co-operation between learners. When designing a specific learning situation, the designers may, for example, decide to include only e-mail for *course communication*s or add telephone and *chat facilities* to provide a bigger variety of options for the communication environment. This paragraph indicates that an e-learning environment should consist of a number of components.

The educational middleware layer

The second layer is the *educational middleware layer*, which provides the services required to ensure a reliable and effective learning environment, which indicates that performance monitoring should be included in an e-learning environment. This is achieved by supplying a set of tools to support educational programmes. These tools include managing access for retrieval of courseware, authorising data entries to the server, providing a central repository structure for course material (with efficient storage mechanisms optimised for different media types, with indexing), and retrieval facilities. Three major functions on this level include:

- the provision of an integrated user interface with the objective to buffer the learner form the technology behind the content,
- the establishment of technologies that enable electronic submissions of assignments for automatic assessment and grading, and
- the integration of the learning environment with other institutional systems.

The electronic paradigm layer

According to Cloete (2000) the objective of the *electronic paradigm* layer is to provide an electronic learning paradigm that is composed of different technological strategies. These strategies form the foundation for the specific learning situation. For example, the technological infrastructure may require a permanent Internet connection. In this case, the *electronic paradigm* requires a *synchronous* connection with software that can handle the permanent connection. In *synchronous* learning environments learners and facilitators are geographically separated, but share a virtual classroom within the same physical time frame. *Methods* for the *synchronous* object in this layer include, for example, media devices that link the facilitator and his/her learners in real time, such as chat rooms or videoconferencing. These indicate that an e-learning environment should consist of a number of components.

The physical layer

The last layer is the *physical layer*, which refers to the hardware infrastructure and operating system that are responsible for the transparent transmission of messages between learners and facilitators. This layer includes the specification of hardware and software technology objects necessary to support e-learning. Hardware consists of items such as the main computer server, network cabling, and network hubs, while software includes elements such as the network operating system, the host software, and system protection (anti-virus) software. The above paragraph indicates that an e-learning environment should consist of a number of components, as well as include performance and configuration management.

The evaluation plane

The model includes an *evaluation plane* that spans over the two top layers (the *instructional* and *educational middleware* layers), which indicates that quality assurance should be included in an e-learning environment. The *evaluation plane* determines whether methods that were selected from the *instructional* and *educational middleware* layers are accomplishing the required objectives. Evaluation is essential because it identifies the strengths and successes, as well as the weaknesses and failures that may exist in the instructional process. Cloete (2000) includes both *formative* and *summative* evaluation in the EESM. *Formative evaluation* is performed during the life of the instruction process and *summative evaluation* takes place at the completion of the instructional process.

To develop an e-learning system by using this model, one of two algorithms (*top-down* or bottom-*up*) can be used. The choice of algorithm will be determined by the circumstances at the particular institution where the model is to be used and indicates the use of project management in the e-learning environment.

The *top-down* approach is used when there are no restrictions to the options available in the *physical layer.* The design team starts by selecting objects and methods from the *instructional layer* that are to be incorporated in the design. Subsequently, related objects and methods in the *educational middleware layer* are selected which support the previously selected objects. The same is done with the *electronic paradigm layer* and the process ends with the selection of the relevant objects and methods in the *physical layer*. For example, if the *video-conferencing* method is chosen (*course communication* object on the *instructional layer),* and the *specialised virtual classroom software* method from the *interface* object on the *educational middleware layer*, it suggests the selection of a *synchronous paradigm* object from the *electronic paradigm layer* with a *permanent connection* object for the *physical layer*.

The bottom-up approach is suitable for situations where limitations exist in the available selection of objects and methods in the *physical layer*, which forces the process to start at this layer. Limitations include, among others, restricted Internet access. According to the *bottom-up* approach, the appropriate objects and methods are selected from the *physical layer,* followed by the related objects and methods from the *electronic paradigm layer*. The relevant objects and methods from the *educational middleware layer* are selected next, and finally, the necessary objects and methods from the *instructional layer* are selected. For example, if Internet access is limited, and in contrast to the top-to-bottom approach, one of the first steps will be to select hardware and software technology objects from the *physical layer* that will support *asynchronous* learning. This means that the *asynchronous paradigm object* should first be selected from the *electronic paradigm layer*, after which, for example, the *downloads on web page object* will be selected from the *educational middleware layer*, and lastly the *web page method* from the *course communication object* will be selected.

Both approaches end with the selection of the relevant and appropriate objects and methods from the *evaluation plane*.

A workflow is established between each set of layers, because each layer is supplied by a set of services that are assembled from the selected objects in the layer just below the current layer, except for the bottom layer.

2.4.2 The EcoSystem

During the development of a training system used by facilitators in the United Kingdom, a need was recognised to move from creating and delivering large inflexible training courses towards producing database-driven learning objects that can be re-used, searched, and modified independent of their delivery media (Ismail, 2002).

The *EcoSystem* model that is suggested is a conceptual model representing the information flow and interfaces between various modules, and the interaction between main processes and the learning value chain. The model's framework provides a means to systematically visualise and mould e-learning systems while retaining the capability to interact effectively with other applications and their content.

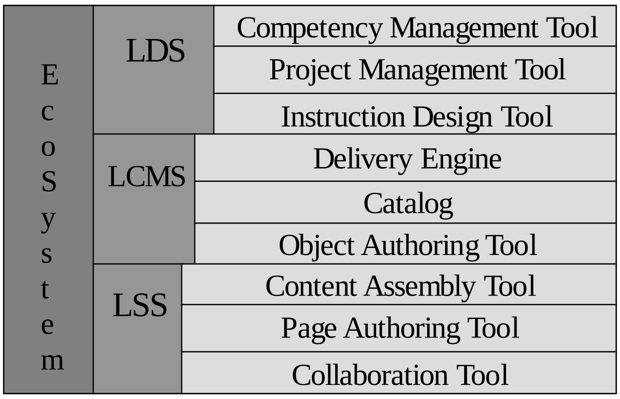

Figure 5: The E-learning Ecosystem (Adapted from Ismail 2002)

This model consists of three levels and a procedure to manage the learning process. The three levels are a) the *learning design system*, b) the *learning content management systems* and c) the *learning support system*, and are shown in Figure 5. In relation to the e-learning model building blocks, the EcoSystem components correspond to the building blocks as follows:

Table 3: Comparing EEDM & EcoSystem building blocks

E-Learning Model Building Block	**EcoSystem Components**
Instructional Interfacing	- LSS (Content Assembly Tool, Page Authoring Tool, Collaboration Tool) - LCMS (Delivery Engine, Catalog, Object Authoring Tool))
Administration	- LDS (Competency Management Tool, Project Management Tool)
E-learning Tools	- LDS (Instruction Design Tool)
Infrastructure	- *(None)*
Quality Assurance	- *(None)*

Learning design system (LDS)

The LDS allows content producers to quickly analyse and design instructionally sound learning programs. It also provides a project management capability that incorporates an instructional design methodology of choice. The purpose of the LDS is to produce a storyboard and flowchart of the complete structure of the final e-learning environment. This structure should consist of learning objects that can be used by content developers to develop instructional material.

Instructional design tasks are embedded into a project management tool to allow tasks to be assigned and tracked. This approach enables developers who are not trained in instructional design principles to adopt and follow a good instructional design methodology in producing learning materials. When supplemented by templates, this approach allows content developers to adequately plan and execute the development of their e-learning project.

It can thus be said that the LDS makes use of three tools:

- the competency management tool, which ensures that the objectives of the system are met,
- the project management tool, in which the instructional design tasks are embedded, and
- the instruction design tool, which shows the objects that can be used by the next level when designing course content.

The above paragraph indicates that an e-learning environment should include project management, modularity and performance management.

Learning content management system (LCMS)

The primary role of the LCMS is to provide a collaborative authoring environment for creating and maintaining learning content. The system consists of a delivery engine, a catalog, and an object-authoring tool, and has four functions. The first function is to capture knowledge in the institution. Secondly, it structures the knowledge into focused, directed learning programs. Thirdly, it incorporates third party content and lastly, it achieves updates, dissemination, management, and utilisation of knowledge throughout the institution. This paragraph indicates that an e-learning environment should consist of a number of components.

Within the LCMS, workflow processes can be activated to co-ordinate collaborative authoring of learning content. Subject matter experts and content developers use the LCMS to develop content, while media developers could add interactive materials and multimedia elements. Finally, editors would use the LCMS to review and approve the submitted objects. This paragraph not only indicates that an e-learning environment should consist of a number of components, but that it should be subject independent.

Traditionally, a single person, usually the facilitator, would have performed such activities. An LCMS provides a structured framework to manage the content development process where more than one person is involved in the development process. If delivered as a web application, content can be created and assembled from multiple remote locations. Revision tracking, task notification, and check-in/check-out facilities provide content developers with a means to collaborate in a systematic manner. This paragraph indicates that an e-learning environment should be modular. This indicates that an e-learning environment should include configuration management.

The LCMS bridges the gap between authoring tools and Learning Management Systems (LMS). An LMS is software that automates the administration of learning events. It registers users, tracks courses in a catalogue, records data from learners and provides reports to management (Schafter, 2001). The LCMS, on the other hand, provides the developer with the tools and functionality that are required to produce and manage effective learning content. Oakes (2002) states that the main aim of an LCMS is managing the content and providing that content to the user more efficiently and more dynamically. He goes further to define the components that a good LCMS need:

- authoring and content creation capabilities,
- support for a wide variety of content formats,
- robust model for creating and managing learning objects,
- scalable object repository (the database where objects and records gets stored,
- good search and browse capabilities,
- ability to personalise delivery of content, and
- detailed tracking and reporting capabilities.

This indicates that an e-learning environment should consist of a number of components, be subject independent and include performance management.

Learning support system (LSS)

An LSS is a web-based environment for supporting teaching and learning activities. The LSS makes use of a) the content assembly tool, b) the page-authoring tool, and c) the collaboration tool that includes threaded discussions, synchronous messaging, and shared whiteboards. This paragraph indicates that an e-learning environment should consist of a number of components.

Learning and the needs associated with supporting learning evolve and change over time, and so should learning systems. This indicates that an e-learning environment should include configuration management. The reference architecture provided by this framework allows an institution to progressively select and construct systems depending on requirements and budget.

In addition, this framework provides a means for institutions to systematically envision and construct their e-learning systems while maintaining interoperability with third party applications and content. This indicates that an e-learning environment should be subject independent and modular.

2.4.3 An E-education Framework

The E-education framework that is presented by Motiwalla (2000) assists facilitators in understanding how to utilise the Internet, Intranet, and Extranet to develop and deliver e-courses effectively. It uses the e-commerce frameworks that are used by many corporations to enhance their businesses. The framework is used as a guide to plan the effective delivery of course materials, as a tool for interaction between faculty and learners, for other administrative support functions - to enhance the learner learning process, and to ultimately design and implement the e-learning environment. Motiwalla (2000) states clearly that it is not the *Golden Rule* for all e-course designs and it does not cover all Web applications.

External		Internal		
Cell 1	Course Syllabus Course Promotional Material Instructor Contact Information College/University Information	Cell 4	Assignments Class Bulletin Boards Ticker Tape Course Notes & Presentation Slides	Informational
Cell 2	Global Chat Rooms on course related topics Usenet, Listserve for student discussions across courses/campus	Cell 5	Chat Rooms Conferencing Boards Group Touring White Boards, Hand-raising & other Collaboration tools Online Exams	Collaborational
Cell 3	Registration Application Forms Online Payments Transcripts Processing	Cell 6	Course Support Material Course Assessment & Grading Student Performance Tracking Digital Library	Transactional

Figure 6: E-education Framework (Motiwalla, 2000)

This framework is divided into two dimensions: 1) the *horizontal dimension*, which views the applications within the framework relative to the three major functional areas of the Web, which are informational, collaborational and transactional, and 2) the *vertical dimension*, which views the applications relative to the Internet Firewall technology, which divides it into external and internal applications. The model is shown in Figure 6. In relation to the e-learning model building blocks, the two dimensions, and their contents, correspond to the building blocks as follows:

Table 4: Comparing EEDM & E-education Framework building blocks

E-Learning Model Building Block	E-education Framework Cells
Instructional Interfacing	- Cell 2 (External, collaboration) - Cell 4 (Internal, informational) - Cell 5 (Internal, collaboration)
Administration	- Cell 3 (External, transactional) - Cell 6 (Internal, transactional)
E-learning Tools	- Cell 5 (Internal, collaboration) - Cell 6 (Internal, transactional)
Infrastructure	- *(None)*
Quality Assurance	- *(None)*

Vertical categories

The *vertical dimension* addresses e-learning applications in terms of Internet Firewall technology, by making use of the same criteria to divide applications into two categories. This dimension is divided into an *internal* category and an *external* category. The *internal* category is only open to registered learners, while the *external* category can be accessed by anyone. This dimension also separates Internet-course applications from Intranet-course applications. This paragraph indicates that an e-learning environment should consist of a number of components and that it should include performance management.

Horizontal categories

The *horizontal dimension* addresses e-learning applications in terms of the major functional areas of the Web, and is divided into three categories.

The first category is the *informational* category, which consists of web sites that only publish static information and are used, for example, for marketing and educational purposes. This indicates that an e-learning environment should consist of a number of components.

The second category is the *collaborational* category that is made up of web sites that provide sophisticated integration of the internal networks for operation of GroupWare and other interaction applications. They enhance internal collaboration and co-ordination activities. This paragraph indicates that an e-learning environment should consist of a number of components and that it should be modular.

Finally, the *transactional* category is responsible for the two-way interaction between the learner and the e-learning system, and the security and authentication of the web sites. These are technically sophisticated web sites. This paragraph indicates that an e-learning environment should consist of a number of components and that it should include quality assurance measures.

The framework cells

The intersections of the *vertical* and *horizontal dimensions* form the basis of the framework and consist of six major areas, known as *cells*. The cells are ordered and are numbered from one to six. The methods used in each cell grow in sophistication from left to right and from top to bottom. This means that cell one has minimal technological sophistication while cell six allows for highly sophisticated implementations.

Cell one requires only basic HTML editors. Cell two requires the applications used in cell one with the addition of software such as Usenet (www.usenet.com) and Listserve (www.Listserve.com). Cell three requires all the applications of cells one and two; together with e-commerce-type applications, that requires the minimum of administrative overheads. Cells four to six require restricted access to sensitive course materials. This paragraph indicates that an e-learning environment should consist of a number of components.

2.4.4 The Demand Driven Learning Model (DDLM)

This model presented by MacDonald, et al. (2001), was developed as a collaborative effort between academics and experts from private and public industries. It is presented as a tool to harmonise and join academic efforts and sets a high standard for web-based learning programs. The DDLM is founded in consumer demands for quality content, delivery, and service that lead to desired learner outcomes.

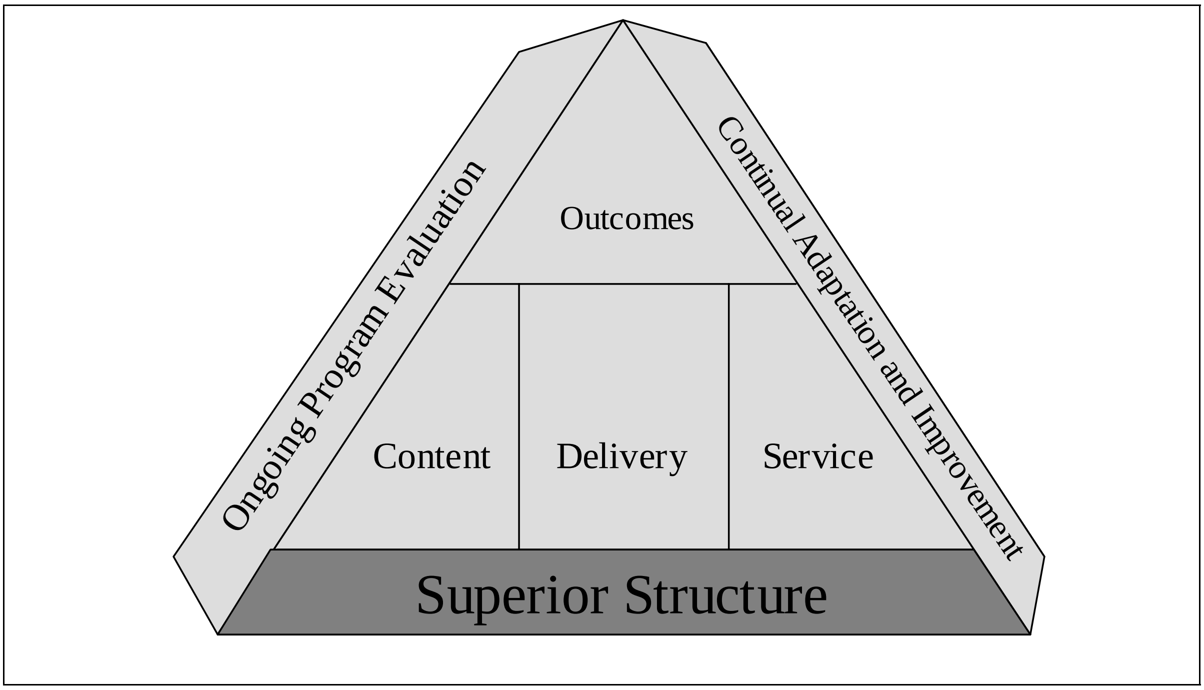

Figure 7: Adapted from the Demand Driven Learning Model (MacDonald, et al., 2001)

The model consists of three main constructs: a) *superior structure* b) *consumer demands*, and c) *learner outcomes*. The *consumer demands* construct is subdivided into *content*, *delivery* and *service* as is shown in Figure 7. In relation to the e-learning model building blocks, the DDLM constructs, and their elements, correspond to the building blocks as follows:

Table 5: Comparing EEDM & DDLM building blocks

E-Learning Model Building Block	**DDLM Constructs and Elements***
Instructional Interfacing	- Superior Structure - Consumer Demands (Content)
Administration	- Consumer Demands (Services)
E-learning Tools	- Consumer Demands (Delivery)
Infrastructure	- Consumer Demands (Services)
Quality Assurance	- Ongoing Program Evaluation - Continual Adaptation and Improvement

* Note: The *Learner Outcomes* construct identifies objectives for the e-learning environment, rather than constructive building block elements for the e-learning development model, and is therefore not listed in this table.

Superior structure

The *superior structure* is the required foundation that makes it possible to provide high quality content, delivery, and service, and is proposed by MacDonald, et al. (2001) as standard for web-based learning. In the DDLM, a *superior structure* is achieved by anticipating the needs of the learners and considering what motivates learners. This requires a collaborative and productive learning environment that has convenient access and where curricula are designed according to program objectives. The quality of web-based learning is monitored through a system of regular evaluation of learners. The following considerations define superior structure: a) anticipation of learner needs, b) learner motivation, and c) the establishment of a collaborative, productive learning environment. This paragraph indicates that an e-learning environment should consist of a number of components.

DDLM-based programs meet the specific needs of individual learners by meeting the demands of learners for content, delivery, and service. For example, programs are tailored to a learner's needs for specific content, media, and applications of technology. Programs also address individual learning styles and preferences, background experience, and knowledge, while providing appropriate assessment and feedback.

DDLM-based programs take into account what attracts and retains a learner's attention and are structured to present relevant content that stimulate learners perceptually. This involves aesthetically pleasing presentation and technology that is innovative and interactive.

Learners also want:

- to be intellectually stimulated,
- to see the relevance and value of what is being learned,
- to feel confident about being able to complete a learning task, and
- to be challenged to find solutions.

The above paragraphs indicate that performance management should be included in an e-learning environment.

The DDLM emphasises the role of collaborative learning environments where knowledge evolves through social negotiation. The learning environment supports and encourages collaboration among learners and between learners and facilitators. The facilitators are considered equal partners in the learning community, not the centre of truth and knowledge, because they also learn in the collaboration process and can gain a heightened understanding of how learners are constructing their understanding (MacDonald, et al., 2001).

In DDLM-based learning programs, the Web site serves as an electronic performance support system, providing tools, resources, and support systems designed to fit the specific learning environment. Depending on what is needed in the environment, the site might contain a database of resources and information, a coaching and guiding system providing assistance with certain tasks, job aids, and administrative tools such as project management software. This paragraph indicates that an e-learning environment should consist of a number of components and include project management.

Consumer demands

The first of the consumer demands is *content*. MacDonald, et al. (2001) states that in the DDLM framework, high quality content is considered comprehensive, authentic and industry driven and well researched. For content to be comprehensive, it should cover all the information that consumers need to know. The information should be presented objectively and unbiased language should be used. Care should be taken that the content matches the consumer's level of understanding, and that it covers topics in appropriate breadth and depth. This indicates that an e-learning environment should be subject independent. To ensure content that is authentic and industry driven, the content designer should obtain direct input from industry professionals on topics such as current and future educational needs of employees and employers. This is necessary, because it ensures that course content faithfully reflects problems and issues that arise in the workplace. Content should be founded in accessible and validated empirical research. The content designer, to ensure that high quality prevails, should solicit input from both academia and industry. This indicates that an e-learning environment should consist of a number of components.

Delivery is considered a consumer demand because the DDLM assumes that learning programs are interactive and Web-based. High quality delivery is defined by the following:

- *Usability* – The user interface of DDLM-based programs is carefully designed and tested to ensure that it is usable. To ensure this, Web pages have strong navigational support and standard Web conventions are adhered to. Web page information is also kept up to date and no dead ends and stale links are allowed. Care is also given to use the appropriate Web page length and new Web technology is used only if it supports consumer needs.

- *Interactivity* – This is the interaction between learners, the learner and facilitator, and between the learner and the content. This interaction is perceived by MacDonald, et al. (2001) to be a critical aspect of delivery, and therefore DDLM-based programs are designed to ensure the incorporation of activities encouraging interactivity.
- *Tools* – The DDLM identifies technology as intellectual tool kits that help learners build interpretations that are more meaningful and representations of the world.

DDLM-based learning programs also divide *instruction* into clear sections, including: opening, information presentation, exercises, interaction, and closing. This gives learners a sense of pacing and completion. The time required to complete each section is monitored and adjusted as needed. The above two paragraphs indicate that an e-learning environment should include performance management.

A variety of media and communication tools are used to accommodate different learning styles and improve the total learning experience, by using a combination of text, graphics, video, and audio.

The type and degree of interaction required directly drive the selection of tools. DDLM-based programs incorporate tools that enable: a) content interactions, and b) social interactions. Content interactions are situations in which the learner interacts with the content of the course, experiences it, process it, and reflect on it. Social interactions refer to social interactions with other learners, as well as the facilitator about content. Tools for content interaction include: Video and audio clips, lectures through video conferencing, text documents, and journal presentations. Tools associated with social interaction include video conferencing, discussion groups, chat rooms, and e-mail. The above two paragraphs indicate that an e-learning environment should consist of a number of components.

The third demand is *service*. DDLM defines high-quality service as service that provides the resources needed for learning, as well as any administrative and technical support needed. Skilled and understanding staff that are accessible and responsive, support such service. DDLM service includes resources, administrative and technical support, staff, accessibility, and responsiveness. In DDLM-based programs, resources help learners determine what their learning needs are and how those needs can best be met. Learning resources are presented in a number of forms to allow learners to examine concepts from multiple perspectives. Resources also encourage learners to be reflective and aware of their own thinking and learning processes; such reflection, combined with how learners comes to view and incorporate new information into the context of their lives, promotes development. Finally, resources are chosen to encourage social negotiation, which allows insight, and the elaboration of concepts and ideas, to occur. This paragraph indicates that an e-learning environment should include performance management.

In DDLM-based programs, administrative and technical support is freely available. Learners receive a thorough introduction to the learning environment when they enter it. Support is provided to help learners use and access the systems supporting the learning environment. Moreover, learning facilitators and professors also have access to technical support, and these support personnel are selected for their experience and formal credentials. This paragraph indicates that an e-learning environment should consist of a number of components.

In DDLM-based programs, the learning facilitators and technical support personnel are qualified and experienced in their fields of specialisation. The learning facilitators create a positive learning experience for each learner and are empathic to individual learner needs. Technical supporters responsible for the design, development, and delivery of the learning environment, work as an effective team. Staff members demonstrate effective collaboration, respect for roles, and effective communication; they also share their expertise and have shared values (Meyen, Tangen, & Lian, 1999).

Access to services and staff is straightforward. Learning facilitators and technical support persons are available and easy to reach. Unconstrained access to services such as libraries, bookstores, and an extensive range of other learning resources is provided via Web links. This paragraph indicates that an e-learning environment should consist of a number of components.

All requests for service and help are met within a minimum amount of time. This is achieved by providing prompt feedback on assignments, fast responses to e-mails, and timely assistance. This indicates that an e-learning environment should include performance management.

Learner outcomes

Learner outcomes include:

- Lower costs for the learner, such as minimised travel expenses,
- Personal benefits for the learner, in that he or she does not experience the personal stress resulting from financial risk, leaving a job, or moving themselves or their whole family to be close to an academic institution, and
- Learning outcomes, by providing a program in which learners are satisfied with the learning experience and acquire new and relevant skills and knowledge, from which they can apply new knowledge and skills in their workplace, and add value to the services delivered by them.

The above paragraph indicates that an e-learning environment should include performance management.

Quality assurance in the demand driven learning model is implied through ongoing program evaluation, and continual adaptation and improvement of the e-courses. This indicates that quality assurance should be included in an e-learning environment.

2.4.5 The Open and Distance Learning Information System (ODLIS) model

Bouras, et al. (2000) developed the ODLIS model in answer to two problems that were identified with the development and implementation of e-learning systems. The first problem is the management of data in web-based applications, which have different characteristics and complexity, while the second problem is the difficulty of integrating different technologies and tools that support educational activities.

In this approach, all application sensitive information is stored in a relational database management system that provides the mechanisms for efficient indexing and ensures their consistency. Information that is more static is stored directly on the file system, while the database maintains annotation about the data elements and pointers to their location.

The ODLIS model is a web-based application, which runs over the Internet, using real time protocols, and provide virtual lectures, virtual conferences, and inter-institutional collaborative projects, amongst others. A system developed using the ODLIS model should be able to manage the educational material and users, as well as information that are useful to the educational procedure.

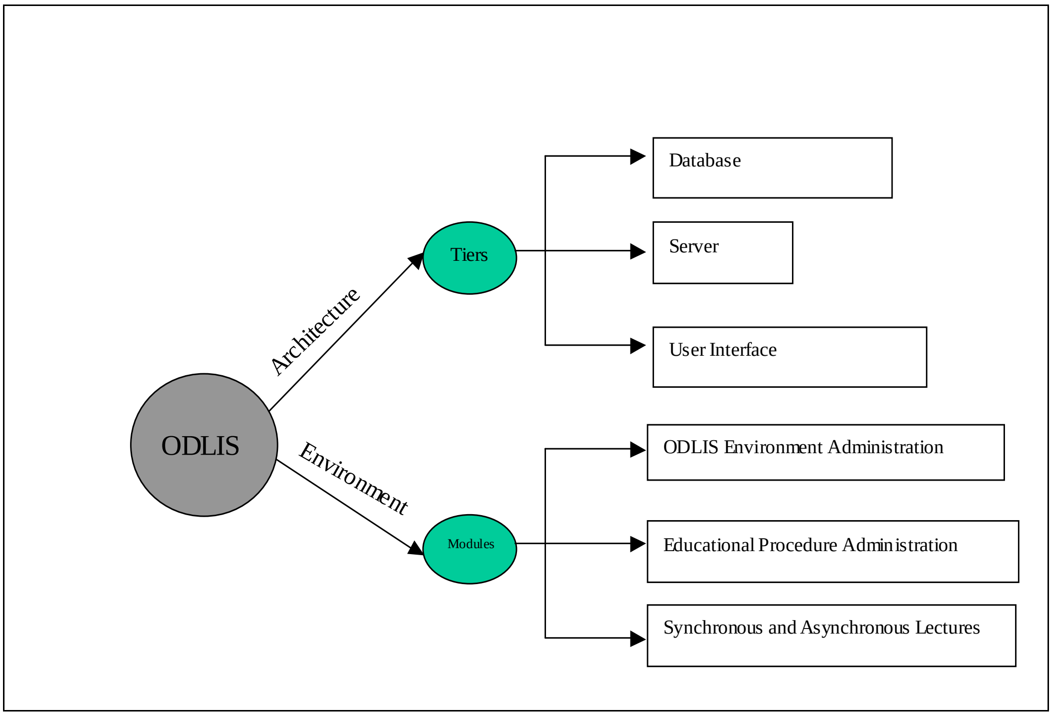

Figure 8: The Open and Distance Learning Information System Model (Bouras,et al., 2000)

The main aim of this model is to provide a wide range of related applications, instead of limiting the capabilities of the model to a specific operation.

The ODLIS model is based on the following concepts:

- An integrated communication environment that covers the communicational needs of a group of participants.
- A client-server model.
- Open platform architecture in order to support different operating platforms.
- Internationally accepted standards.
- Access through web pages.
- Object-oriented design and implementation.
- Modular scalability.

The model consists of an *architecture* and *environment* as shown in Figure 8. The *architecture* is based on a three-tier architecture model and the *environment* consists of three modules. The three tiers in the *architecture* are a) the *database,* b) the *server*, and c) the *user interface*. The modules of the *environment* include the *administration of the ODLIS system*, the *administration of the educational procedures* and the provision of *synchronous* and *asynchronous* lectures over the network. In relation to the e-learning model building blocks, the ODLIS elements correspond to the building blocks as follows:

Table 6: Comparing EEDM & DDLM building blocks

E-Learning Model Building Block	**ODLIS Elements**
Instructional Interfacing	- Architecture (Database) - Architecture (User Interface) -Environment (Educational Procedure Administration) - Environment (Synchronous and Asynchronous Lectures)
Administration	-Environment (ODLIS Environment Administration) -Environment (Educational Procedure Administration)
E-learning Tools	- Architecture (User Interface)
Infrastructure	- Architecture (Server)
Quality Assurance	- *(None)*

The architecture

The first of the three tiers of the *architecture* is the *database* that provides the initial information received from the users of the system. The second tier is the *server* that will process the information received from the database. The *user interface* is the third tier, which has a two-fold purpose. The first is the presentation of the results from the database to the users and the second is the interaction with the users of the systems. This paragraph indicates that an e-learning environment should consist of a number of components and that it should include performance management.

The environment

The first module of the environment is the *administration of the ODLIS system*, which serves two functions, namely the *administration of users* and the *administration of lessons*. This module provides capabilities to create, delete, or modify a lesson, the educational material of a lesson and the characteristics of a user. It also offers the capability to search the database of the ODLIS. The second module provides for the *administration of the educational procedures* and is responsible for the interaction between the learners and the facilitators, the submission of exercises, and the accessing of a file with the grades of each learner. The last module is responsible for the provision of *synchronous* and *asynchronous* lectures over the network. This makes it responsible for the interaction between learners and the facilitators during a synchronous lesson and for the attendance of the asynchronous lessons by the learners. This paragraph indicates that an e-learning environment should consist of a number of components.

This model was included to show that models exist that are developed for the design of one specific institution's learning environment and not as a generic model that can be used by any e-learning developer. This indicates that an e-learning environment should include performance management.

In the next section, a summary is given of the characteristics that are included in each of the discussed models.

2.5 Characteristics included in each of the models

In this section I will briefly show which of the requirements identified in section 2.2 are complied with by each of the models discussed in section 2.3. Table 7 gives a summary of all models and indicates which model adheres to which requirement.

Table 7: Summary of requirements met by models

	Project Management	Elements of e-learning	Modular system	Subject independence	Performance	Quality assurance	Report system faults	Configuration management
The Electronic Education System		Y	Y	Y	P	Y		
The EcoSystem	Y	P	Y	Y				
The E-education Framework		P	Y	Y				
The Demand Driven Learning Model		Y	Y	Y	Y	P	P	
The ODLIS Model		P	Y					
Y = Adhere to requirement P = Adhere to requirement only partially								

2.5.1 The Electronic Education System

No provision is made for project management (requirement 1) in this model. Through the different layers and the evaluation plane, this model addresses all the elements of an e-learning environment (requirement 2). The EES consists of layers that make it a modular system and which facilitates modification to suit different user environments. The use of objects further increases the modularity (requirement 3) of the Electronic Education System. It also has generic characteristics that is used to develop e-learning environments over a wide spectrum of subject material (requirement 4). Since the model evaluates deliverables of only two layers, decisions made concerning the other two layers cannot be evaluated or verified (requirement 5). No explicit provision is made for quality assurance (requirement 6). The model provides no mechanism to report any system faults (requirement 7). No provision is made for configuration control or management (requirement 8).

2.5.2 The EcoSystem

Project management (requirement 1) is included in this model as part of the Learning Design System. The EcoSystem addresses all the elements of an e-learning environment, except continuous evaluation (requirement 2). It is also modular (requirement 3), because it consists of three different levels, each consisting of different tools, and it can be used in different user environments. It is possible to use this model to generate an e-learning environment irrespective of the subject material (requirement 4). Evaluation (requirement 5) of the model's deliverables is not included in the model. No explicit provision is made for quality assurance (requirement 6), and no fault reporting mechanism is included in the model (requirement 7). No configuration management (requirement 8) is included in the model.

2.5.3 The E-education Framework

No provision is made for project management (requirement 1) in this model. The model addresses all the elements of an e-learning environment, except continuous evaluation (requirement 2). The model consists of a vertical and horizontal category that forms cells (or modules), which makes it a modular model (requirement 3). The E-education Framework can be applied on any subject material (requirement 4). No provision is made for evaluation of the model's deliverables (requirement 5). No explicit quality assurance processes (requirement 6) are included in models and no fault reporting mechanism (requirement 7) is included in the model. Further, no provision is made for configuration management (requirement 8) in the model.

2.5.4 The Demand Driven Learning Model

No provision is made for project management (requirement 1) in this model. The Demand Driven Learning Model provides for all the elements that are included in an e-learning environment, by means of layers and the ongoing evaluation activities (requirement 2). The model consists of three main constructs that are supported by the superior structure and continuous evaluation construct. This makes it a modular model (requirement 3). It can be utilised to implement any e-learning environment irrespective of the subject matter (requirement 4) and evaluation is covered by the continuous evaluation construct (requirement 5). Quality assurance (requirement 6) is addressed in the ongoing adaptations and improvement construct of the e-learning environment and the model provides for continual adaptation and improvement, which implies that there should be a mechanism to report faults in the e-learning environment. The existence and detail of such a mechanism are not reported in the description of the model (requirement 7). No configuration management is included in the model (requirement 8).

2.5.5 The ODLIS Model

No provision is made for project management (requirement 1) in this model. The ODLIS model addresses all the elements of an e-learning environment, except continuous evaluation (requirement 2). It consists of three tiers and three modules, which makes it modular (requirement 3) and is used for the development of an e-learning environment irrespective of the subject matter (requirement 4). No evaluation measures were developed for this model (requirement 5). No explicit quality assurance (requirement 6) processes are included in the model and no fault reporting mechanism is included in the model (requirement 7). No configuration management is included in the model (requirement 8).

From the above analysis, it can be seen that not one of the models adhere to all the requirements of an e-learning environment. The DDLM comes closest to meeting all the requirements. Of particular significance is the fact that none of the models adhere to the requirement of configuration management. I consider this as a definite shortcoming in the models.

2.6 Summary

In this chapter, eight requirements were established to which EEDMs should adhere to be considered a comprehensive EEDM. Five existing EEDMs, which are the Electronic Education System Model, the EcoSystem, the E-education Framework, the Demand Driven Learning Model and the ODLIS Model, were described and tested against each of the requirements. It was found that none of the models discussed adhere to all of the requirements, and that none of the models consider configuration management. It was found that the Demand Driven Learning Model adhered to most of the requirements.

In the next chapter, the knowledge gained from our literature study is used to identify criteria used in the evaluation of e-learning development models, and to develop and propose an EEDM that is based on scientific analysis and a structured approach.

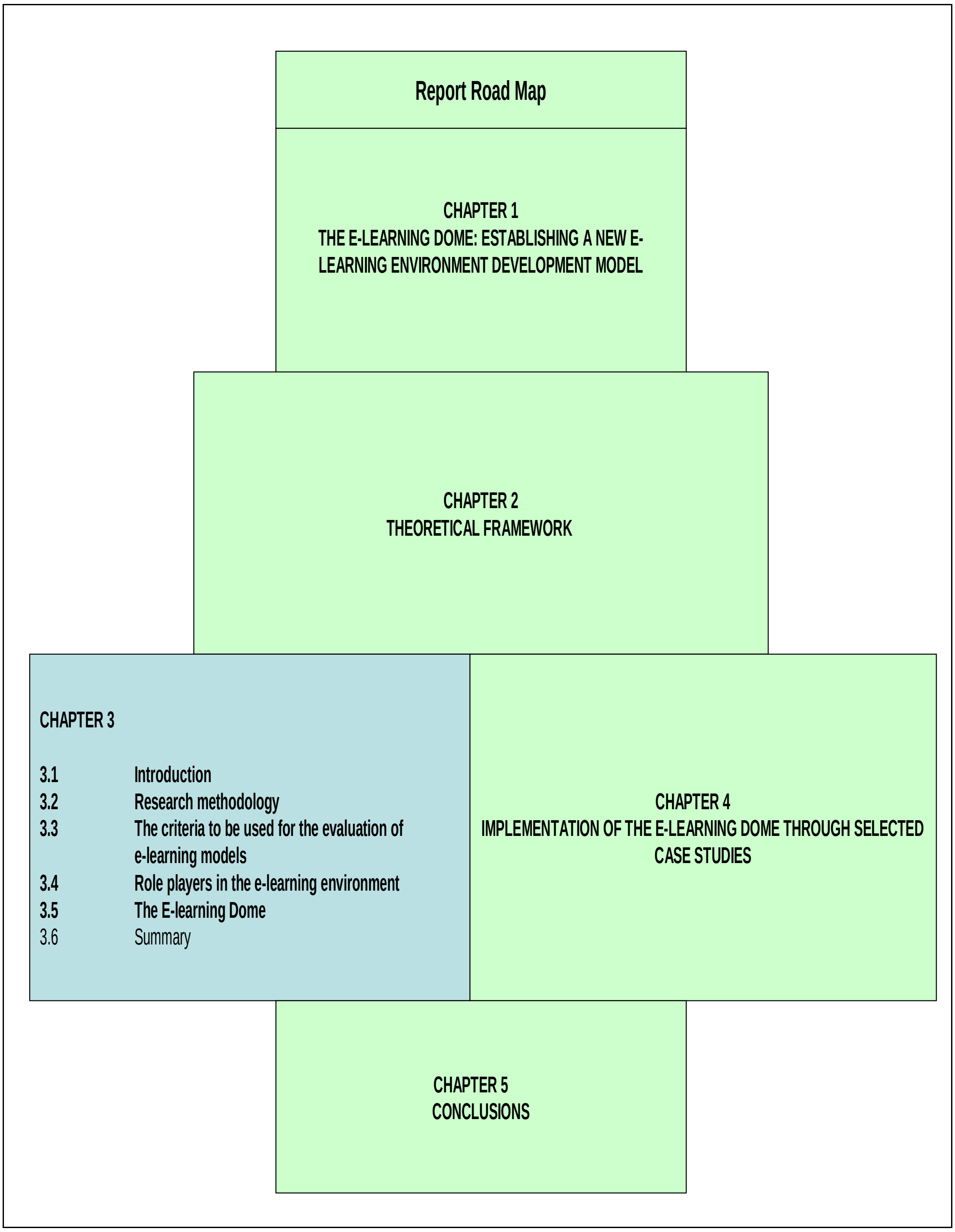

Figure 9: Layout of Chapter 3

3. The E-learning Dome: An e-learning environment development model

3.1 Introduction

In Chapter 2 the most common requirements for an e-learning model were established. The characteristics of 5 models were compared with the requirements identified and it was found that none of these models adhere fully to the requirements. To facilitate improved acceptance and usage of e-learning as an instructional medium, this study proposes an EEDM that addresses all the requirements, as established in section 2.2. For clarity, these requirements are summarized in section 3.3.

The key elements (identified in section 2.3) that an EEDM should include comprise of the following elements:

- an appropriate infrastructure,
- relevant management and administration processes,
- subject content, and
- a quality assurance process to ensure continued client satisfaction.

An e-learning model should consist of appropriate components to ensure that the e-learning course developer addresses all the necessary and required elements of the e-learning environment.

The research methodology used in conducting this research is introduced in section 3.2. Section 3.3 introduces the role players in the e-learning environment. In section 3.4 the model proposed is described in detail, and the chapter is concluded with a summary in section 3.5.

3.2 Research methodology

In terms of a research approach, this study is not a quantitative study which measures through numbers. Instead, my research is based on building and presenting a motivated argument, rather than measuring through numbers (Miles & Huberman, 1994). For this research, a qualitative methodology was used to develop and derive the new EEDM model proposed in this study.

The method used for discussions and evidence are given in Chapter 4 and a combination of interpretive research and grounded theory (Meyers, 1997) were used. Interpretive research in IS are aimed at producing an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context. Grounded theory is a research method that seeks to develop theory that is grounded in data systematically gathered and analyzed (Myers, 1997). This study includes a theoretical study, which was conducted to establish the requirements and contradictions, and interpretation was applied to the information obtained (Myers, 1997).

3.3 The criteria to be used for the evaluation of e-learning models

Using the requirements as identified in Chapter 2, the following criteria were identified.

3.3.1 Criteria 1: Project management guidelines and tools

The model should include a project management component to assist the institution with collecting, organising, managing, maintaining, re-using, and targeting instructional content (Ismail, 2002).

3.3.2 Criteria 2: Components of an e-learning environment

The model should include the following *elements of e-learning*:

- *Content*: the subject matter that will be presented in the e-learning environment.
- *Pedagogy*: the teaching methods that are used by the facilitator of the subjects.
- *Technology*: the hardware and telecommunication devices needed to develop and run an e-learning environment.
- *Support*: the action *behind the scenes* to help an e-learning environment run effectively.
- *Interaction*: the way in which all the programs work together and how the learner and facilitator communicate with the e-learning environment.
- *Continuous evaluation*: the evaluation of the e-learning environment by learners and facilitators to identify strengths and weaknesses.

3.3.3 Criteria 3: Modularity

The model should be engineered as a *modular system* to facilitate modification to suit different user environments.

3.3.4 Criteria 4: Subject independence

The content developer should be able to use the model to develop a learning environment for a *variety of subject matter,* whether it is theory-based (for example history) or practical-based (for example a software programming course).

3.3.5 Criteria 5: Performance

The evaluation process should provide data on defensibility, flexibility, interactivity, convenience, and collaboration (MacDonald, et al., 2001), that can be analysed to *determine the performance* of the e-learning environment.

3.3.6 Criteria 6: Quality assurance guidelines and tools

Quality assurance in accordance with, for example, the appropriate ISO 9000 modules should be included in the model.

3.3.7 Criteria 7: System fault reporting capabilities

The model should provide a capability to *report system faults* for analysis and corrective action purposes.

3.3.8 Criteria 8: Configuration management guidelines and tools

The model should facilitate proper configuration management of all its inherent elements.

In the next section the role players in the e-learning environment are addressed in order to show their involvement in the development of an e-learning environment.

3.4 Role players in the e-learning environment

From the previous section, we can draw the conclusion that the typical e-learning model focuses on the building blocks that make up an e-learning environment. The human element is not addressed specifically, but is assumed as a given (yet critical) entity in the e-learning environment.

For the purposes of this discussion, however, it is important to identify the various role players that are involved in the development and operation of an e-learning environment, and also to summarise their responsibilities and roles.

In the development phase, the primary role player is the organisation or institution that initiated the project, and which will eventually be the *owner* of the e-learning environment.

The *e-learning environment developers (EED)* usually consist of a team of people that is responsible for executing the e-learning environment development project. This team may typically be composed of technical specialists, instructional designers, subject experts and even the facilitators. It is, however, also possible that only one person can take the role of the EED and that this person can also play a number of other roles (for example, subject expert or facilitator). The EED is also responsible for implementing the e-learning environment at completion of the development phase, and may also be contracted to provide technical support during the operational phase. During the development phase, the EED may sub-contract specific tasks and responsibilities to other role players, persons or organisations.

The *facilitator* is the person who is responsible for the facilitation of the *educational* part of the e-learning environment. The facilitator is typically a subject specialist with training and/or educational experience.

The *learner* is the person for whom the e-learning environment is established and who participates as an *e-learner*, or student, in the e-learning process. Once registered, the learner is responsible for completing the course in order to obtain the qualification that is associated with the specific e-learning environment.

The *subject syllabus or course material owner* is the organisation or person who owns the copyright for the specific subject content for which an e-learning environment is to be developed. It is possible for the e-learning environment owner and the course material owner to be the same entity/person, but in the instance where an institution makes use of third party's content, the institution only pays for a license to use the content, while the ownership of the material stays with the third party.

Finally, the e-learning environment cannot be developed or applied in a vacuum, and *associated service providers* may be needed to provide specialist support elements for the e-learning environment.

3.5 The E-learning Dome

In compliance with the recommendations made in section 3.3 regarding the components of a typical e-learning model, and following the example of Cloete's model (2001), the *E-learning Dome* was developed as an e-learning model that consists primarily of *three* generic component layers, enclosed by a common quality assurance dome. The generic component layers are: 1) the Infrastructure layer as the foundation of the model, 2) the E-learning Administration layer, which is constructed on the foundation of the model, and 3) the Content Development layer which is supported on top of the Administration layer. Q*uality assurance processes* are included in the Quality Dome, which ensures the management of the quality of the e-learning environment in all the layers of the model. The E-learning Dome is shown graphically in Figure 10.

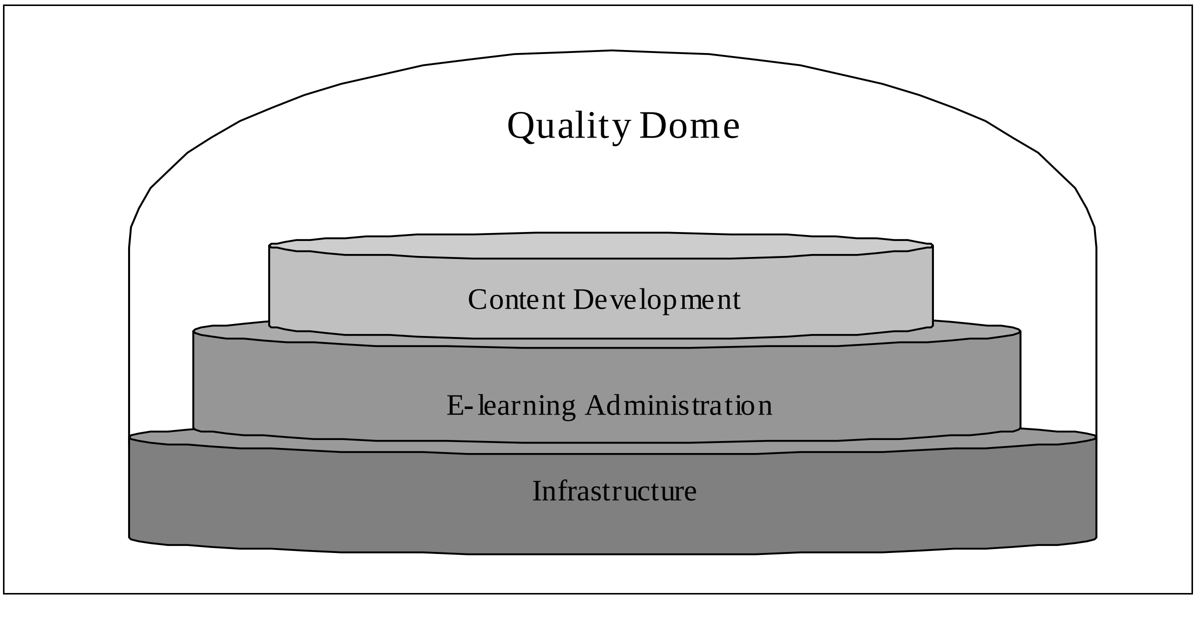

Figure 10: The E-learning Dome

Each of the four primary components of the E-learning Dome *(the Infrastructure layer, the E-learning Administration layer, the Content Development layer, and the Quality Dome)* consists of secondary components that have been selected from models described earlier. In addition, the secondary components were also selected to ensure that the E-learning Dome, as an e-learning model, addresses the requirements, and conforms to the evaluation criteria, that this study has identified and established.

The secondary components of the *Infrastructure* layer require the EED to: 1) identify relevant hardware to be used, 2) identify relevant software to be used, and 3) identify the required communication technology. These components form the backbone of the e-learning environment and define the borders (specifications) within which the *administrative* and *course* components should be established.

The secondary components of the *E-learning Administration* layer require the EED to address management and administrative matters and include:

- applying project management procedures during development of the e-learning course,
- applying configuration management procedures during development of the e-learning course and ensuring continued configuration management of the e-learning environment during operation,
- overseeing learner registration processes,
- establishing procedures for submissions by learners,
- establishing procedures for delivery to learners, and
- defining procedures for managing finances specifically related to the e-learning environment.

The secondary components of the *Content Development layer* require the EED to address the subject material of the e-learning course and include: 1) developing the e-learning course content according to selected content delivery and learner interaction mechanisms, and 2) developing assessment procedures for the specific course.

The secondary components of the *Quality Dome* require the EED to address the requirement for quality and include:

- applying quality control measures both during the development and during the operation of the e-learning environment,
- developing and applying system fault reporting procedures, and

- developing and applying procedures to take corrective action, when required.

In applying the E-learning Dome model to the development of an e-learning environment, either a bottom-up, or top-down, workflow approach may be followed. The bottom-up approach requires the EED to start the development process *Infrastructure* layer activities, proceed to the *E-learning Administration* layer activities and then complete the process by carrying out the activities from the *Content Development layer*. *Quality Dome* activities are continually performed throughout the development process.

The bottom-up workflow approach, as is used in this study, is typically applied when the e-learning environment is to be developed within specified infrastructure limitations. In this study, a bottom-up approach is used where the available infrastructure dictates the type of services that might be available to the upper levels. An example of where the bottom-up approach is suitable is in a situation where the available infrastructure includes only a low speed connection (bottom level of model) and care has to be taken when including multimedia features in course content (top level activity). Similarly the required infrastructure for software systems that provide support services (middle level activity) should not exceed the available capacity of the connection (bottom level service).

3.5.1 Infrastructure

3.5.1.1 Purpose of the infrastructure layer

The Infrastructure layer of the E-learning Dome model is used to guide the EED in identifying the hardware, software and communication technology components that are required to establish the appropriate *infrastructure* for the e-learning environment that is being developed (Khan, 2001).

In identifying the infrastructure, the EED should attempt to make use of modular components as far as possible to enhance the modularity of the e-learning environment. Each *module* of the infrastructure should be specified in sufficient detail to ensure correct interfacing between modules, and to allow for replacement of modules with equivalents.

It is beyond the scope of this study to provide an extensive list of available hardware, software and communication technology components that might be used in, or would be required to set up an e-learning environment. It is however, essential for the user of our proposed development model to appreciate the scope of the elements that are required to establish an effective infrastructure for an e-learning environment. Guidelines in this regard are given in the following paragraphs.

The EED identifies the infrastructure hardware, software and communication technology components that are required (defined as secondary elements). In addition the EED should also identify which of these elements are available at the site where the infrastructure is to be established and which elements are to be acquired. When this is done the EED should complete the *Infrastructure* layer effort by defining the architecture, structure, form and configuration of the *infrastructure* of the e-learning environment.

3.5.1.2 Guidelines for identifying infrastructure hardware

Since the e-learning environment is based on information technology, it follows that the infrastructure that supports such an environment should contain appropriate information technology hardware (Carliner, 2000; Anon (b), 2003). Examples of the *infrastructure* hardware that should be considered during the development of an e-learning environment includes: appropriate computer equipment (such as servers and desktop computers), printers, scanners, and other peripheral equipment (such as audio and video equipment) which the EED considers essential for the purposes of the environment being developed (Montgomery & Little, 1997).

3.5.1.3 Guidelines for identifying infrastructure software

In contrast with older generation teaching aids (e.g. overhead projectors, video machines and television monitors), the typical E-learning Dome infrastructure hardware relies on supporting third party software to operate effectively. This *infrastructure* software commonly includes operating systems (e.g. Windows or UNIX) as well as required drivers (Carliner, 2000; Anon (b), 2003).

3.5.1.4 Guidelines for identifying communication technology components

Communication technology components refer to the *communication* hardware and software that are required to enable the *infrastructure* hardware to communicate with remote computers. These components typically include networking hardware (cabling, routers, switches, and other networking devices), modems, workstations (other than the infrastructure *hardware* computers), networking software (e.g. Novell NetWare, .NET/Windows Server), and the Internet (and related) technologies[1] (Cloete & Schremmer, 2000).

The EED may typically choose between a synchronous and asynchronous approach to facilitate the e-classroom. Specific communication tools have to be set up for each of these approaches.

Asynchronous communication tools allow learning and teaching to take place with time delay and while the facilitator and learners are physically separated from each other i.e. participating parties do not have to be online at the same time - eliminating space and time limits (Colace, et al., 2002).

Examples of asynchronous communication tools include videotaped classes/ presentations, recorded audiotapes, e-mail, newsgroups, and discussion forums.

Synchronous communication is computer-mediated communication that takes place in real-time, where participants are all logged in to one network at the same time from a variety of remote locations, and where participants' input is immediately conveyed to other users for immediate response.

Examples of synchronous communication tools include live radio or television broadcast, audio/video conferencing, Internet telephony, two-way live satellite broadcast, chat rooms and whiteboards.

Integrating synchronous communication tools into e-learning processes is subject to limitations that do not normally exist in traditional learning. For example, the need for larger than usual communications bandwidths may make the learning process more expensive because of a higher technical complexity. Rashty (2000) recommends that the use of synchronous communication in e-learning should be limited. In essence I agree with Rashty (2000), especially where additional expenditure is required to make synchronous resources available. However, in certain countries, synchronous resources may require additional capital layout.

---

[1] E-learning can be conducted in laboratory conditions where only an intranet connection is required or as a form of distance learning where the Internet is required. For the purpose of this study I assume both intranet and Internet connection to facilitate maximum flexibility.

Synchronous communication also requires time, and sometimes place, regularity from the participants, due to the need to be near appropriate transmitting and reception equipment, which causes a problem in cases of students who are widely spread out in different time zones. On the other hand, synchronous learning decrease the feeling of estrangement that might be caused by asynchronous communication, and enhance the sense of community among the participants (Rashty, 2000).

3.5.1.5 Evaluation of the infrastructure

McAlister, Rivera and Hallam (2001) states that part of the evaluation of the infrastructure should include the definition of realistic goals and performance measures through which program progress may be evaluated.

An e-learning environment is typically evaluated in terms of its performance (Cloete, 2000), which is, according to Schach (2002), an important aspect of the environment that should be evaluated. It is for example essential to know the extent to which the environment meets its constraints with regards to the e-learning environment’s response time or space requirements. It is therefore necessary for the EED to quantify and measure the performance of the infrastructure of the e-learning environment during the development process. It is also necessary for the EED to ensure performance measurement of the infrastructure during operation, firstly to ensure continued client satisfaction and secondly, to act as triggers for system improvements. This can be achieved by including performance measurement mechanisms in the e-learning environment, or by ensuring that the infrastructure components are equipped with such mechanisms.

In addition to performance measurement, the e-learning environment should also be equipped with appropriate and effective system fault reporting mechanisms (such as a email address displayed at the bottom of a web page so that learners can report any problems they experience). The EED may also be required to identify and develop appropriate procedures for correcting faults in the infrastructure components.

Throughout the development of the infrastructure of the e-learning environment, as well as during its operational life, the configuration, and the configuration status, of all critical components of the infrastructure should be managed in an appropriate manner. The EED may elect to employ standard configuration management procedures, or may develop specific procedures for specific components of the infrastructure. The same method used for configuration management of information systems can be used for e-learning environments.

3.5.2 E-learning administration

3.5.2.1 Purpose of the e-learning administration layer

The E-learning Administration layer of the E-learning Dome model is used to guide the EED in identifying the management and administrative support functions for the *e-learning environment*. These support functions include *project management, configuration management, learner registration and finances, processing learner submissions,* and *managing deliveries to learners*. This layer does *not* address the general management and administration of the institutions or organisations that are associated with the e-learning environment but only functions that relate directly to the e-learning systems.

In specifying the scope and contents of the e-learning administration functions, the EED should utilise such procedures and processes that ensures the most cost-effective management and administration of the e-learning environment (Khan, 2001).

Project Management

The development process of an e-learning environment is in itself a project that requires proper management to ensure the timely and successful implementation of the end product.

3.5.2.2 Configuration management

Configuration management reflects the development and evolution of the configuration of an e-learning environment. Psaromiligkos and Retalis (2002) states that configuration management is the process of identifying, organising, and controlling changes of software configurations in all stages of the e-learning environment life cycle. However, since the e-learning environment consists of both hardware and software elements that are *(or may be)* subject to change, it follows that configuration management should be applied not only to the software configurations, but also to the hardware elements. Configuration management therefore ensures and maintains the consistency and integrity of the underlying configuration. For the EED and stakeholders, the configuration management process provides the means for 1) identifying configurations and changes, 2) controlling the applications of changes, 3) ensuring the proper implementation of changes, and 4) publicising changes for incorporation into implemented e-learning environments.

In previous paragraphs it was shown that the e-learning environment infrastructure consists of hardware, software, and communication technology *(hardware and software)* components. It will also be shown in later paragraphs that additional software elements may be introduced into the e-learning environment, both at administrative level and at the course development level, and in the quality control process. A specific arrangement of inter-related hardware and software elements are combined to form the e-learning environment, which is known as the configuration of the e-learning environment. A *baseline* (or *reference*) configuration is usually established by defining a specific combination of elements, as well as their details, at a given milestone in the e-learning environment lifecycle. This *baseline* is the basis configuration used to set up all the elements and is the foundation of the management of the configuration of the e-learning environment and should be established and documented at an early developmental point to ensure an operational e-learning environment.

Before the *baseline* of the e-learning environment can be established, the configuration management process should be in place and in operation. At the start of the development project, the EED should therefore 1) develop a configuration management plan, 2) develop and establish a configuration management database, and 3) implement the configuration management plan. One approach to develop and implement a configuration management plan and associated database is to make use of industry standards such as SABS ISO/IEC TR 15846.

As an alternative guideline, the modelling of the e-learning environment configuration by Psaromiligkos and Retalis (2002) may be considered. Psaromiligkos and Retalis (2002) model the e-learning environment configuration as a three-dimensional space. The first dimension represents the *configuration development*, the second dimension represents the *configuration evolution* and the third dimension represents the *decomposition of a configuration*.

The *configuration development dimension* represents the way in which the configuration of an e-learning environment is developed. At macro level, this involves the definition of the configuration of each of the top-level elements, or *building blocks,* of the e-learning environment.

An important element of the configuration management process is to identify, at the micro level, each e-learning environment sub-element that will be placed under configuration control *(identification of configuration management items)*. Normal configuration control procedures require that once a configuration management item has been identified, and has been put under configuration control, a new version of the item should be created each time it is subject to change.

Configuration changes are the basis of an evolution process and the *configuration evolution dimension* represents how each configuration management item evolves over time. Therefore, at macro level, the evolution process creates the sequential configuration versions of the top-level e-learning environment building blocks, while at the micro, or sub-element level, it generates the configuration versions of the various configuration management items that comprise each of the top-level building blocks of the e-learning environment.

The micro, or sub-element, level configurations are the subjects of the *configuration decomposition dimension*. In this dimension, each composite configuration management item is analysed to identify its constituent sub-elements. If the configuration management item is composed of other composites, the process of *decomposition* is continued until all sub-element items, to the lowest level *(i.e. single component level)*, of the configuration management item are defined and configured.

3.5.2.3 Learner registration and finances

Each person who intends to participate formally in an e-learning course should be recognised by the e-learning environment as an official learner. This recognition is acquired by means of an *e-learner registration process*. The EED of the e-learning environment should therefore establish such an e-learner registration process as part of the e-learning environment administration functions.

Most LMSs available commercially include a registration function (Donello, 2002; Schafter, 2001; Dean, 2002), therefore the EED can make the selection between utilising one of the existing registration systems, or design a dedicated registration system specifically for the e-learning environment under development. When a new registration system is to be developed, the elements discussed in the following paragraphs should be addressed to ensure compatibility with the e-learning environment.

Establishing the e-learner registration process involves defining the registration requirements for the particular course, analysing existing registration procedures for conversion into an e-learner registration process, developing the process, and implementing the process in the e-learning environment.

When an e-learning environment is developed for a specific institution or organisation, that institution or organisation should identify the relevant learner, administrative, and other information that it would require from the registration system. Registration requirements (such as subject prerequisites) for a particular course should be sourced from the institution or organisation for which the e-learning environment is being developed. Similarly, the institution or organisation is required to provide details regarding existing registration procedures, and/or should define appropriate policy regarding the e-learner registration process. The EED is required to analyse the registration requirements, the details of existing registration procedures, and the policy on e-learner registration, after which the e-learner registration process should be developed and implemented in the e-learning environment.

One example of a system that can be used for e-learner registration is the *Registration Information Gathering System* that is used to establish an e-learner user identification *(userid)* and password. Learners enter data in a series of online forms when they register for an e-learning course. This information which is stored in a database, can be made available to facilitators, and can be used by any of the e-learning environment functions that may require such information (Downes, 1997).

Each learner, who registers to participate in the e-learning process, is allowed to do so on condition that the necessary registration and course fees are paid in accordance with the relevant payment schedule. Thus, the e-learning environment should include appropriate facilities for e-learner fee payments, as well as tools and procedures to manage the account details of each e-learner. An online, secure payment facility should be considered for inclusion in the e-learning administration system, and the EED of the e-learning environment should implement an appropriate e-learner account management system. Some LMSs include charging mechanisms for users and methods of paying providers (Dean, 2002).

3.5.2.4 Processing learner submissions

One of the important elements of the e-learning environment is the inclusion of tools to manage the retrieval of course material, permit data entries, and establish enabling technologies for the electronic submission of assignments and for automatic assessment and grading (Cloete & Schremmer, 2000). It is deduced from this that the primary learner submissions consist of *data entries* and *assignment submissions*. The EED is thus required to implement a system and associated process that allows relevant data entries *(other than for registration purposes, as discussed in the previous paragraph)* and assignment submissions to be performed online. The EED may develop such a *learner submission system* or may elect to utilise an appropriate existing system.

In developing a learner submission system, several influencing factors should be accounted for. Thus, the EED should take note of at least the following factors that may affect the learner submission process.

The methods used for assignment submission depend on factors such as the course itself, the support system being used *(WebCT is one example)*, and the teaching strategy (Van der Merwe & Cloete, 2000).

When e-mail submissions are accepted, large file sizes and faulty compressed *(zip)* files may present administrative problems. In addition, the facilitator may be reluctant to send automatic replies upon receipt of learner submissions, which in turn may frustrate the learner's study progress.

Assignments that are to be submitted electronically are typically prepared on an available word processing computer program. Unless specific limitations regarding word processing software are provided for in the e-learning environment, the use of different word processors (or different versions of the same word processor) may present additional administrative problems.

Although assignment submissions in PDF format may reduce administrative problems, this method of submission can only be insisted on if the appropriate infrastructure has been established that enable learners to create PDF documents.

Some learner submission problems may be overcome by using simple HTML forms or a support system such as *WebCT*.

Finally, the EED is well advised to heed the finding of Van der Merwe and Cloete (2000) that problematic learner behaviour, such as disregarding file-naming specifications or neglecting to correctly identify himself or herself, may be circumvented temporarily by introducing innovative procedures, but cannot be eliminated permanently.

While developing the e-learning environment, the EED should attempt to define all potential administrative functions related to the specific e-learning environment's learner submission process. He or she should develop and establish or acquire and deploy a learner submission system, which is well-defined, effective and user friendly, yet which is flexible enough to allow for adaptation as may be demanded by changing e-learning environment conditions (Luca & McMahon, 2000).

3.5.2.5 Managing delivery to learners

As much as the learner has the responsibility to make submissions to the e-learning environment during the e-learning course, the e-learning environment is required to make deliveries of relevant *course-related* information and material to the learner. *(The administration of the learner's registration account details is addressed in the following paragraph.)* Cloete and Schremmer (2000) indicate that the e-learning environment should include tools to manage the retrieval of course material by the learner, which can be considered a specific form of delivery to the learner. However, the e-learning environment should also deliver new assignments to the learner, and should convey relevant course-related information and bulletins to the learner. Finally, at the end of the course, the e-learning environment should deliver the end results of the learner's study performance to the learner.

The EED should therefore implement appropriate systems, tools and processes to enable the learner to retrieve appropriate course material from the e-learning environment, and to manage this retrieval process. A number of LMSs include features such as: online delivery of teacher based training (TBT), online conferencing with peer groups, bookmarking so that learners can restart a module where they left it the last time they were studying it, online tutorial support and downloading of support materials that might be either for printing or TBT for studying offline (Dean, 2002), and support to the launch to e-learning courses (Donello, 2002). The e-learning environment may undergo configuration changes during its operation (for example new technologies that are continually being introduced, and therefore require continual update of course materials and methods), and such changes may have an effect on the course, as well as on the procedures that the learner should follow. This information, as well as relevant course-related information, and the final results of the learner's performance should be made available to the learner and the EED should facilitate a process of delivery of such material in the most effective manner.

3.5.2.6 Learning Management Systems (LMS)

The WWW is an accessible platform for developing learning content and tools to assist in the creation of unique learning environments. However such a customised approach may not always be required. There are commercial environments that have been developed with the goal of providing an *out of the box* e-learning solution, called an LMS (Luca & McMahon, 2000). A LMS's primary role is to automate the administrative aspects of training (Donello, 2002 Dean, 2002).

In the next few paragraphs a number of the most popular LMSs that are available will be looked at.

The first LMS that is discussed is the Blackboard e-Education Suite (http://www.blackboard.com)[2] which is aimed primarily at the education market at all levels including higher education and further education. The suite is comprised of three interoperable, but independent, systems. The three systems are *Blackboard Learning System, Blackboard Community Portal System,* and *Blackboard Transaction System*. This is a Web-based server software system that offers course management, customisation and integration with learner information systems and authentication protocols. Whether locally installed or hosted via Blackboard ASP Solutions, the main features of *Blackboard Learning System* are:

- *Course Management:* There are four primary parts to *Course Management*. These are *Content Management, Communication, Assessments* and *Control*. *Content Management* allows facilitators to make learning materials available to learners. They can author basic content items through the form-based Blackboard interface or incorporate existing instructional content by uploading the files into the course web site for online delivery. Users can upload and deliver a large number of file formats through Blackboard, e.g. Microsoft Office (http://www.microsoft.com/office/), Adobe® PDF[3] (http://www.adobe.com), HTML[4] (http://www.w3.org/MarkUp), digital images, digital audio/video files and multimedia like Flash[5] (http://www.macromedia.com/spftware/flash),

---

[2] A complete suite of enterprise software products and services to power e-learning programs.

[3] Software to create and exchange Portable Document Format (PDF) files.
[4] HyperText Markup Language used to create web pages.
[5] Flash is used to create rich content and applications across desktops and devices.

Shockwave[6] (http://www.shockwave.com), and Authorware[7] (http://www.macromedia.com/software/authorware). In the *communication* part of Blackboard Learning System learners and facilitators have enhanced collaboration with asynchronous discussion boards and synchronous chat tools. Forums are an important part of communication in Blackboard Learning System. Users can manage participation by sorting messages according to author, date, or subject. They can track read and unread messages and collect multiple messages onto one page for easy reading. Learners can be given administrative responsibilities, locking messages so they can be viewed but not modified and creating archives of past messages. With the *assessment* part facilitators can customise lessons by creating quizzes and surveys. Facilitators can mix and match question types: multiple choice, true/false, ordering, fill-in-the-blank. Facilitators can create question pools that can be shared across courses. With the *control* part of the system facilitators can monitor, control and customise their course web sites from a web browser. Courses can be managed through an easy-to-use control panel. The facilitator can easily enroll/un-roll learners or they can give learners enrolling power.

- *Building Blocks Architecture:* The Blackboard *Building Blocks* programme centres on an open platform architecture, which enable clients and other third-party application EEDs to seamlessly integrate tools, content, and applications with the Blackboard platform.
- *Advanced Integration and System Management:* The *Advanced Integration and System Management* addresses a key problem that can occur in e-learning. As institutions adopt a virtual learning environment (VLE), often the rapid adoption becomes an administrative challenge. Regardless of the size of the institution itself, the large-scale usage requires an infrastructure that permits data integration and customisation to allow operational system management.
- *Blackboard* provides a comprehensive platform that can be readily integrated with an institution's administrative software systems. Blackboard claims to be able to integrate with any learner information system or Enterprise Recourse Planning system, including custom/proprietary systems.

Trainersoft Manager 2.09[8] (http://www.trainersoft.co.uk/) supports learning over the Internet or an intranet. It provides an interface that can be tailored to meet the requirements of the purchasing institution to support learners throughout the world. Trainersoft Manager claims to provide a scalable

[6] Software used to create multimedia graphics.
[7] Visual authoring tool to create rich media e-learning applications for delivery on corporate networks, CD/DVD and the Web.
[8] Software package to manage the learning experience.

easy-to-use solution to the training needs of an institution starting with a system that supports a few hundred learners. Functions that are supported include:

- *Learner management:* Learner registration takes place by importing their details in bulk or by entering the information individually. Learners can be grouped and new groups can easily be created. Budgeting and billing management is also carried out by this LMS.
- *Course management:* Course requirements for certification can be set up and include prerequisites and unit charges. Courses can be assigned to individuals, all learners and groups, or to any defined set of learners. Course material formats can vary from a Microsoft Word document or PowerPoint presentation to sophisticated multimedia. Attributes can be set for each course to provide an introductory summary, expiry date, price, testing functions and duration of the course. Customised course catalogues can be set up so that different learners only see courses that they are authorised to study. A facilitator can be assigned to a learner for a specific course and learners can log into Trainersoft Manager to study courses and to monitor their progress. Any courses that are IMS compatible[9] (http//www.imsglobal.org) can be delivered using Trainersoft Manager. This makes it possible to use commercial and other courseware available in the e-learning market.
- *Reporting*: A number of reports can the generated using the package.

Virtual Campus 3 and eLearning Enterprise[10] (http//www.teknical.com) are systems intended for use over the Internet or intranet. Virtual Campus is aimed at education and eLearning Enterprise is designed for businesses. The Virtual Campus concept is based on the facilities provided by a physical institution's campus. The main features of Virtual Campus are:

- Administration facilities allow registration of learners and course and assignment of courses to learners. Progress of individuals and details of their activities can be recorded and monitored. Learners are allowed to study only those courses that are assigned to them. Facilitators can create user groups of learners. The administration databases are all in standard SQL format.
- Virtual Campus can be linked to College Management Information Systems (MIS)[11] (http://www.cbstraining.com/management/) allowing single entry or user details and storage data.

---

[9] Complying with IMS standards for delivering learning products and services.

[10] Used to create multimedia e-learning environments.

[11] College MIS provide online support and links to general computer-related questions and information.

- Personal management facilities allow individuals to record or review their activities in a personal diary. Some information such as test scores or the list of studied modules is stored automatically but the learners can record information in their own diary. The diary logs all activities by the learner on the campus.
- There is a large online courseware library available from TekniCAL[12] (http//www.teknical.com) that is continually expanding. Specialists in institutions using the virtual Campus authoring tools can also create course content.
- Virtual Campus can launch multimedia training written in a variety of authoring systems and record progress. The course facilitators can then use the Virtual Campus authoring capabilities to develop tests so that progress can also be recorded. Courses can be delivered and tracked if they are HTML based or AICC[13] (http://www.aicc.org) compliant.
- Virtual Campus features a content management tool that allows courses to be built form a series of learning objects.
- Virtual Campus can support laboratory practical work using Discovery II[14] (http://www.feedback.plc.uk/) software. This means that compatible hardware can be controlled within the Virtual Campus.
- Facilities such as e-mail, conferencing and notice boards allow two-way communication between the learners and facilitators.
- Audio conference servers can be added to the system allowing conferencing via relatively low bandwidth connections.
- The user interface can be customised to meet the requirements of the purchasing institution.

WebCT Campus Edition[15] (http://www.webct.com/) is aimed primarily at the education sector. Its purpose is to provide a software platform that allows institutions to deliver courses over the Web. The main features offered by WebCT are:

- a broad range of licensing options for institutions in various stages of e-learning adoption. One licensing option is designed for institutions that wish to deliver courses and support users over the Web but do not need extensive features for scaling or integration with campus systems.

---

[12] TekniCAL provides global e-learning solutions and services.

[13] Aviation Industry CBT Committee that developed nine guidelines and recommendations for CBT courseware.

[14] Web based software delivery system interacting with a range of hardware experimental units.

[15] Manages student and course data.

- it does not require any specialised software. Everyone uses a common browser as the interface.

3.5.3 Content development

3.5.3.1 Purpose of the Content Development layer

The E-learning Dome model makes provision for the development of an appropriate infrastructure for an e-learning environment, it facilitates the establishing of relevant administrative procedures, and it requires quality assurance management of both the development and the operational phases of the e-learning environment. However, without course material it would only fulfill the purpose of another LMS.

The Content Development layer guides the EED of the e-learning environment through the process of developing the *e-learning course content,* which is a continual process (Crosby & Schnitzer, 2003), the means of *content delivery and learner interaction*, and the *assessment procedures* for the specific course. Cloete and Schremmer (2000) suggest that this layer should include components such as the development of course material, the incorporation of the course material in the e-learning environment, and the defining of course communication methods.

Course development tools

The LMS systems are usually not used for the development of the course content. A broad range of external tools is used to develop the content before it is published in the LMS system. The interviews show that the LMS systems use text, multimedia sound, HTML-pages, graphics, and tests that are developed with external software. Examples of software tools for course creation are:

- for text: MSWord and PowerPoint,
- for multimedia: Macromedia Authorware and Director, and Flash,
- for sound: Windows Sound Recorder and Wimba,
- for HTML-pages: Dreamweaver and NetScape Composer,
- for graphics: View let, Coral and PhotoShop, and
- for tests: AutoTest, Web winder.

3.5.3.2 E-learning course content

E-learning course content consists of the instructional subject matter, assignments and evaluation material, which are required to satisfy the subject syllabus requirements. It is the responsibility of the

EED to facilitate the necessary means for the subject facilitator to develop the e-learning course content, unless the EED is explicitly also contracted to develop the content.
Development of course content is not trivial and facilitators rarely develop course content without support from others, because facilitators do not always have the technical expertise necessary to prepare class material in the appropriate format for Web delivery (McAlister, Rivera & Hallam, 2001). They seem to use content developed by others, collaborate, or work in teams. Some teachers that participate in the development of courses have support from web-designers or support staff (Paulsen, 2002).

Furthermore, once the material is in the right format, there is no guarantee that students will be capable of using them. It is crucial then, that adequate provisions be made for technical support for both course facilitators and students. Among those provisions required, course design expertise should be available to help facilitators develop and organise their course content (McAlister, et al., 2001).

Preparing materials for web delivery requires facilities for the collection of graphic, video, voice, and text content. Hardware and software capable of doing this are readily available, but requires some investment in adequate facilities. It is unreasonable to expect the development of adequate course materials without providing adequate support. While these technologies do not have to be *cutting edge*, they should be current. It is also important to understand that new technologies are continually being introduced, and therefore require continual update of course materials and methods (McAlister, et al., 2001).

The steps involved in developing the e-learning course content focus primarily on the following:

- determining the source, or sources, of the content,
- acquiring the relevant study material,
- ensuring the study material is suitable to use in the e-learning environment developed, and
- incorporating the e-learning content into the e-learning environment.

The e-learning content EED (typically the EED or the facilitator) is responsible for establishing whether suitable subject material already exists for the specific course, and if so, for determining the source, or sources, for the required subject material that will form the basis for the e-learning content. As far as is practicable, the use of existing subject material should be given preference (Banks &

McGrath, 2003). Van der Merwe and Cloete (2000) report that it is costly to develop high standard, quality courses, and converting ideas, notes, and paperwork into an acceptable format for e-learning environments intensifies the required effort exponentially. Spending many man-hours to design high-tech courseware may be valuable for subjects whose syllabi and contents do not change regularly, such as Algebra or History. However, where new developments in technology and the environment require frequent changes to the subject syllabus and/or contents (for example, Computer Science and Law), such intensive effort may not always be appropriate.

Once the investigation regarding availability and sources of subject material is completed, the relevant subject material should be acquired. This may require a commercial purchase from an external source, or could be an official internal transfer of (usually) proprietary material to the e-learning environment development project. The e-learning content EED should, however, ensure that the acquired subject material is suitable for, and compatible with, the e-learning environment that is under development. It should also be confirmed whether the subject material would be under configuration control during both the development and operational phases of the e-learning environment.

Unless the acquired subject material is already in an appropriate electronic format, the content EED is responsible for coding the subject material into an electronic format that is compatible with the e-learning environment. The coding of subject material into e-learning content is usually accomplished by means of a suitable programming language or software program. Although many content EEDs may not have the skill, the time or the desire to program in raw HTML source code, this may be a less expensive option for developing e-learning course content. However, HTML-based material could be subject to display monitor limitations, and different web-browsers mean that users may view the course content differently from what the content EED intended. Such inconsistencies could affect the perceived quality of the e-learning environment and could frustrate participating learners. To ensure WYSIWYG, downloadable course content can be developed as PDF files, which are flexible and can accommodate a wide scope of high-tech multi-media technologies. However, in a synchronous, or online, e-learning environment, the PDF files may be inflexible (Van der Merwe & Cloete, 2000), because they cannot be changed after it was created – this means that another document need to be created, which slows the whole process down. The alternative to using HTML code to develop course content is to utilise an appropriate authoring tool. Authoring tools are described below in more detail.

Another important aspect concerning course content development is that of learning objects. According to Govindasamy (2002) e-learning content should be designed and developed in smaller manageable chunks, known as learning objects. The use of learning objects makes e-learning content more re-usable. To further ensure the learning object's re-usability an EED should invest in a learning object standard, such as SCORM[16] or IMS/EML. Both these standards can be used to code learning objects that is then stored in databases. A translator is built into the system to translate the raw learning object into a suitable format, for example HTML or PDF.

The final step in the process of developing the e-learning course content is to incorporate the e-learning course content into the e-learning environment. This step requires the EED to co-operate closely with the subject facilitator to ensure that the course content is not only incorporated in the e-learning environment, but is also thoroughly tested and evaluated prior to making it available to e-learners.

3.5.3.3 Authoring tools

A software authoring tool is required to create and maintain learning content. An authoring system is a software package that supports EEDs and facilitators so that they can produce interactive multimedia courses efficiently (Dean, 2002).

According to Dean (2002) authoring systems include the following essential components:

- facilities that allow EEDs, who may not be computer experts, to enter the training content onto screens in an attractive way,
- support for linking screens of training material together into modules,
- support for a range of question types so that the course designers can choose the most appropriate for a particular situation and provide variety for the learner, and
- response analysis that takes the learner’s answers to questions and provides feedback and makes branching decisions based on the learner response.

Other features that are usually provided with differing levels of sophistication are multimedia support, recording of learner and course details and support for the Internet and intranets.

---

[16] Sharable Content Object Reference Model

Cloete and Kotze (2002) distinguish between four types of instructional authoring namely:

- software intended to be used by instructional designers who are both technically and pedagogically skilled,
- software intended to be used by computing design specialists, but which do not necessarily comply to instructional design principles,
- software intended to be used by pedagogically skilled persons who may not have advanced computing skills, and
- entry-level instructional authoring software offering restricted functionality and limited deployment options without much instructional design at the front-end.

Although it is advantageous that educational institutions employ enough professional instructional designers who can, together with facilitators, develop e-learning courseware, the scarcity of these professionals combined with the potentially large number of courses (sometimes thousands) often force facilitators to take responsibility for the development part, or all of their e-materials. In such cases, if the target end user is supplied with authoring tools intended for the professional instructional designer, the working environment is bound to lead to dissatisfaction, loss in efficiency and may possibly also lead to the failure of e-learning (Cloete & Kotze, 2002).

In the subsequent paragraphs a brief description of a number of different authoring systems that are widely used for the creation of e-learning content will be given. Commercial examples, although with restricted pedagogical freedom of this category, will be discussed in the following paragraphs.

The first authoring system is called *Authorware 6.5*.

Authorware (http://www.macromedia.com/software/authorware) by Macromedia is a multimedia authoring system of considerable power for developing multimedia training for delivery over the web, local networks and using CD-ROM.

Pages can be created using XML and Flash movies can be included. A training course is developed by building a flowchart of the course structure. The flowchart is built from a small set of icons that are displayed in a toolbox of the screen. The flowchart is fundamental to the design process and prevents the author from branching to paths that do not exist. Other features include extensive self-documenting capabilities including the flowchart. This authoring system will be suitable for use by instructional designers who are both technically and pedagogically skilled. Authorware 6.5 complies with the following standards: AICC< IMS, SCORM and ADL.

Dreamweaver MX[17] *with CourseBuilder* (http://www.macromedia.com/resources/elearning/) is the next authoring system discussed. This is an example of an authoring system that can be used by instructional designers that is pedagogically skilled, but may not have advanced computing skills. It is Micromedia's own WYSIWYG web editor for creating web sites and Internet applications. The CourseBuilder for Dreamweaver MX extension adds features that are needed for delivering training to the features of Dreamweaver. It is a free download. The basic Dreamweaver package allows web pages to be created without any knowledge of HTML. Pages can be created which include JavaScript and other features such as Flash, Fireworks or Shockwave Director movies. With CourseBuilder for Dreamweaver MX the author can create interactions such as: multiple choice, True/False, Matching, Fill-in-the-blanks, hot areas/hot text, text entry, sliders, drag and drop, buttons and timers. Dreamweaver complies with AICC, IMS, SCORM and ADL standards.

ToolBook Assistant 8 and Facilitator 8.5[18] (http://www.albit.de/produkte/toolbook2003engh.php) is an authoring system that is used by pedagogically skilled persons who may not have advanced computing skills. Assistant is designed for those who do not require the more sophisticated features of Facilitator. It is designed to support delivery of the training over the Internet as well as CD-ROM and directly on a PC. Pages can be created using DHTML[19]. Book Specialists are provided to take the developer through the initial process of producing the framework for the course, which ToolBook refers to as a *book*. The structure is built up from a group of related templates that cover basic navigation, background, buttons and page types such as table of contents, main training pages, glossary and tests. Once the course structure has been specified the Assistant's Toolbar is used to build the content for individual frames (pages) and Assistant provides a *catalogue* containing over 1000 objects of different types that can be included on pages. The objects can be drawing objects, navigation objects, media players and assessment objects. Assessment objects include a number of question types such as multiple choice, fill-in-the-blanks and true/false. Objects can be animated using the built in *path*

[17] An authoring tool used to build professional web sites and applications.

[18] A tool to create training that involves thorough instruction, use of media, and innovative navigation.

[19] Dynamic HyperText Markup Language is an extension of HTML that gives greater control over layouts.

animation utility. ToolBook complies to the following standards: AICC, IMS, SCORM, ADL and IEEE.

3.5.3.4 Content delivery and learner interaction

It was reported in a previous paragraph that Cloete and Schremmer (2000) suggest that the defining of course communication methods should be included in the Content Development layer. For the purposes of this study, course communication methods include methods for content delivery, and methods for learner interaction.

By its nature, content delivery *(or content interaction)* is dependent both on the course contents that should be presented to the learner, and on the methods of delivery that are available to the EED and the facilitator.

The Web offers a wide range of methods for delivering content. These methods range from simple text based formats to audio and video formats. Although this wealth of methods exists for delivery, not everyone may be able to receive content in all forms. For example, the student's choice of ISP may play a role in this, as well as the computing platform that they are using. It is therefore important to understand the facilities available to students who may enroll in these courses, and select content that they will be able to receive and comfortably use (McAlister, et al., 2001).

According to McAlister, et al. (2001) the choice of content methods should also be periodically analysed. As more people acquire high speed Internet access, and new core capable hardware and software become widespread, content delivery should be altered to present a richer learning experience. This may also be necessary if programs are targeted at selected audiences, for example corporate programs that already possess high-speed access and more advanced capabilities.

The course contents, and specific instructional delivery requirements unique to the particular subject or course, should be identified during the e-learning course content development phase. The facilitator and the course content developer should, however, consider the capabilities and the limitations of the e-learning environment in which their courses is developed and operated. Specifically, available features and capabilities for content delivery should be utilised to their fullest extent, but care should be taken to ensure that content delivery can be accomplished to the widest possible audience. Typically, then, the methods to be used for content delivery need to be deliberated and identified by the EED, the facilitator and the e-learning content developer, and these methods is usually based on a combination of technologies and media elements.

Learner interaction consists of 1) instructional interaction with the facilitator, and with other learners, and 2) social interaction. This interaction is typically administrated and managed by the facilitator and forms part of the requirements that should be fulfilled to complete the course. Social interaction is informal, yet related to the e-learning environment, and is not necessarily administrated or managed officially.

To facilitate interaction, Draves (2000) recommends the developing of an interaction plan for the e-learning environment and gives the following guidelines: Depending on the e-learning environment, the EED and facilitator may be required to investigate the structure of the discussion forums. It may be necessary to have both synchronous and asynchronous discussion forums, and it may be necessary to have more than one discussion forum site to deal with different discussion topics. It follows that the more complex the discussion forum structure becomes, the more complex the supporting infrastructure of the e-learning environment needs to be. A positive and useful aspect of the asynchronous discussion forum is the ability to save and archive a discussion. By saving and archiving the discussion, learners can view and download comments at any time in the future for as long as access to the saved material is authorised by the facilitator. The EED should therefore ensure that the necessary infrastructure and configuration management processes exist to allow the saving and archiving of the discussion forums.

Many other methods for learner interaction in an e-learning environment exist, each with its unique features, benefits and limitations. A few of these methods are briefly discussed below (the application of the method, rather than its technicalities, are focused on). It is, however, the prerogative, and the responsibility, of the EED and facilitator, to identify and implement the correct method, or combination of methods, to ensure interaction that is of the greatest benefit to the learner.

Internet Video conferencing

Video conferencing is real-time conferencing that can be made available on the individual *(properly equipped)* desktop computer. Video conferencing over the Internet offers an opportunity to bridge the issue of face-to-face contact. It is also an opportunity to aid in collaboration between learners in an e-learning environment, facilitate communication, and improve the e-learning environment instructional offering (Montgomery & Little, 1997). Examples of video conferencing systems are *CU-SeeMe* (http://www.cu-seeme.net/) and *Quicktime Video Conferencing* (http://qtc.quicktime.apple.com/).

Chat rooms

Structured chat rooms conducted by the facilitator provide group discussion on course activities and assignments. Using real-time chat, the facilitator can ask questions in a similar manner to the traditional classroom (Barker, 2003).

Chat rooms are useful when a group of learners cannot meet at the same location, but could be online at the same time to exchange information (Nguyen & Kira, 2000). A typical e-learning chat room should allow the facilitator special privileges, such as muting learners, disconnecting learners, or even assigning special privileges to special guests who are invited to participate in the discussion. Chat rooms also allows the facilitator to provide immediate feedback to learner questions, evaluate learner participation and take attendance (Barker, 2003).

Draves (2000) identifies two important challenges in the application of the real-time chat rooms for online discussions. The first challenge results from time differences - learners in different time zones around the globe may be required to participate in discussions at inconvenient times of the day. The second challenge is a result of one specific feature of chat rooms - chat rooms typically only allow short comments, which may present problems when long explanations are typical of the subject matter of the course.

Free chat room software is available at http://www.hearme.com and http://www.ichat.com. Other examples of chat rooms include Global Chat, E-Pub Chat, I-Chat, WBS Chat, and Netscape Chat.

Discussion forums

In an e-learning environment, a discussion forum is the central meeting place of learners and facilitators. In a discussion forum, the facilitator can post notes, comments and administrative arrangements, and can answer questions from learners. Conversely, learners can study the material that is posted by the facilitator, and can ask questions and have group discussions (Draves, 2000; Moore, et al., 2001). A discussion forum allows learners to log in at different times, locate a relevant topic of interest, and respond to it. These responses are posted in the discussion forum with the *names* of the respondents and the date of their posting, along with previous responses to the discussion topic. It also allows the learners to collaborate on projects, exchange ideas and participate in group activities (Barker, 2003).

All of this is done independently of learner location and time of actual participation in the discussion forum (Markel, 2001).

Examples of discussion forums include *NetForum* and *Bulletin Boards* (Montgomery & Little, 1997).

A *threaded bulletin board* is a special type of discussion forum in that it is useful for posting static or stand-alone comments. In an e-learning environment, a threaded bulletin board can be used as a message or comment board, for posting a daily question for learners, and for listing information directories and references. However, Draves (2000) advises that a threaded bulletin board should not be used as the central discussion forum for an online course.

Whiteboards

In the e-learning environment, the *whiteboard* is a window that appears on the computer screen during a video conferencing session. It allows the facilitator or learner to work on-screen, in the same way as one would use a chalkboard or whiteboard in a classroom (Barker, 2003). The notes and drawings that are produced may be viewed simultaneously on the screens of all other participants in the environment. Many whiteboard programs offer a variety of simple drawing tools that allow the user to offer a lecture-style presentation while illustrating points on the whiteboard. A user may also capture windows or portions of windows and place these *snapshots* on the whiteboard where the user can draw over them to point to relevant objects (Moore, et al., 2001). The use of whiteboards in e-learning give learners the ability to visualise the process of animation and also to identify where errors may have occurred. This can then be shared by the whole group, reinforcing communally constructed learning.

E-mail

E-mail is another method of learner interaction in an e-learning environment, and is widely used by facilitators and learners. The interaction varies from a one-to-one message, to one-to-many messages that are sent to a distribution list. Some advantages of e-mail include: 1) parties involved can send and answer messages at their own convenience, 2) electronic files can be attached to e-mail messages, and

3) a message can be edited and then forwarded to one or more parties. However, being an asynchronous method of communication, the response to an e-mail may not provide necessary timely feedback if the response from one party is delayed. Another big disadvantage of e-mail is that the facilitator can become flooded with e-mails from learners asking the same questions, because e-mail does not allow others to participate or benefit from learner questions, comments and sharing (Draves, 2000).

Interactive television

The scope of interactive television ranges from unidirectional *telebroadcasting* with audio feedback, to fully interactive video conferencing, and is implemented via satellite, telephone lines or computer networks (Cronje, 1996). Interactive television addresses several problems that are associated with the use of normal television in education. According to Cronje (1996), normal television learning programs: a) do not allow learners to talk back, ask questions, stop the program, or argue with the facilitator, b) provide the learners with almost no say in the choice of content, and c) are subject to rigid programming schedules, as determined by the broadcaster.

Claassen (1994) lists the following advantages of interactive television:

- instantaneousness - a geographically dispersed population can be reached immediately (irrespective of location),
- simultaneousness - information is broadcast to all receiving sites at the same time (regardless of their distance from the source),
- unfiltered information transfer - all viewers receive the same message,
- accessibility – programs can reach anywhere within the broadcasting *footprint* (irrespective of distances or geographic obstacles), and
- affordability - the larger the target population, the smaller the unit cost.

Interactive television does, however, also have disadvantages, as highlighted by Cronje (1996) in the following:

- if the use of interactive television is not managed properly, learners can waste time with irrelevant questions or questions with too narrow a focus,
- an increase in the number of participants may lead to a decrease in interaction,

- cost-effectiveness is achieved with large audiences, but often at the expense of the level of interaction,
- a lack of visual feedback may limit the effectiveness of the interactive process,
- a lack of knowledgeable facilitators at receiving sites may limit the effectiveness of the learning effort,
- resources are limited in terms of prepared lessons that can be presented, and printed material available to learners, and
- although the image and voice of the presenter and the images of laboratory equipment and other visual aids can be broadcast, it is impossible to broadcast a library.

Satellite technology can, as pointed out above, be used to deliver interactive television. According to Anon (1999), satellite technology is a one-to-many distribution medium, because once programs are received at a site, they can be streamed live over internal networks to individual desktop computers, or they can be stored on local servers for playback on demand at a later stage. Satellite technology may offer advantages when used as part of an e-learning environment, as is proposed by Rack and Cantu (2000) and Al-Sharhan (2002) in the following examples. The technology for delivering a distance-learning program via satellite is relatively simple to set up and use. Improved lecture structures, enhanced visuals, increased learner interaction, and a high-quality environment for better learner concentration can be achieved, and in a single broadcast a satellite can cover large geographical areas and can reach all receivers within its footprint (Rack & Cantu, 2000).

Advanced error correction processes result in high reliability transmissions and ensures the integrity of the information that is delivered (Rack & Cantu, 2000; Al-Sharhan, 2002). Finally, technological developments that result in reduced equipment, maintenance and operational costs make exploitation of satellite communications in education a viable possibility (Al-Sharhan, 2002).

With the development of MPEG-4 multimedia authors can create interactive multimedia content that can be streamed at variable bit rates over high and low bandwidth connections. The standard has the potential to bring interactive multimedia to a larger audience, for instance providing interactive television (Calitz & Cowley, 2003).

3.5.3.5 Assessment procedures

Whatever method is used, assessment of a learner's performance is essential in an e-learning environment as this usually is the only measurement that can be used to determine whether the learner had satisfactorily completed all the requirements to obtain the qualification that is associated with the e-learning environment.

Some of the commercially available systems have no built-in tools for assignments or assessments. However, there are external tools that could be used to design assignments, like AutoTest and Webwinder. WebCT seems to provide a range of useful tools (Paulsen, 2002).

According to O'Rielly and Newton (2002) there are a number of assessment methods available in an e-learning environment. These methods include timed online examinations, group projects, international collaboration, peer assessment and self-assessment. The facilitator of the course is responsible for identifying all appropriate assessment methods for the course under consideration, and should select the most effective methods that satisfy the course assessment requirements that should be prescribed by the course owner. Once the facilitator has selected the assessment methods to be used, the EED is responsible to assist the facilitator in adapting and applying the methods to the e-learning environment that is being developed.

In converting existing assessment methods to an e-learning environment, or when new procedures are developed for such existing methods, the EED and facilitator are required to keep in mind the potential problems that may be experienced.

For example, virtual examinations may be considered feasible and may be implemented world wide at special examination centres. However, the investment that is required to establish the necessary infrastructure to facilitate virtual examinations, and the administrative problem of authenticating learners, are only two of the unknowns that should still be investigated.

Credibility and accountability have shifted to the learner (Ross, 2002). One should therefore realise that no single method for assessment is considered ideal. Rather, several methods is used within a single course to provide a summative evaluation of student’s knowledge, ability and participation. For example, in the online classroom, where a facilitator is using threaded discussion to augment the learning process, the assessment method would involve more than administering a formatted examination. A facilitator will be evaluating a student’s performance throughout the entire discussion process with attention toward the quality of interaction between the facilitator/learner and learner/learner (Edelstein & Edwards, 2002).

Probably the most troublesome issue with administering assessment instruments is insuring that those being assessed are who they say they are. It is difficult if not impossible to reliably ascertain a participant’s identity when communicating over the Internet. If reliable identification is necessary to maintain course integrity, arrangements should be made to administer assessment instruments through a proctored arrangement. This may require that participants meet periodically at a central location, or that arrangements be made at a reliable institution near the participant’s vicinity (McAlister, et al., 2001).

E-marking is one other method of assessment in which the facilitator assesses learner submissions on-screen. When successful, e-marking results in shorter turn-around times, a feature that usually satisfies learners. However, the experience of many facilitators is that e-marking is an exhaustive process in that the reading of the learner submissions, and the administration associated with e-marking, take much longer than what is usually anticipated. A simple, workable assessment method that produces satisfying results is essential to ensure both high quality learning systems and satisfied facilitators (Van der Merwe & Cloete, 2000).

3.5.4 Quality dome

3.5.4.1 Purpose of the quality dome

In an e-learning environment the quality of the environment is the deciding factor in the reputation of the e-learning organisation or institute (Van der Merwe & Cloete, 2000). Khan (2001) states that not only the learners, but also the instruction, and the e-learning environment should be evaluated *(subjected to some form of quality control)*. Even though the EED has little interest in evaluating the hardware and software *standards*, the choices made and the implementation of these choices can, and should be, evaluated. This implies that, if a high level of quality is required, the EED is obliged to develop and implement an appropriate quality system for the particular e-learning environment.

The purpose of the Quality Dome of the E-learning Dome model is therefore to guide the EED in the development and implementation of a quality system for the e-learning environment.

To understand the motivation for a quality system, it is necessary to briefly revisit the meanings of some terms, as described by the *International Standardisation Organisation (ISO)* (Peach, 1994).

Quality is the totality of characteristics of an entity that bear on its ability to satisfy stated or implied needs. Popularly, *quality* is used to refer to *fitness for purpose*. However, technical specifications may not guarantee that the client's requirements are met consistently, and the ISO 9000-1 standard (http://www.iso.ch/iso/en/ISOOnline) focuses on the following four aspects of quality:

- quality to meet marketplace requirements,
- quality to build the right characteristics into the product,
- quality to consistently conform to product design, and
- quality to furnish product support throughout the product's life cycle (Peach, 1994).

A *quality system* is the organisational structure, responsibilities, procedures, processes and resources that are required to implement quality management, but only to the extent required to meet quality objectives (Peach, 1994).

Quality management includes that part of the organisational management function that determines the quality policy, objectives and responsibilities, and which implements the policy, objectives and responsibilities by means of quality planning, quality control, quality assurance and quality improvement within the quality system (Peach, 1994).

Finally, *quality assurance* includes all the planned and systematic activities of a quality system that were demonstrated, and are implemented, to provide adequate confidence that an entity meets, and continue to meet, requirements for quality (Peach, 1994).

In terms of the above descriptions, the e-learning environment is an entity in itself for which a quality system should be implemented, but obviously consists of many components that are, at their levels, *entities* that qualify for inclusion in such a quality control system. The EED is advised to develop and implement a quality system, the *Quality Dome* in this case, in accordance with the requirements and prescriptions of an industry standard for such systems, such as the ISO 9000 system of standards.

At the development and operational level of an e-learning environment, and recognising the ISO quality standards, the Quality Dome requires the EED to address the requirements for quality and include: 1) applying quality control measures both during the development, and during the operation of the e-learning environment, 2) developing and applying system fault reporting procedures, and 3) developing and applying procedures to take corrective action, when required.

3.5.4.2 Application of quality control measures

Before the EED can apply quality control measures, the quality system should be in place. The EED is responsible for ensuring that the following steps are taken as early as possible in the development project of the e-learning environment. Firstly, a *project quality plan* should be developed and initiated. This plan should then provide for the development of a quality system for the e-learning environment, and should ensure that the correct quality management policies, objectives and responsibilities are defined and implemented. Finally, the quality system can then be implemented, and the appropriate quality control measures can be applied.

The primary quality control measures in the e-learning environment include 1) the initial and subsequent evaluation of all entities that are subject to quality control, and 2) the carrying out of quality assurance activities.

All e-learning environment entities that are subject to quality control should be evaluated, both in the development phase of the e-learning project, and subsequently during the operation of the e-learning course. One method that is used is to archive entire courses so that it can be used for comparisons (Heberling, 2002).

According to Cuhadar, et al. (1999), evaluation is one of the most important, yet neglected, elements of designing e-learning environment. Evaluation provides feedback for course developers on teaching and learning, and is an important part of quality assurance (Dyson & Campello, 2003). Oliver (2000) has explained evaluation as the process by which people make value judgements, and when applied to learning technology, he suggests that this is often the educational value of innovations in new teaching methods and resources. Whilst the overall objectives of evaluations are likely to be identifying that which may improve learning, some evaluations have specific outcomes, whilst others aim for more general relevance.

According to De Villiers (2000) it is important to consider the following during evaluation

- the characteristics of the users of the system,
- the types of activities the users will do,
- and the nature of the product (prototype or fully developed system) being evaluated.

According to Strother (2002) the techniques to evaluate e-learning are the same as those needed to evaluate other training solutions. The steps involved in carrying out such evaluations include the following:

- for each entity, the appropriate evaluation method, or methods, should be selected,
- an evaluation time frame should be determined, indicating when and how often each evaluation is carried out,
- from manufacturer specifications, quality requirements for the e-learning environment, and industry standards and recommended practices, the evaluation criteria for each quality entity should be established,
- the evaluations should be conducted,
- the data collected during the evaluations should be analysed, and
- recommendations for improvements or corrections should be considered and implemented.

There are a number of different types of evaluation that is used in e-learning. De Villiers (2000) suggests the following: observing and monitoring usage, collecting user's opinions and surveys, experiments and benchmarking, interpretive evaluation, predictive evaluation, usability laboratories, field studies, cognitive walkhrough, heuristic evaluation, review-based evaluation, model-based evaluation, empirical methods, et cetera.

According to De Villiers (2000) both summative and formative evaluations can be used. *Summative evaluations*: The aim of this evaluation it to justify the implementation of an instructional technology. Summative evaluation seeks to answer the following questions:

- What are the most effective e-learning teaching and learning processes and how differences in these processes relate to comparative outcomes between new and traditional environments,
- What are the advantages and disadvantages of this delivery mode in attaining specific educational goals as compared to other traditional means, and
- How the merits vary with the characteristics of learners, subject matter, teaching methods and teaching equipment (Nguyen & Kira, 2000).

Some researchers view the instructional technology primarily as made up of technology knowledge to operate the medium in terms of software and hardware. Others concentrate on the accessibility of devices and materials to users. Still others focus of the questions of what good does a particular instructional technology provide for education and what characteristics make it of particular value for the promotion of learning. The conditions for effective learning include not only capabilities and qualities of an individual learner, but also other important issues related to the media used in teaching and learning. However, the focus of designing and implementing an instructional technology is not just on technology as such, but should be on how to improve performance resulting from learning. From this perspective, the choice of an effective teaching method or an instructional technology is subject to the course content, the needs of the facilitator as well as those of learners.

Formative evaluation: Formative evaluation investigates the feedback on any factors that effect teaching and learning processes, and then designing and implementing the instructional technology appropriately. The development of an e-learning environment could be considered from a systems design and analysis perspective. As such, formative evaluation should be conducted at every stage of a systems development life cycle to improve the functionality and ease of use of the final design (Nguyen & Kira, 2000).

These evaluations are conducted on a regular basis at pre-course, in-course and post-course stages.

A number of metrics that is used in the evaluation of e-learning environments is discussed in the following paragraphs.

Usability: Usability measures effectiveness, efficiency and satisfaction according to the ISO9241 standard. Other criteria that can be measured under usability are that of ease of remembering and error rate (Dyson & Campello, 2003). These measures are suitable for a large range of systems, including those for computer assisted instruction systems and intelligent tutor systems (Dyson & Campello, 2003). Issues of usability can be addressed by looking at responses to the system and extracting perceptions. Learning is generally assessed through outcomes, but perceptions may again be informative. There may also be interactions between the usability of the system and the nature and extent of learning. Therefore comparing participation in discussions may contribute to assess the role of the interface in the facilitation of learning. The usability of e-learning programs can be broken down into two distinct issues: the usability of institution's site and the learnability of the course content (Karoulis, Polyxenidou & Pombortsis, 2002). A usable site adds to this direction, not only by becoming *transparent* to the user allowing him to concentrate on his goal, which is the acquisition of knowledge, but also by becoming *intuitive* supporting thus exploration and experimentation, two important features for every instructional environment (Karoulis, et al., 2002).

Flexibility: Discussions on flexibility tend to focus on two main issues: Flexibility in delivery, and flexibility in the pace and distribution of learning. The flexibility of delivery offers organisations the ability to deliver consistent learning experiences, independent of time and place. This offers great advantages to a geographically dispersed workforce, those working non-standard hours and those employees who work from a home base. Flexibility in the pace of learning is represented largely as an advantage to the learner in that they can learn at a time and pace to suit their own capability and life circumstances and enable their continued marketability through lifelong learning (Macpherson, et al., 2002).

There are a wide variety of evaluation methods, which can be put to use to evaluate any given e-learning environment. Not all types of e-learning environment, however, call for the same type of evaluation. Multiple evaluation methods capture the variety of issues to be analysed. It is imperative that more than one method be used (Cuhadar, et al., 1999) to ensure that all aspects of the e-learning environment has been evaluated. The following is a number of methods that is used to conduct evaluations:

- *Interpreting results*: Employing experimental methods to evaluate learning technology are often considered inappropriate due to the difficulty of controlling variables that may affect outcomes (Dyson & Campello, 2003).

- *Process evaluation*: One approach to the classification of methods is to consider which aspect of the activity is evaluated. In relation to assessment the focus should move from the product to the process. The way a student completes a task should be considered as important as the final product. Process measures deal specifically with how learners use documents, and outcomes (or products) are reading and comprehension. Both process and outcome are appropriate to the evaluation of learning technologies (Dyson & Campello, 2003).
- *Subjective and objective evaluation*: Although the importance of measuring learners' perceptions of many aspects of e-learning environment should not be understated, such measurements cannot indicate, for example ease of use nor ability to support learning. Marks from facilitators for individual contributions (performance, albeit marked subjectively) and patterns of exchanges can provide useful information. As is often the case, employing different methods, hoping to converge on a single outcome, is a sensible policy. Questionnaires is used to ask students for their opinions and analysing their performance (Dyson & Campello, 2003).
- *Expert and user evaluation*: When gathering subjective judgements, evaluations may adopt a technique from usability studies, heuristic evaluation, or ask for feedback from learners. In heuristic evaluations, a small number of *usability experts* evaluate the interface against a set of heuristics. Experts should be used because heuristics that are used may be too difficult for beginners to understand. It is unlikely that these techniques would be suitable for a summative evaluation of learning outcomes, although facilitators or content developers are probably carrying out an informal version of this test when developing material for inclusion in a e-learning environment (Dyson & Campello, 2003). According to Cuhadar, et al. (1999) the purpose of the expert evaluation is to get the opinion of persons skilled in the fields in question. These may include experts in the area of course content, in language and in technical design. It is the role of the content expert to ensure that all materials used and presented are not only correct, but up to date as well. The language expert is used to evaluate the appropriateness and correctness of the syntax and semantics used in the courseware. The purpose of the technical design expert is to make sure the materials are presented in both an aesthetically pleasing as well as functional manner.
- *Learner evaluation and revision*: The overall purpose of learner evaluation and revision is to determine the value and effectiveness of the e-learning environment (Cuhadar, et al., 1999). The goal is to obtain a measure of efficiency of the materials and how they are implemented.
- *Focus groups*: The purpose of a focus group is to receive input from learners as to their impressions of the functionality and usefulness of the instructional materials. The results obtained

from the focus groups are used to assist in ensuring a user-friendly and learner oriented design (Cuhadar, et al., 1999).

- *Beta-testing*: The underlying goals of beta-testing are to evaluate the materials as they have been implemented and determine their effectiveness. The importance of this type of testing is that it provides an early reading of how the students interact with the web site. This type of testing is completed earlier on to catch mistakes or difficulties, which may be experienced when accessing the site. The test is to be carried out with a group of learners, using the web materials for the first time. The beta-testers are then asked a series of questions in order to determine how the site initially performs in the field and then appropriate modifications are made where necessary.
- *Student evaluation:* This evaluation is used to determine the overall effectiveness of the materials and to determine to what extent the goals of the educational materials have been met. Questions such as, "Was the site an effective teaching instrument? "Were the materials theoretically sound?, and "Is it appropriate to teach such a course/module via the Internet?, are answered through this summative evaluation approach (Cuhadar, et al., 1999).

The second set of actions that is carried out is that of *quality assurance.* Quality assurance is necessary to ensure the continued delivery of a quality e-learning environment. Quality is defined in terms of *appropriate* and *complete* e-learning, with appropriateness and completeness to be adjudged by the faculty (Garson, 1999). The first action is to *set up a quality assurance plan*. As with all projects quality does not appear by itself, it is planned. This plan includes the metrics that is used to measure the quality of the e-learning environment, because quality is defined in terms of the *evaluation* of specific, measurable learning outcomes or competency-based objective (Garson, 1999). As in traditional courses, content of the objectives is the prerogative of the faculty member. Quality standards assess the objectives, not their content. The second action is to *execute the quality assurance plan*. A plan on its own is of no use and it is implemented to ensure that the services provided by the e-learning environment are of a high quality. Thirdly, *regular reports is generated and presented* to the stakeholders. These reports are generated and presented to the stakeholders so that the necessary corrective actions can be decided on, approved and taken. Lastly, all *required corrections to the e-learning environment* are made.

3.6 Summary

In this chapter a new EEDMs model, called the E-learning Dome, is discussed. This model consists of three layers: the *infrastructure layer* as foundation, the *e-learning administration layer* supported on the foundation, and the *Content Development layer* constructed on the administrative layer. The combination of these three layers is encompassed by the *quality dome,* which ensures that a quality e-learning environment is developed and maintained.

In the next chapter, the E-learning Dome will be evaluated as an EEDM, and sample methods for implementing each component of the E-learning Dome are presented.

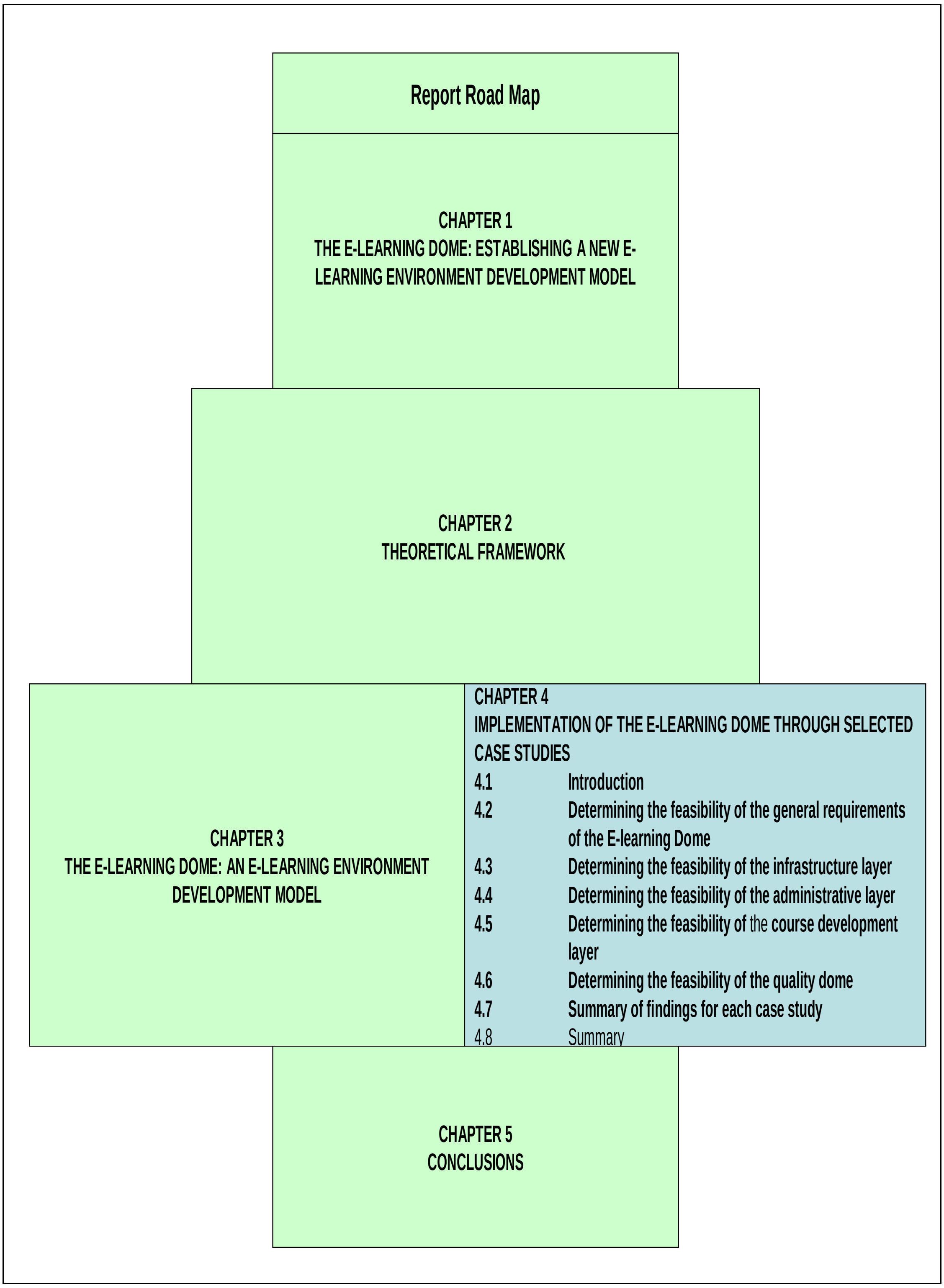

Figure 11: Layout of Chapter 4

4. Implementation of the E-learning Dome through selected Case Studies

4.1 Introduction

The research problem of this dissertation is to establish an e-learning development model that is scientifically irrefutable, sensible as well as practicable. I considered several e-learning models (in Chapter 2) to establish a set of requirements that such a development model should adhere to. Essential elements were extracted from existing models whilst at the same time these models were evaluated for their scientific quality as well as their practicality. In Chapter 3 these elements (summarised below) were introduced into the model that I developed in this research and called the E-learning Dome. Chapter 4 is not an exposé or appraisal of existing e-learning systems or development models, but concerns itself with implementation and deployment issues pertaining to the E-learning Dome. As shown in Chapters 1 and 2, there is presently no model that adheres to specific requirements, which can create an environment that is both scientifically sound as well as practical. I have already established (in earlier chapters) the requirement for such a model, but now want to show how it is possible and practical to implement each of the required elements by considering how these elements are already successfully deployed elsewhere. Although I briefly comment on weaknesses (with regards to the E-Learning Dome) of these deployments, the purpose of this discussion is not to highlight these limitations, but rather to demonstrate how it is possible to implement certain required components successfully (this may be considered in feature research).

For this purpose then, I regularly return to the basic requirements that were set in Chapters 2 and 3 with regards to implementation issues of the E-Learning Dome. For each section, I briefly summarise the basic requirements pertaining to the section heading, and then describe specific case studies that relate to these requirements.

In this Chapter I will first introduce the reader to the all the case studies measured against the general requirements established in Chapter 2. After that I look at the case studies that specifically pay attention to the elements included in the Infrastructure Layer, Administrative Layer, Content

Development layer and the Quality Dome of the E-learning Dome. I then summarise the findings. The case studies used are:

- the e-learning environment of the University of Vigo called *SimulNet*
- University of Mississippi's Virtual Campus
- University of Wisconsin-Stout's Asynchronous Learning Network
- the pilot course on *Introduction to MIS* at the College of Management at the University of Massachusetts
- City University of Hong Kong
- Boston University College of Engineering Distance Learning Initiative
- Open University of Catalonia
- Purdue University School of Engineering and Technology
- the University of Pretoria's virtual classroom
- University of Patras' Open and Distance Learning Centre
- Clemson University Graduate School
- The Indian government's VSAT system
- *Introduction to C Programming Course* of Cleveland State University
- the National Technical University of Athens
- the Universal College of Learning
- The Higher Access to Web based learning project of the Community University of North Wales

4.2 Determining the feasibility of the general requirements of the E-learning Dome

In summary, I consider the following requirements as fundamental to the E-learning Dome environment:

The implemented system should -

1. encourage a modular development approach,
2. distinguish between various constituent components of an e-learning environment and also facilitate generic groupings,
3. facilitate effective management of an e-learning environment development project,
4. cater for subject autonomy,
5. promote the best possible operational performance,
6. facilitate effective *quality* control of both the development and operational phases,

7. facilitate system fault reporting mechanisms, and
8. facilitate configuration management mechanisms during development as well as operational phases.

4.2.1 SimulNet

The first case study implementation that I consider is *SimulNet* (Anido, et al., 2001), which is developed and implemented at the University of Vigo. *SimulNet* follows the guidelines established by ADL SCORM[20]. Figure 12 illustrates the basic functioning of the *SimulNet* system. As depicted, several levels have been identified in the client and server interfaces showing the modular approach of this system. These levels interact with each other and through the Internet with levels at different interfaces.

SimulNet adheres to the first requirement as it is based on a modular development approach. This modularity enables the system to facilitate for both remote access to on-campus equipment as well as virtual access to simulation-based laboratories for practical training[21]. The *SimulNet* system consists of different modules (components) such as web-based interactive and collaborative business applications, *SimulNet* software components, services and COTS client components. Each of the modules can be developed and maintained individually which makes it easier to use. I believe the modularity requirement of the *SimulNet* system is well thought out and implemented successfully.

---

[20] The Advanced Distance Learning Sharable Content Object Resource Model that defines a Web-based learning Content Aggregation Model and Run-time Environment for learning objects and references interrelated technical specifications to bring together diverse and disparate learning content and products to ensure reusability, accessibility, durability, and interoperability. ADL SCORM is based on the AICC document *CMI Guidelines for Interoperability*.

[21] The specific description of the system as found in (Anido, et al., 2001) describes how the system is implemented for the Computer Science field of *Computer Architecture*, where practical training is a requirement.

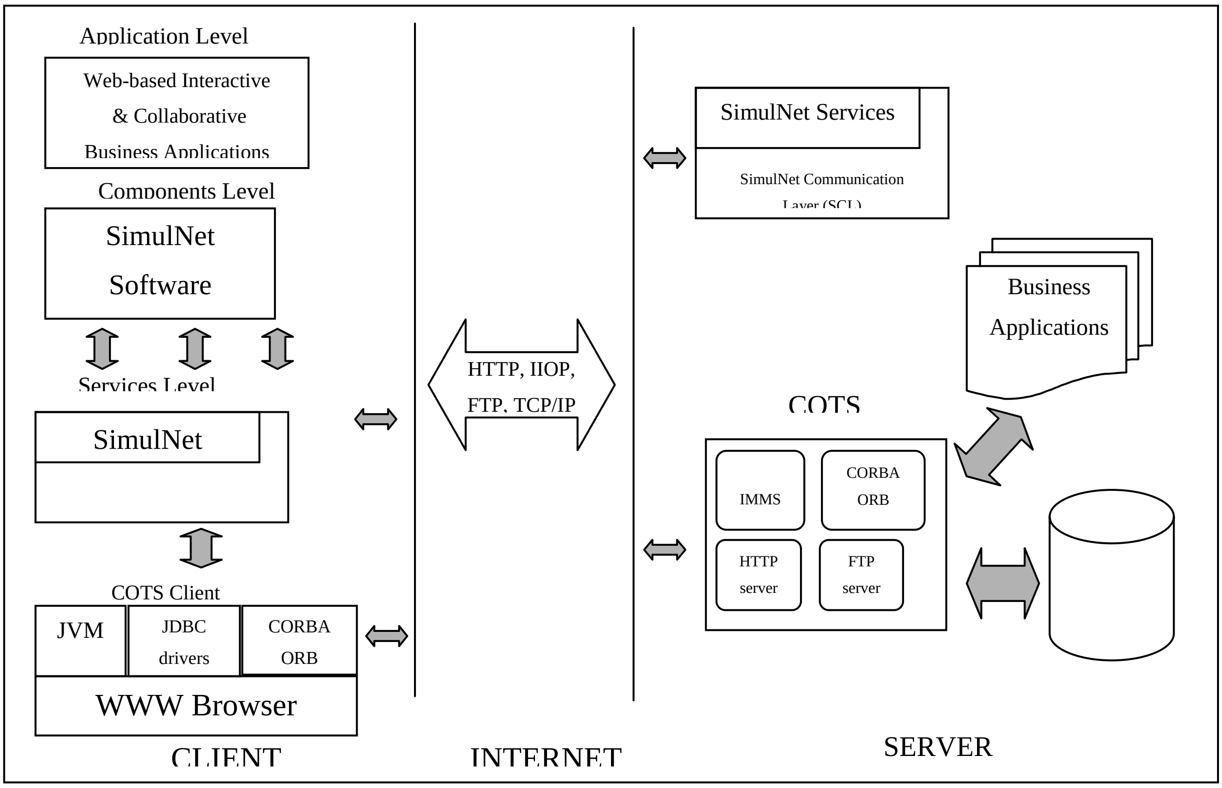

Figure 12: The basic functioning of the SimulNet system

Furthermore, *SimulNet* also adheres to the second requirement as it successfully distinguishes between various constituent components of an e-learning course and also facilitates generic groupings. This can be seen at course level by how learners are guided through the learning experience catering for simpler or more complex learning objects (depending on the cognitive level of the student), and how the simulators (or remote objects) execute, run and trace students' efforts. I am of the opinion that this requirement is implemented successfully and no further improvements can be suggested to the work done on the *SimulNet* environment.

Another constituent component is found at the administrative layer where *SimulNet* uses a Web-based run time environment that interfaces with assignable units that are launched from an underlying LMS. This works well in this environment and it is my opinion that it will work in other environments as well.

SimulNet also addresses the requirement for subject autonomy by allowing COTS components to be incorporated into the environment. Another factor that simplifies the inclusion of a number of different subjects is the fact that *SimulNet* can handle different file formats, such as http and ftp. I do not consider how other requirements as summarised in 4.2 are implemented in SimulNet, because in my view, SimulNet fail to address them.

4.2.2 University of Mississippi's Virtual Campus

The second case study implementation that I consider is *Virtual Campus*, which is developed and implemented at the University of Mississippi (Lawhead, 1997). *Virtual Campus* has the objective to provide the community college learners with engaging laboratories. Figure 13 illustrates the basic operational functioning of *Virtual Campus* by showing that a learner can interact with the system through courseware or a lesson that is connected to the SQL database through the script. A learner can also retrieve information through the HTML pages on the Internet. *Virtual Campus* adheres to the second requirement, as it addresses the components of flexibility, content and pedagogy. This is achieved through the thorough development of the courseware and lessons. The fact that lessons can be added without difficulty makes the system very flexible. It is my opinion that the use of HTML for the Internet pages makes it very adaptable and allows easy access for learners. The *Virtual Campus* also adheres to the fourth requirement by allowing any subject content to be included in the courseware and lessons component of the environment. Furthermore the *Virtual Campus* also adheres to the fifth requirement, which is the promotion of the best possible operational performance. This is done through the use of an SQL database to store information. The use of SQL makes it a database that can be created and modified without a large learning curve for the user of the database as SQL is a standardised, easy to learn, and easy to use language. SQL allows the user to write his or her own queries and makes it easier to use the database. In my opinion, this is a good feature as users can easily retrieve information on an ad hoc basis without learning a complicated programming language.

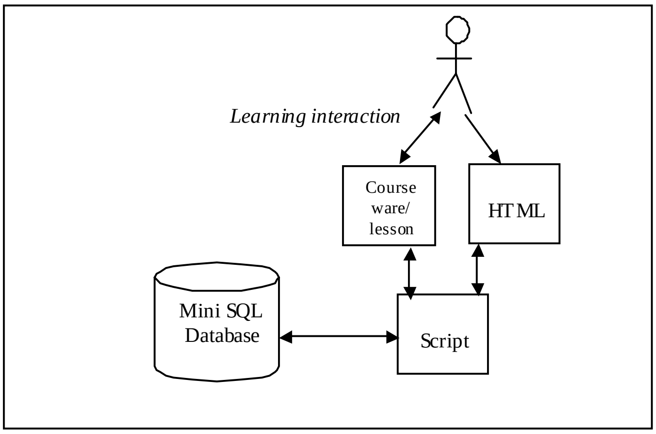

Figure 13: University of Mississippi Virtual Campus

4.2.3 University of Wisconsin-Stout's Asynchronous Learning Network

In the next case study, I describe the University of Wisconsin-Stout's (UW-Stout) involvement in developing its Asynchronous Learning Network (Holland, 2000).

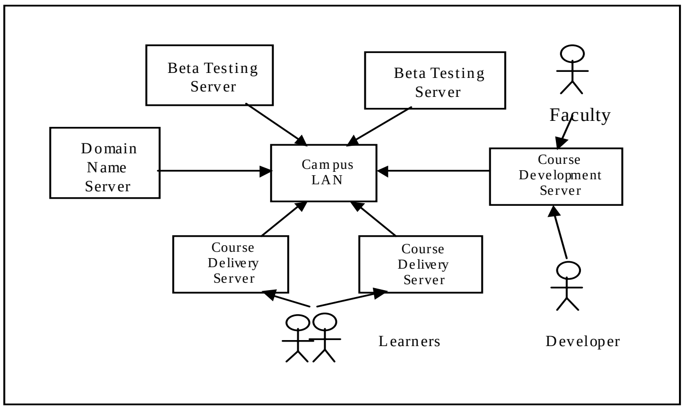

Figure 14: UW-Stout ALN

This ALN adheres to the second requirement as it distinguishes between the hardware, software, pedagogical and content components of the environment. Figure 14 shows the interaction in the system between the different servers and the campus LAN. Learners interact with the LAN through one of two course delivery servers, while the faculty and developers interact with the LAN through the course development server. Separating the development component from the delivery component and running it on different servers makes it easier to keep the development component secure. Furthermore, the development can be continued without affecting the course delivery. In my opinion, this is a good way of providing modularity to a system.

4.2.4 University of Massachusetts

The next case study is the pilot course on *Introduction to MIS* that is developed and offered as a non-credit course at the College of Management at the University of Massachusetts (Motiwalla, 2000). This e-learning environment addresses the first requirement (that of modularity) as it divides the environment into six different components that can be developed and maintained separately. This is a well-established method of developing interactive environments as it uses the same underlying principles as an e-commerce environment. It also adheres to the second requirement as it addresses the content, pedagogy and flexibility components of the e-learning environment. The content component is addressed by cells 4 to 6 the *internal informational cell* (that handles assignments, course notes, etc.), the *internal collaboration cell* (that handles chat rooms, conferencing boards, etc.) and the *internal transactional cell* (that handles the online examinations, course support material, etc.). The pedagogy component is addressed be cells 4 and 6 the *internal informational cell* and the *internal transactional cell*. The flexibility component is addressed by the fact that the environment can be adapted easily by just updating one or more of the cells. It is further addressed by the fact that it combines a variety of Internet technologies to augment the student learning process. More emerging applications in each of the six cell areas can be added to successfully implement e-courses.

4.2.5 City University of Hong Kong

In the following case study I look at an e-learning environment that is developed using the agent-based approach as proposed by Leung and Li (2001) for the City University of Hong Kong. The e-learning environment adheres to the first requirement which encourages a modular development approach as it consists of six agents, which are the Home-based Teaching Agent, Personal Profile Agent, Assessment Agent, Dynamic Study Plan Agent, Course and Study Material Design Agent and Home-based Learning Agent. The *Home-based Teaching Agent (HTA)* provides support for the stable interface elements to manage the interaction with the other agents. Furthermore, the *agent-based approach* also adheres to the second requirement as content, pedagogy and flexibility is addressed by the different agents. The Course and Study Material Design Agent address the content aspect, while the pedagogy the Home-based Teaching Agent, Assessment Agent and the Dynamic Study Plan Agent address aspect. Flexibility is provided by the fact that courses can easily added to the Dynamic Study Plan

Agent. Figure 15 gives an overview of how the agents interact. Facilitators and learners interact with the environment through the Internet, while most of the agents interact through the environment's data warehouse. In our opinion, making use of agents to implement different components is a good solution to the question of modularity.

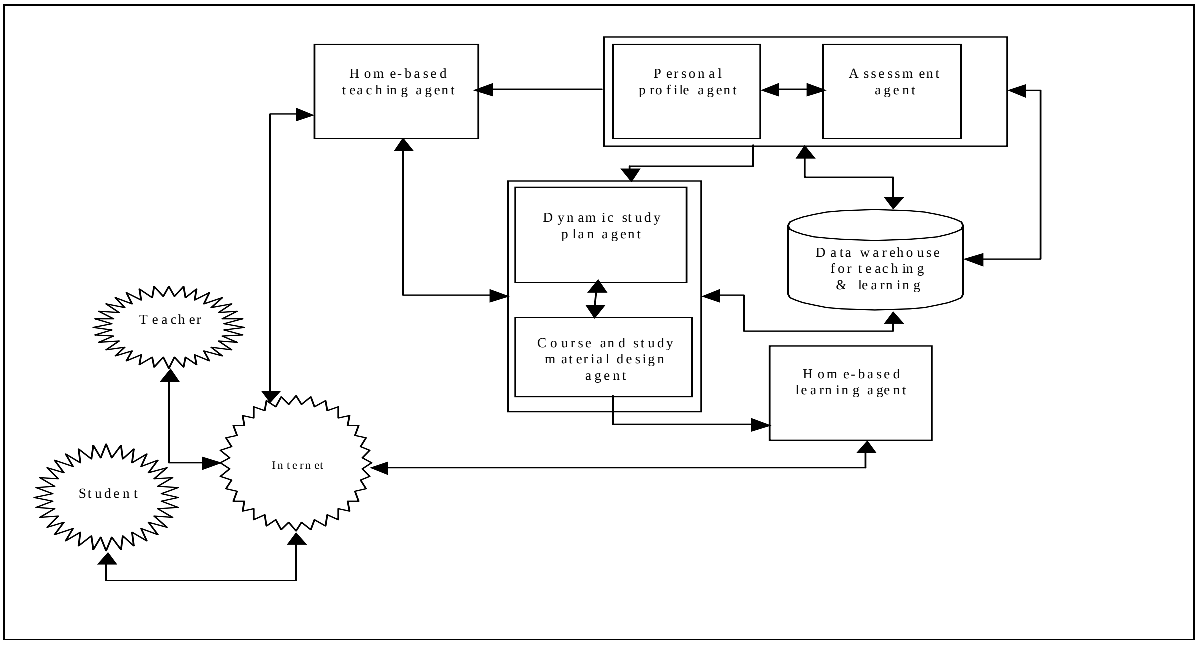

Figure 15: An agent-based approach to Internet online education

4.2.6 Boston University College of Engineering Distance Learning Initiative

The Boston University College of Engineering Distance Learning Initiative (DLI) integrates computers, digital video, and the Internet to deliver graduate degree courses in engineering to learners in companies distant from the Boston University campus (Brackett, 1998). A key objective of the DLI is to support learning wherever it is most convenient, whether by groups in a classroom, at the workplace desk, or at home. The DLI adheres to the second requirement by providing flexibility. The learner has a choice of where the learning process will be the most convenient for him/her to *attend* the class. It also adheres to the fifth requirement by providing the best possible operational performance for the high video quality used. A study was conducted to determine the best possible way to provide the video classes. Figure 16 shows the basic operations of the DLI. Learners connect to the LAN server, which is connected to the television, VCR and satellite dish. The use of satellite technology increases the number of learners that can be reached – the institution does not have to rely on an existing telecommunication infrastructure (like telephone lines to connect to the Internet Service Provider).

Learners in remote areas that have access to a satellite dish can register for courses and join classes through the satellite facility.

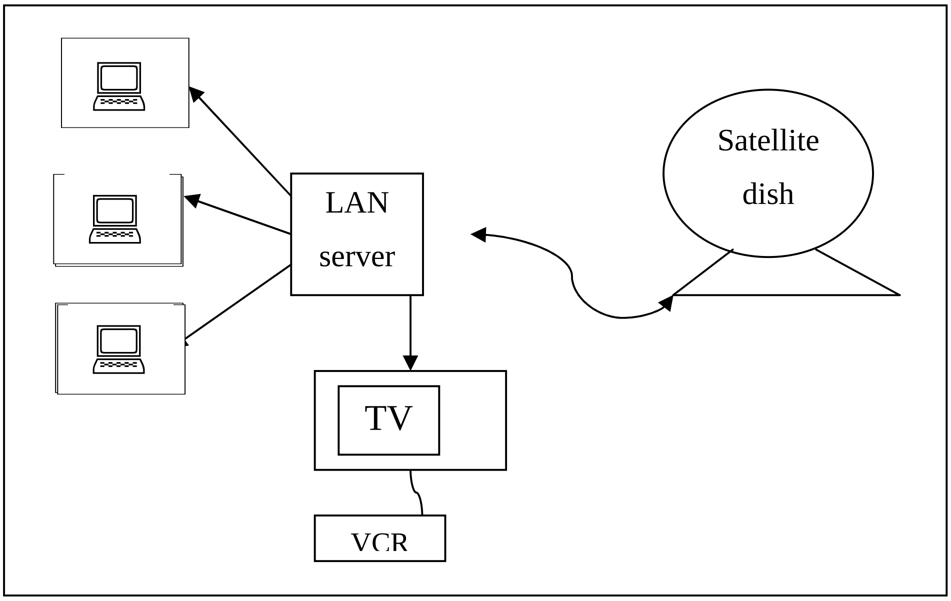

Figure 16: Boston University College of Engineering Distance Learning Initiative

4.2.7 Open University of Catalonia

The Open University of Catalonia (http://campus.uoc.es) created an e-learning environment that constitutes a large complex organisational virtual campus (Daradoumis, et al., 2001). The environment supports two subjects called Multimedia and Communication (MiC) and Information Structure (IS). The virtual campus adheres to the first requirement by offering a modular environment through three components, the Forum, the Debate and the Workspace.

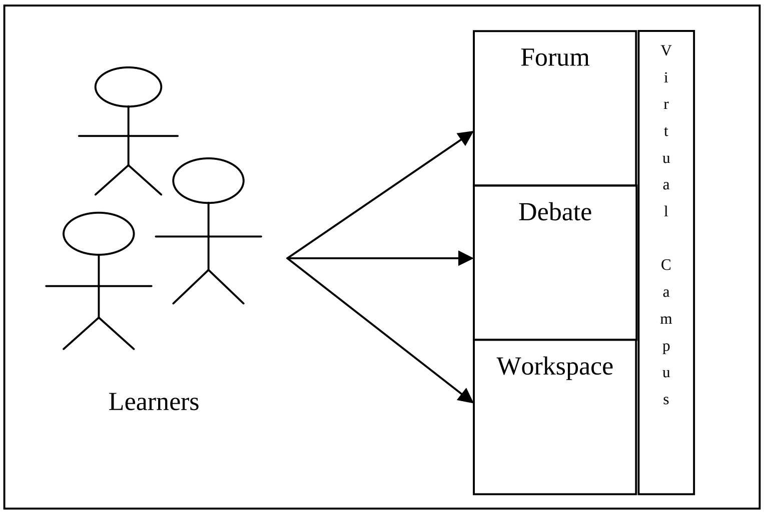

Figure 17: Open University of Catalonia

By addressing content and flexibility the virtual campus also adheres to the second requirement. The content component is addressed in the *workspace* where the course information is uploaded. The different components of the Virtual Campus make the way, in which learners interact with the environment, very flexible. The fourth requirement of content independence is also met by offering more than one subject. Figure 17 shows that the learner can interact with the virtual campus using the forum, debate or workspace.

4.2.8 Purdue University School of Engineering and Technology

The Purdue University School of Engineering and Technology, Department of Computer Technology, at the Indiana University Purdue University Indianapolis is involved in Webcasting[22] (Williamson, 1999). Webcasting courses use an interactive environment known as ClassCast, within the Oncourse environment, to involve distant learners in content presentations. The webcasting environment adheres to the first requirement, as it is modular. These modules are combined to form the ClassCast Web environment. It also adheres to the second requirement by providing flexibility. Facilitators can make use of a number of different media to present the course content, such as video clips, audio and text. This makes it possible to cater to different types of subject matter, which allows the environment to adhere to the fourth requirement as well. As can be seen in Figure 18 the environment exists of Audio IRC and Text IRC.

[22] live real-time streaming audio and video broadcasting over the Internet

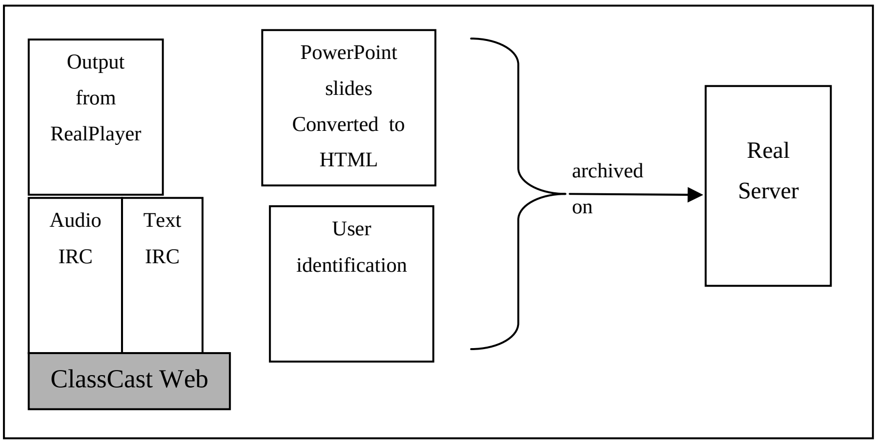

Figure 18: Purdue University School of Engineering and Technology ClassCast environment

4.2.9 University of Pretoria

The University of Pretoria presents a two-year tutored Master's degree in Computer-Assisted Education (Cronje & Clarke, 1999). One of the elective courses for the second year is a module on the use of the Internet in education and training (RBO880). For maximum authenticity, it is presented on the Internet by means of a *virtual classroom*, a computer accessible, e-learning environment attached to the WWW. This case study's e-learning environment adheres to the first requirement of modularisation as the virtual classroom consists of two parts: a web site and a listserver. The web site, which represents the physical part of the classroom consists of four sections, namely the blackboard and notice boards, the administrative section, the poster wall (with links to projects of previous students), and the learners' virtual desks. Each of the components can be maintained separately. In my opinion the virtual classroom components make it easy for learners to adapt to the new environment and it gives them a sense of ownership as they each have their own *desk*. The environment also adheres to the second requirement as it addresses the pedagogical and content components of an e-learning environment. The pedagogical component was addressed by developing a virtual classroom with virtual posters, virtual desks, and virtual portfolios. The events of a real classroom were mimicked with good pedagogic effect. The content component was addressed by encouraging learners to use the World Wide Web to gather and manage information relevant to the course.

4.2.10 University of Patras' Open and Distance Learning Centre

The University of Patras developed, and operates, an Open and Distance Learning Centre, and implemented the ODL program (Bouras, et al., 2000). The Open and Distance Learning Centre offers a number of curricula to undergraduate learners. The ODL program adheres to the first requirement of modularity as it consists of a number of independent modules that work together to form the e-learning environment. These modules are the databases, the environment (which in itself consists of several modules) and the learner, facilitator and administrator's computers. It also adheres to the second requirement by addressing the key components of an e-learning environment. These components are the flexibility of the system (e.g. the database management system that is separated from the learning environment) and the content (stored in the lessons database). Lastly, it adheres to the fourth requirement of subject independence as the e-learning environment caters for a number of different subjects. These subjects' course material is stored in the Lessons database. Figure 19 shows the general architecture of the Open and Distance Learning Centre. The Administrator gains access to the environment through the Web-based GUI, while the facilitator and learner can access the Web-based GUI, T-120 Server and the Media server. Through the GUI a person can access a chat server, e-mail server, the login procedure and a search engine that is connected to the DBMS through the interface.

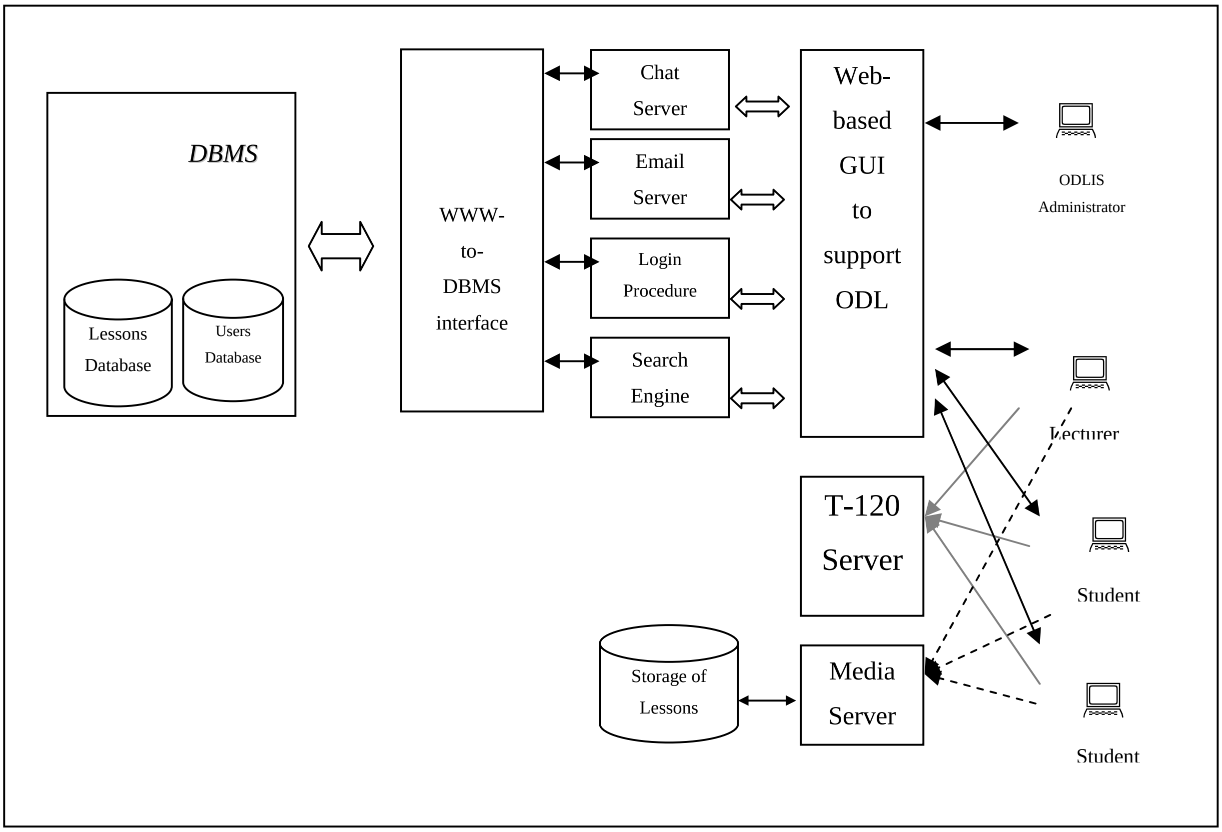

Figure 19: General architecture of the ODLIS environment

4.2.11 Clemson University Graduate School

Clemson University Graduate School in the USA makes use of hybrid audio-data collaboration to present a course called Statistical Methods (Freeman, Grimes & Holliday, 2000). This case study adheres to the first requirement of modularity and the second requirement as it addresses the different components of an e-learning environment. The environment (as seen in Figure 20) consists of several different modules, each which can be maintained separately, which makes it modular. The learner can link to the hybrid audio-data host through the telephone bridge or the Internet. This provides for the flexibility component of the second requirement. The hardware and software components are addressed by the hybrid audio-data host and their connections to the learners' classrooms. This e-learning environment has the drawback that it is not fully asynchronous, because it still requires learners to gather at specific times and specific places.

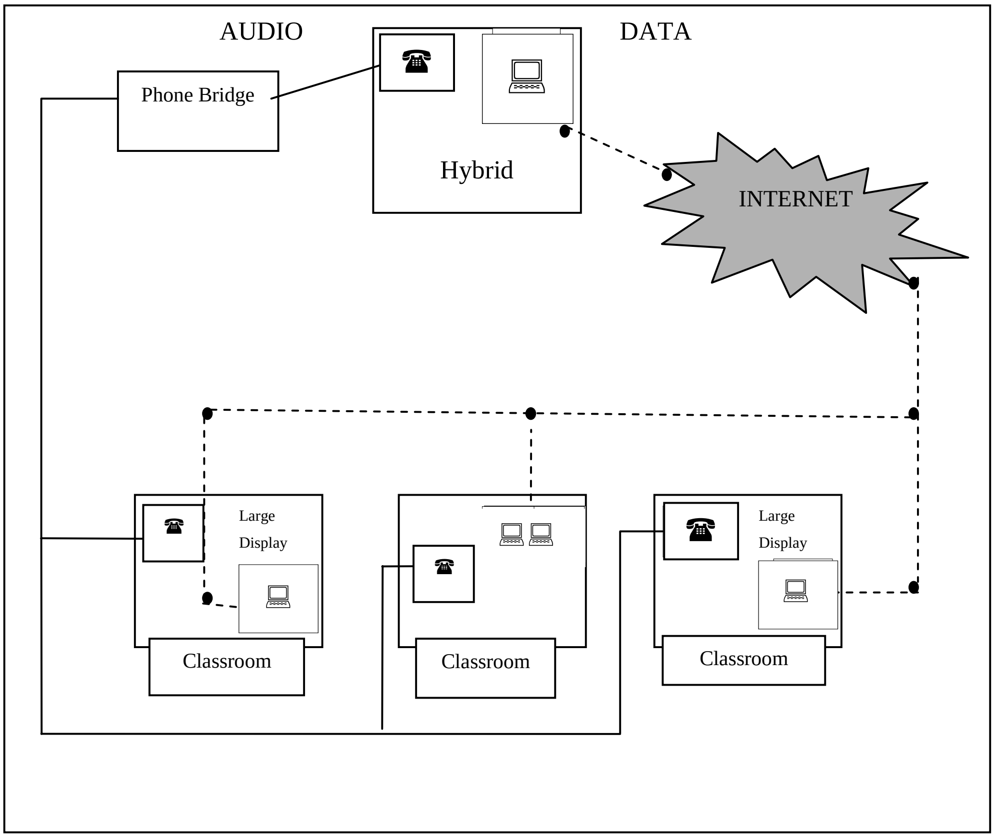

Figure 20: Typical Hybrid Audio-Data Connectivity

4.2.12 VSAT system

The Indian government makes use of the VSAT system for an e-learning environment to supplement their teacher's training (Sharma, 2000). This system adheres to the first requirement by being a modular system by making use of separate presentation centres, learning centres and delivery and interaction channels. In the event that one of the learning centres should experience technical difficulty it will not affect the other learning centres or the presentation centres. The flexibility component of the second requirement is adhered to by allowing learning centres to link to presentation centres either through satellite or through ISDN dial-up connections. The hardware component is also addressed by the use of a variety of hardware. It also adheres to the fourth requirement of subject independence by presenting a number of different subjects using the satellite technology. Making use of satellite technology allowed this institution to reach very remote areas where telephone communication infrastructure is not a given.

4.2.13 Cleveland State University

McIntyre and Wolff (1998) use interactive learning on the Web in an *Introduction to C Programming Course* taught in the Department of Computer and Information Science at Cleveland State University. This environment adheres to the first requirement by addressing the modularity of e-learning environments as it consists of different modules. Figure 21 shows how that the client machine interacts with the server machine through a browser and downloadable web pages. The e-learning environment makes use of the World Wide Web because of a number of reasons such as the fact that it is highly accessible (learners can dial in any time and from anywhere), it is platform independent and it is well established and it is relatively permanent. In our opinion, this environment is a good example of an entry-level environment – it does not involve huge development costs or expertise in using a specialised tool.

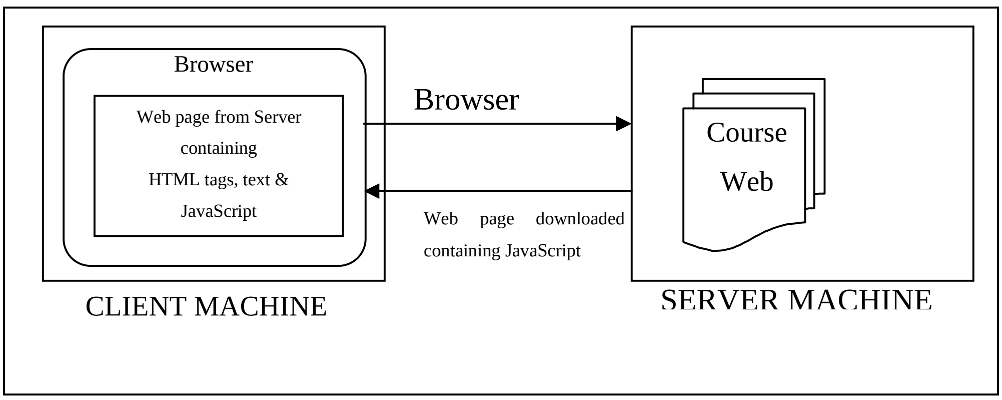

Figure 21: Web pages downloaded from server to client

4.2.14 National Technical University of Athens

An e-learning environment was developed and evolved at the National Technical University of Athens (NTUA), Greece to support an introductory course in software engineering (Psaromiligkos & Retalis, 2002). This case study addresses the need for *configuration management* in an e-learning environment. It does that by incorporating software configuration management from the very beginning of the development. After the first *evolution*/*draft* of the environment learners evaluated it. Using this feedback the second evolution was created and evaluated, etc. The environment also addressed the first requirement for modularity by dividing the environment into three components, namely the *human part* (which includes the facilitators, learners and administrative staff), the *webware* (which consists of everything related to the course material) and the *technological infrastructure.* The technological infrastructure is divided into *common infrastructure* such as laboratories, libraries and the LAN and WAN, and the *special infrastructure*, which is the software tools, needed to create the environment and courseware and the course management system (WebCT in the case of the NTUA).

4.2.15 Universal College of Learning

Nichols (2002) from the Universal College of Learning (UCOL) was involved in a project where Blackboard was adopted as the Learning Management System. The use of Blackboard limits the functionality of this environment, because it does not help in the creation of multimedia resources which forms an important part of e-learning. In our opinion this is a good method to use for institutions that want to start up an e-learning environment, though once the e-learning environment is established and the learners become more sophisticated the institution needs to address the lack of multimedia resources by investing in another learning management system. In this project the focus was on the quality of the instruction environment, which addresses the sixth aspect which is *quality control*. The quality assurance system (QAS) developed by UCOL was developed with its primary aim being to ensure process accuracy. To develop the QAS the procedures for quality assurance was created. Four distinct procedures where created: the training process, the consultancy and training process, the full project process and the minor/single task project process. Each process has an activity flow chart and set of steps that show what each step needs to achieve, who is involved, who is responsible, the format of the activity, a list of things to be aware of during the step and a list of key tasks that need to be performed in that step. Key tasks have check boxes next to them so that quality can be assured throughout the process and a documented track of progress is kept. In our opinion, this is an excellent way to ensure quality.

4.2.16 University of North Wales

The Higher Access to Web based learning (HAWL) project supported e-learning in the Community University of North Wales (CUNW). The project aimed to implement and evaluate e-learning for several modules developed by the CUNW (Smart & Holyfield, 2001). The environment was adapted for use in several of the modules developed by CUNW, which addresses the *subject independence* aspects of e-learning environments. It also addresses the flexibility component of requirement two as the institution attempts to create more flexible learning opportunities for their learners.

Table 8: General Requirements Matrix

	SimulNet	Virtual Campus	UW-Stout	University of Massachusetts	City University of Hong Kong	Boston University College of Engineering DLI	Open University of Catalonia	Purdue University	University of Pretoria	University of Patras ODL	Clemson University Graduate School	VSAT system	Cleveland State University	National Technical University of Athens	UCOL	HAWL
A modular development approach	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓
Constituent components of an e-learning environment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓
Effective management of an e-learning environment development project																
Subject autonomy	✓	✓					✓	✓		✓		✓				✓
Best possible operational performance		✓				✓										
Effective *quality* control of both the development and operational phases															✓	
System fault reporting mechanisms																
Configuration management mechanisms																

4.3 Determining the feasibility of the infrastructure layer

As mentioned in Chapter 3, the purpose of the Infrastructure layer is to guide the EED in identifying the hardware, software and communication technology components based on a basic underlying framework for the e-learning environment. A number of important factors that I described for the required infrastructure layer include:

1. Identification of hardware.
2. Identification of software.
3. Identification of communication technology. Specifically, a distinction was made between synchronous and asynchronous communication technologies.
4. Selected components should be evaluated in terms of realistic goals and performance measures.
5. The inclusion of effective system fault reporting mechanisms.
6. Establishment of configuration management procedures for components on this layer.

4.3.1 SimulNet

I again consider *SimulNet*, as described earlier. *SimulNet* proposes a client / server architecture. At the structure level, an analogy between component and tool (auditing tool, e-mail, bulletin board, chat, whiteboard, agenda, project management, event delivering, producer-consumer manager…) is present in the project. *SimulNet* was developed using a component-based approach. Its components provide plug and play communication and collaboration tools. Collaboration is allowed at software and user level. *SimulNet* also provide interactivity, which is designed to guarantee a quick response to any action performed by the user. In terms of software, *SimulNet* relies on commercial-of-the-shelf (COTS) services and standard Internet protocols. On the client side, basic user interfacing and connectivity is provided by a standard WWW browser (e.g. Netscape Communicator of Microsoft Explorer) with some embedded capabilities: a Java Virtual Machine, drivers for the Java database Connectivity, and a CORBA object request broker (ORB). On the server side, HTTP and FTP servers, a CORBA ORB, and a Database Management System are used to provide access to the *SimulNet* database. Regarding the network protocols, the services use HTTP, FTP, Internet Inter-ORB Protocol, and TCP/IP. No mention is made that any evaluation methods had been used to evaluate the *SimulNet* environment components. This seems to be a shortcoming of the development process of *SimulNet*. Furthermore, no fault reporting mechanism is included in the environment and no configuration management procedures are stipulated.

4.3.2 University of Mississippi's Virtual Campus

The *infrastructure* of the University of Mississippi's *Virtual Campus* is based on a small computer laboratory to develop the master facilitator's lessons. Two high-end personal computers are used, one to develop the lessons and the other as a server. The development platform runs Windows NT and the server runs a public domain operating system, Linux. Although the *Virtual Campus* was developed and tested for Netscape Browsers, it can be viewed in any Internet Browser that supports VRML.

4.3.3 University of Wisconsin-Stout's Asynchronous Learning Network

The initial infrastructure of the UW-Stout's ALN is based on a client-server configuration. Since the first course was in Lotus Notes, and since no Web-accessible version of Lotus LearningSpace was available at that time, learners used personal computers with Lotus Notes clients in personal computers laboratories. Lotus LearningSpace became Web-accessible in January 1996, and learners have a choice of accessing the ALN via the Internet or via a Lotus Notes client. This places an additional responsibility on the course designer, because multimedia attachments need to be created twice, once for Lotus Notes client access and once for Web access.

4.3.4 University of Massachusetts

For the *Introduction to MIS*-pilot course, Motiwalla (2000) specifically describes the case of Web applications such as Chat rooms, Conference-boards, and White-boards for each course module, as elements of the *communication technology component* of the infrastructure.

4.3.5 City University of Hong Kong

The infrastructure architecture of the City University of Hong Kong case study is based on three tiers, the client, the Web server, and the database. All three tiers can be on one machine, or they can be spread over the network on different machines. The *client* part is responsible for the presentation of data, receiving user events and controlling the user interface. The *web server* handles all communication with the client and handles most of the communication with the database. The *database* part is responsible for data storage, and supports an Open Database Connectivity (ODBC)[23] interface. The *HLA* is a general interface that provides support to the stable interface elements to manage the

[23] ODBC is a Microsoft established standard that enables software developers to create applications that can work with a number of SQL-based data sources.

interaction with other agents. This addresses the *communication technology component* of the *infrastructure layer* of the E-learning Dome.

4.3.6 Boston University College of Engineering Distance Learning Initiative

The Boston University College of Engineering DLI integrates computers, digital video, and the Internet to deliver graduate degree courses in engineering to learners in companies distant from the Boston University campus. The DLI uses direct broadcast satellite video technology to provide sufficient performance (throughput, delay, and delay jitter) for the high video quality necessary to transmit instructional materials like text, sketches, and facilitator nuances.

4.3.7 Open University of Catalonia

The Open University of Catalonia created an e-learning environment that constitutes a large complex organisational virtual campus. This case study shows how the *communication technology component* of the *infrastructure layer* of the E-learning Dome can be implemented. Learners are in permanent contact with University services, facilitators and other learners from their home, via a Virtual Campus (on the Internet) and a personal computer.

4.3.8 Purdue University School of Engineering and Technology

The Purdue University School of Engineering and Technology, Department of Computer Technology, at the Indiana University Purdue University, Indianapolis, is involved in Webcasting. This is another example of how the *communication technology* component in the *infrastructure layer* of the E-learning Dome can be implemented. The interactive environment ClassCast is a web window containing five frames. One frame contains the output from RealPlayer, thus presenting the audio and video output of the live class. A second frame involves push technology. In this frame, PowerPoint slides that have been converted to HTML format are presented, which supports course content, and are pushed to any virtual learner logged on to the ClassCast environment during Webcasting of a presentation. The third and fourth frames consist of Interactive Relay Chat formats where distant learners can respond to audio questions from the facilitator or where they can present typed questions to the facilitator, who then can respond either verbally or via a typed response. All presentations utilising Webcasting are archived and stored on a Real Server so that class presentations are available twenty-four hours a day, seven days a week, for review by all learners.

4.3.9 University of Pretoria

Referring to the University of Pretoria case study, the learners participate in the virtual classroom by constructing their own web sites in response to the course objectives. The static web site is supported by a dedicated electronic mail server which re-distributes messages to all participants, enabling online discussions. The virtual classroom has two components: Web site and listserver. The web site represents the physical portion a real classroom and the listserver allows the interpersonal interaction that occurs in a classroom. The virtual classroom contains a blackboard and notice boards, and links to subject matter and web site construction programs such as graphic and hypertext markup language (HTML) editors. Each learner also has a virtual desk. Each learner is assigned a WWW directory that is linked to a desk graphic. What distinguishes this classroom is that learners do not only find information on the WWW, but generate their own web pages as part of their individual and collaborative projects. This is an example of how the *communication technology component* of the *infrastructure layer* of the E-learning Dome can be implemented.

4.3.10 University of Patras' Open and Distance Learning Centre

In the first phase of the ODL program of the University of Patras' Open and Distance Learning Centre, three curricula were implemented; two for undergraduate studies and one for postgraduate studies. In particular, a postgraduate curriculum on Special Themes on Computer Science and undergraduate curricula on Computer Science and Neuro-Science are operated. All the curricula use both asynchronous and synchronous lectures.

4.3.11 Clemson University Graduate School

The Clemson University Graduate School case study addresses a possible implementation of the *communication technology component* of the *infrastructure layer* of the E-learning Dome. The facilitator maintains a learner oriented World Wide Web with course administrative data, background information and instructional content. The facilitator also posts the presentation graphics used, and the whiteboard annotations made during each lecture, to create an asynchronously accessible record of the synchronously delivered courseware.

4.3.12 VSAT system

The VSAT system used by the Indian government is an example of how a satellite can be implemented as the *communication technology component* of the *infrastructure layer* of the E-learning Dome. The system configuration consists of presentation centres, learning centres and delivery and interaction channels. Learning centres are equipped with dish/antenna and receiver with delivery channel, television receiver with digital video and audio input, and learner interactive terminals. The learning centre system is controlled and supervised by the site control computer. This computer provides communications multiplexing-demultiplexing, voice message compression-decompression and data management. Presentation centres contain a presentation studio, database, helpdesk and network controller. A common database of all system information and transactions is maintained on a server. The presentation studio is equipped with 3 cameras, graphics computer, interactive presentation computer, cassette player/recorder, vision and sound mixing and communications equipment. Access to voice, fax and message interactions in the database are through the presentation computer. Interaction through the interactive channel is by two-way audio and video. At some learning centres VSAT satellite transmissions are used, while at others, ISDN dial-up channels are used.

Table 9: Infrastructure Layer Matrix

	SimulNet	Virtual Campus	UW-Stout ALN	University of Massachusetts	City University of Hong Kong	Boston University College of Engineering	Open University of Catalonia	Purdue University	University of Pretoria	University of Patras ODL	Clemson University Graduate School	VSAT system
Identification of hardware.	✓	✓				✓						
Identification of software.	✓	✓	✓					✓	✓	✓		
Identification of communication technology. Specifically, a distinction was made between synchronous and asynchronous communication technologies.	✓			✓	✓		✓	✓	✓		✓	✓
Selected components should be evaluated in terms of realistic goals and performance measures.												
The inclusion of effective system fault reporting mechanisms.												
Establishment of configuration management procedures for components on this layer.												

4.4 Determining the feasibility of the administrative layer

As described in Chapter 3, the purpose of the E-learning Administration layer of the E-learning Dome model is to guide the EED in identifying the management and administrative support functions for the *e-learning environment*. These support functions include:

1. project management,
2. configuration management,
3. learner registration and finances,
4. processing learner submissions,
5. managing deliveries to learners, and
6. general administration issues.

4.4.1 SimulNet

The only project management deployed in *SimulNet* is the component oriented towards the management of projects carried out by a group of students. No project management is implemented with the development and maintenance of the environment. No configuration management is included in the *SimulNet* environment. The aspects of learner registration and finances, and general administration issues are not dealt with directly in *SimulNet*. The management of deliveries is handled by the LMS and submissions take place through e-mail.

4.4.2 University of Mississippi's Virtual Campus

Before a learner from the University of Mississippi's *Virtual Campus* can access the actual lessons on a campus, that learner should enroll for the course and be given a user ID and a password by the course facilitator for that lesson. The logon information is used as a key to the learner database stored on the server. Once the learner begins the lesson, start and stop times for each segment are recorded. Quiz records are also maintained in the database. A grade book is created for each facilitator with whatever information the facilitator requests. This facility assists with the registration of students, the processing of submissions and other general administration tasks.

4.4.3 University of Massachusetts

Considering the pilot course on *Introduction to MIS,* this *course's administration* is facilitated by access to online examinations, performance tracking, assignment submission, and links to the digital library, as well as a frame that provides access to applications, such as the logon prompt for registered learners to enter the online course area and hyperlinks to relevant Usenet and List-Servers for global interaction, online registration and admissions information.

4.4.4 City University of Hong Kong

As discussed in section 1, the City University of Hong Kong's e-learning environment consists of a number of agents. The administration of the e-learning environment is based on the *Personal Profile Agent*, which manages all learner information. The *Dynamic Study Plan Agent (DSPA)* addresses the *delivery component* of the course *administration layer* by requesting information from the *Personal Profile Agent* and *Assessment* on prerequisites and learning sequences. The *Data Warehouse for Teaching and Learning* is a central storage area for the administration of items such as the course material, learner profile, assessment result, learner study plan, and knowledge rules.

4.4.5 Cleveland State University

The Cleveland State University case study is an example of how the *delivery component* of the *administration* of the E-learning Dome can be implemented using JavaScript and HTML, which allows the ability to program executable functions on the local client computer. A web page contains text-formatting commands and possibly JavaScript commands, both implemented via HTML tags. JavaScript provides the ability to dynamically (possibly through user interaction) create a web page at the local client computer. It also provides for general administration tasks.

Table 10: Administrative Layer Matrix

	SimulNet	Virtual Campus	University of Massachusetts	City University of Hong Kong	Cleveland State University
Project management	*				
Configuration management					
Learner registration and finances		✓	✓		
Processing learner submissions			✓		
Managing deliveries to learners	✓	✓	✓	✓	✓
General administration issues		✓	✓	✓	✓

4.5 Determining the feasibility of the Content Development layer

As described in Chapter 3, the Content Development layer guides the EED in the development the *e-learning course content.* Required aspects to be addressed include

1. appropriate authoring tools
2. additional course development tools if required
3. design of specific content units, which includes processes such as
    a. determining the source, or sources, of the content,
    b. acquiring the relevant study material,
    c. ensuring the study material is suitable to use in the e-learning environment developed,
    d. incorporating the e-learning content into the e-learning environment.
4. content delivery and learner interaction mechanisms
5. appropriate assessment procedures

4.5.1 SimulNet

SimulNet illustrates the necessity of including an authoring tool in their system – it has included an authoring tool that adheres to the requirements set for the Content Development layer of the E-learning Dome. The authoring tool supports the design and creation of learning contents, the definition of the static and dynamic course structure, and the creation of tests and questionnaires. Assessment procedures exist therefor in the form of tests and questionnaires. The use of the authoring tool allows the definition of simple and complex prerequisites and completion rules. No mention is made of additional course development tools included in *SimulNet*. Interaction in *SimulNet* is provided through the use of a whiteboard, e-mail, chat and a bulletin board. In this environment both content and content management are clearly separated in order to get interoperability between different content management systems. The learning management system (LMS) sends data to contents with necessary information to launch a lesson. Content provides LMS with information about student progress, test results, etc. These data allow the LMS to both track student progress and make routing decisions through the course.

4.5.2 University of Mississippi's Virtual Campus

In the University of Mississippi's *Virtual Campus*, the *content development layer* of the E-learning Dome is addressed by the creation of lessons that appear to be created using Virtual Reality Markup

Language (VRML). The final campus is managed totally by scripts written in C and C++ so that many of the features used in traditional HTML page design and viewed on Internet browsers are not available. This process also allows many features to appear in the lessons that would not ordinarily be possible. For instance, the answers to the quizzes can be randomised so that learners working side by side will have *different* correct answers. According to the developers of this project only scripts and databases could provide them this level of flexibility.

The *assessment procedure* aspect of the *Virtual Campus* is addressed by the five different quiz formats that are used. This was done to illustrate to future developers the flexibility of the system. The designing facilitator determines the format of a quiz for a lesson. All pedagogical issues for each lesson are the responsibility of the designing facilitator. The designing facilitator (at lesson creation time) can choose to have a quiz in a traditional manner, e.g., the lesson text is no longer viewable, or the learner can be taken back to a text segment when a wrong answer is presented or finally, all quiz exercises can be complete and the frames can be used as another tutorial event. The wrong answers can be highlighted and the appropriate lesson text can be presented. If the facilitator prefers, the glossary box can even include explanations about the wrong or inappropriate answer.

4.5.3 University of Wisconsin-Stout's Asynchronous Learning Network

The UW-Stout case study, as discussed earlier, addresses the *assessment component* of the E-learning Dome's *content development layer* with the use of a Web-based assessment tool, Question Mark, to deliver their quizzes, tests, self-assessment, and surveys. This tool allows UW-Stout to create assessments that learners can use to evaluate their own progress, and also as a learning tool. In addition, courses include case studies, projects, written assignments, presentations, and research activities as a basis for evaluating learner performance. Frequent quizzes and self-assessments are also included. The assessment tool provides a mechanism to randomly generate the quizzes and tests so that each learner would have a unique test instrument.

4.5.4 University of Massachusetts

The University of Massachusetts case study addresses the *development of external content* aspect of the *Content Development layer* of the E-learning Dome. The registered learners, with username and password, can access internal contents.

4.5.5 City University of Hong Kong

In the City University of Hong Kong case study the *Assessment Agent (AA)* provides assessment for learners. This agent addresses the *assessment component* of the *content development layer* of the E-learning Dome by providing two types of assessment. The first provides the assessment to learners prior to admission, and the second provides the ongoing assessments during the studying period. The *Course and Study Material Design Agent (CSMDA)* manages all course materials and information. The materials may contain graphics, sound, and video. It is stored in a central database for future development of course material.

4.5.6 Cleveland State University

The Cleveland State University case study is an example of how the *content development layer* of the E-learning Dome can be implemented using JavaScript and HTML.

Table 11: Course Development Layer Matrix

	SimulNet	Virtual Campus	UW-Stout ALN	University of Massachusetts (MIS)	City University of Hong Kong	Cleveland State University
Appropriate authoring tools	✓					
Additional course development tools if required						
Design of specific content units, which includes processes such as - determining the source, or sources, of the content, - acquiring the relevant study material - ensuring the study material is suitable to use in the e-learning environment developed - incorporating the e-learning content into the e-learning environment	✓	✓		✓		✓
Content delivery and learner interaction mechanisms	✓					
Appropriate assessment procedures	✓	✓	✓		✓	

4.6 Determining the feasibility of the quality dome

As described in Chapter 2, the purpose of the Quality Dome is to guide the EED in the development and implementation of a quality system for the e-learning environment. To achieve this purpose, I described the primary quality control measures to include 1) the initial and subsequent evaluation of all entities that are subject to quality control, and 2) the carrying out of quality assurance activities. I also distinguished between *summative* and *formative* evaluation measures. *Summative* evaluation is usually conducted at the end of a programme to measure the success or failure thereof, while *formative* evaluation usually estimates the significance of the programme during its operational life. Finally, I also stressed the importance of other quality measures such as *usability*, which measures effectiveness, efficiency and satisfaction, and also *flexibility* in course delivery, as well as in the entire e-learning dome environment. I concluded our discussion on evaluation requirements by considering a number of methods that is used to conduct evaluations, including interpreting results, process evaluation, subjective and objective evaluation, expert and user evaluation, learner evaluation and revision, focus group evaluation and beta testing.

4.6.1 SimulNet

The literature on the *SimulNet* environment does not mention the evaluation of the entities that are subject to quality control, neither the carrying out of quality assurance activities. However, basic evaluation was carried out when its developers performed general performance surveys among 180 learners, and also collected data from the information generated by *SimulNet's* auditing tool. According to this data, there was a general improvement in learners' theoretical examination results. The number of learners who succeeded in the theoretical examination increased by 14%. In the practical examinations, 81% of the grades for learners who attended the traditional laboratory were at least a *B*. This percentage was 84% for those using the educational platform. This indicates that the performance of these *telelearners* was at least as good as that of the *conventional learners.* Most learners used the virtual laboratory in the evening, and after everyday activities. Electronic mail is the communication tool that learners mostly use. The facilitator starts most conversations (65%) between a facilitator and a learner. 91% of the learners rated the communication tools as good, or very good, while 94% of the learners rated the system as a whole as good, or very good. Interactivity and the collaborative feeling this platform provides are the most outstanding features. Finally, learners were asked if this approach to practical training indeed helped to understand the theoretical concepts. The results were coherent with the result of the corresponding examinations, and only 7% of the learners considered that SimulNet did not contribute to their learning process.

Although the collection of data was gathered by the auditing tool, this can, to a certain extent, be considered as formative evaluation, since the processing of the gathered data only took place at the end of the learning period. By assessing the evaluation activities, it appears that *SimulNet* implements mostly summative evaluation measures. It also appears that the issues of usability and flexibility are vaguely touched on by questions on whether the *SimulNet* approach to practical training helps to understand the theoretical concepts.

4.6.2 University of Mississippi's Virtual Campus

The University of Mississippi's Virtual Campus evaluation was implemented by asking the learners to evaluate each lesson pedagogically, and they were also asked to proof-read each section. The discussions that followed each evaluation period were lively and provided the designers and the developers with a rich source of information that was used for lesson improvement. The facilitators were asked to carefully evaluate each lesson for accuracy and completeness. The data collected on the comment sheets was evaluated for incorporation into the final lessons. A round table discussion was held after each lesson was evaluated, so that a consensus could be reached about any changes that needed to be made. Each lesson was then modified as per the results of the evaluation and round table discussion processes. The issues of *flexibility* and *usability* are not addressed. *Formative* and *summative* evaluation was used.

4.6.3 University of Massachusetts

The e-course *Introduction to MIS*, presented at the University of Massachusetts, was evaluated with a pilot study to measure learner perception of the learning process with this e-course environment. All learners participating in the pilot study were provided with a username and password to access the material from the course and participate in the discussion board conference and chat room. At the end of six weeks, learners were surveyed through a questionnaire. Learners were adult learners, with an average age of 37 years, and a full-time working experience of 15 years. None of the learners had participated in a DL course before, while 11 learners were somewhat familiar with the Internet environment and had a total or average of 8 years of computer experience before taking the course. 44% of the learners were neutral on the course expectations and 41% were satisfied with this e-course.

The majority of learners were satisfied with their material presentation (53%) and course methodology (56%). The majority would take another course in the Virtual Campus environment (56%) and would also recommend the Virtual Campus environment to their friends (56%). With regards to the quality of the distance education environment, 61% of learners liked the self-paced learning aspect, flexibility, and learning from anytime and anyplace. 44% thought the quality of time they could spend on learning were better from the relaxed atmosphere of their homes. For discussions, learners preferred the asynchronous discussion boards (25%) to the synchronous chat room (13%). 79% of the learners liked the ongoing discussion with their classmates. Learners also reported liking the ability to communicate with other classmates from the home page. They were neutral on the quality of the classroom discussion, feedback and responses from facilitators and fellow classmates, even though they were not in a face-to-face environment. Learners rated the opportunity to take this course on the Internet highly, as it provided them with flexibility in accessing the material when they had free time from anywhere. Both *summative* and *formative* evaluation was used for evaluation. Specific mention was made of *flexibility* but usability was not addressed.

4.6.4 University of Pretoria

With reference to the University of Pretoria case study, the results of seven learners in the same year of study were compared with the results of three previous modules that they completed with the same course facilitator. There is some overlap between the distribution of the results of the RBO course and those of the other courses, although the mean and median of the RBO course were below those of two of the other courses. For four of the seven learners, the RBO mark was their best or second best result out of the four courses. Learners considered that their marks were a fair reflection of their knowledge and abilities.

4.6.5 Clemson University Graduate School

When the performance of the learners using the Clemson University Graduate School e-learning environment were compared with learners that take the same subject in a face-to-face class, the comparison showed that there is no significant difference in the results of the two different groups.

4.6.6 Cleveland State University

As mentioned previously, the Cleveland State University case study used two introductory C programming classes, one using the WWW interactive learning tool and the other not, to evaluate the e-learning environment. Both classes were given the same quiz on C pointers during classroom time following the learning process. While the experiment involved only two classes, it is clear from the results that the ability to leisurely interact with several examples out of classroom time appeared to significantly raise grades on the identical quiz. The learners in the class using WWW interactive learning were surveyed after taking the in-class quiz on C pointers. The survey was unstructured with no leading questions and simply asked the learners to assess the benefits and disadvantages of WWW interactive learning on C pointers in their learning experience. The learners unanimously felt that introducing WWW interactive learning, as a supplement to in-classroom learning, was significantly beneficial to their individual learning process. In particular, the following opinions about WWW interactive learning were frequently expressed:

- learners could leisurely review the step-by-step tracing of code related pointers,
- 75% of the respondents indicated that WWW interactive learning should not replace in-classroom learning, while the remaining 25% made no comment regarding this issue,
- it was an easier, fun way of learning complex issues,
- it allows a learner to thoroughly explore a large number of troublesome issues with feedback - such depth of coverage would not be possible in limited classroom time,
- it is convenient to use the Internet from the home or office to access the WWW interactive learning environment, and
- it clarified difficult issues in the literature.

Often several fellow learners would practice WWW interactive learning sessions together and discuss results. The evaluation that was conducted was only summative as it was conducted after the experiment was completed. The issues of *flexibility* and *usability* were not addressed and no formative evaluation was conducted.

4.6.7 National Technical University of Athens

The National Technical University of Athens' project incorporated configuration management, which can be implemented in the *configuration management component* of the *quality dome layer* of the E-learning Dome. The first version of the environment was evaluated in 1997. After its first evaluation, a new development process started in order to implement the necessary changes as suggested by the results from quantitative and qualitative analyses of learners' feedback. The second version was evaluated in 2000. After this evaluation a number of minor changes were made to the environment. The evolution history of the e-learning environment for the introductory course in software engineering counts three versions, which can be characterised as revisions in terms of configuration management terminology. The common parts of the configurations between subsequent versions denoted the reusability of resources, as well as the need for version management. For example, the transition of common content between the subsequent versions of the WebCT environment was done by using the backup/restore features of the system, albeit a primitive function. Both *formative* and *summative* evaluations were used. No specific mention was made of *usability* or *flexibility*.

4.6.8 Universal College of Learning

UCOL’s project focussed on the quality of the instruction environment, which addresses the *quality assurance component* of the *quality dome* of the E-learning Dome. The e-learning quality assurance system has the primary aim of ensuring process accuracy. Each stakeholder in the project was considered for every stage of quality assurance development. The quality assurance system exists in the context of other policies and sector documents, particularly those of QAANZ (Quality Assurance Association of New Zealand), APNZ (the Associated Polytechnics of New Zealand), internal systems (particularly those of UCOL's Curriculum and Academic Services) and UCOL's strategic direction. The latter is particularly important as it serves to give an overall direction to e-learning development.

Creating the actual quality assurance procedures was the most time consuming step. It required the creation of quality assurance procedures that:

- are workable (flexible), while still producing a firm set of steps to ensure quality,
- are self-correcting,
- are consistent with the aim, objectives and core values of the eCampus initiative,
- take the interests of all stakeholders into consideration, and
- are compatible with the existing systems of UCOL and other relevant bodies.

E-learning pilot programmes present opportunities to gain experience in the area of development. The pilot programmes resulted in the creation of four distinct quality assurance procedures:

- the training process - quality assurance for the e-learning environment,
- the consultancy and training process,
- the full project process - used in the development of courses into an RBL (resource-based learning) mode, and

- the minor/single task project process - a *catch-all* process that ensures quality in additional activities such as resource digitisation.

These procedures ensure that quality can be assured throughout the process and a documented track of progress is kept. They also call for a time of reflection on the overall training/project to ensure that experience is learnt from and documented. The reflection stage also provides opportunity for review of the quality assurance procedures themselves. This means that evaluation takes place during the process and afterwards - thus *formative,* as well as *summative,* evaluation takes places. The issue of *flexibility* is also addressed.

4.6.9 University of North Wales

The HAWL project is aimed at implementing and evaluating e-learning for several modules developed by the CUNW (Smart & Holyfield, 2001). This case study addresses the *continuous evaluation component* of the *quality dome* in the E-learning Dome. The project began by developing a simple e-learning environment, which attempted to model what happens in face-to-face teaching. The use of the HAWL e-learning environment was evaluated with tutors and learners on the Studying in Higher Education module. The online materials section included details about the course, learning outcomes and assessment methods, as well as an extensive area of study skills resources. The discussion area was used to set tasks, share resources, and reflect on activities. The learners weren't actually assessed online, but via a reflective journal which was assessed at the end of the module.

Evaluation of the use of the HAWL e-learning environment was carried out by a combination of quantitative and qualitative techniques. In the evaluation of this case study, the issue of *usability* was addressed by the following topics that were chosen for evaluation:

- access,
- ease of use,
- usefulness, and
- opinions about e-learning and the internet

The following evaluations were carried out:

- pre-module questionnaire to assess confidence and access to computers,
- post-module questionnaire to assess access and use, and

- post-module interviews and focus groups to discuss ease of use, usefulness, and opinions about e-learning.

These evaluations are both *summative* and *formative.*

In general the learners and tutors found the system to be easy to use. Those that accessed the materials from home (80%) liked the flexibility of being able to work from home and to have access to materials when they were carrying out assignments. All the learners used the HAWL e-learning environment, predictably some more than others. The HAWL project found that the biggest determining factors on usage were how much time the staff and learners had available, and whether there was a need to use the system.

Table 12: Quality Dome Matrix

	SimulNet	Virtual Campus	University of Massachusetts	University of Pretoria	Clemson University Graduate School	Cleveland State University	National Technical University of Athens	UCOL	HAWL
Evaluation of quality control aspects							✓	✓	✓
Quality Assurance		✓					✓	✓	✓
Summative		✓	✓	✓		✓	✓	✓	✓
Formative	✓	✓	✓		✓		✓	✓	✓
Usability	*								✓
Flexibility	*		✓					✓	✓

4.7 Summary of findings for each case study

4.7.1 The SimulNet environment

In our opinion, SimulNet has successfully implemented some aspects of the e-learning dome. E-learning dome aspects that were not addressed that could improve the system's effectiveness and usefulness, include the effective management of the e-learning environment using a project management tool, the use of configuration management, and making use of quality assurance and fault reporting. Other aspects that can be addressed are the development of additional content, and delivery and learner interaction mechanisms.

4.7.2 The University of Mississippi's Virtual Campus

The University of Mississippi's Virtual Campus has, in our opinion, successfully implemented a substantial number of aspects of the e-learning dome. One of the aspects that are not addressed is the fact that the e-learning environment does not support modular development. This could cause problems when the environment should be extended to incorporate new courses, or to handle a growing number of students. Another aspect that is not addressed is that of effective management of the e-learning environment's development. The environment might have problems dealing with a variety of subject matter, as it does not appear to be subject independent. Quality assurance is also not addressed.

4.7.3 The UW Stout e-learning environment

The UW Stout e-learning environment has implemented some of the e-learning dome aspects, but gives no indication of any evaluation that was performed or how it should be performed. Other aspects of the e-learning dome that are not addressed – and which can improve the e-learning environment significantly – are the following: quality assurance, configuration management procedures, the effective management of the e-learning environment, and administration aspects.

4.7.4 College of Management at the University of Massachusetts

The pilot course developed by the College of Management at the University of Massachusetts successfully implements a number of aspects of the e-learning dome, especially those addressing the administration and quality layers of the dome. Other aspects that can improve the effectiveness of the environment include the proper management of the environment, configuration control, and fault reporting.

4.7.5 City University of Hong Kong

The e-learning environment of the City University of Hong Kong successfully implemented several of the aspects of the e-learning dome; especially those dealing with content development, delivery and administration. To add to the effectively of the environment, the following aspects should, in our opinion, be addressed: the formal evaluation of the environment to ensure the best possible operational performance and quality at all times, configuration management and fault reporting, as well as flexibility and usability aspects to allow the environment to be subject independent.

4.7.6 The Boston University College of Engineering DLI

The e-learning environment of the Boston University College of Engineering implemented several of the aspects that are addressed by the Infrastructure layer of the e-learning dome. Shortcomings, in our opinion, include the lack of quality control and evaluations. Other aspects that can be addressed are configuration management, project management and fault reporting procedures.

4.7.7 Open University of Catalonia

The Open University of Catalonia's virtual campus successfully implemented some of the infrastructure aspects of the e-learning dome. It is our opinion however that this e-learning environment should address the aspects of quality assurance, configuration management and fault reporting. Further improvements can be achieved by addressing the aspects included in the Administration layer of the e-learning dome.

4.7.8 Purdue University

The Purdue University's e-learning environment implemented some of the Infrastructure layer aspects. There are some aspects that they should, in our opinion, include to promote the best possible operational performance. These aspects include the management of the development process, configuration management and fault reporting, and evaluation and content development should also be addressed.

4.7.9 The University of Pretoria

The e-learning environment of the University of Pretoria successfully implemented a number of aspects from the e-learning dome. Quality assurance aspects, configuration management and the management of the development process are lacking, in our opinion. The administration of the environment should also be addressed.

4.7.10 The University of Patras' Open and Distance Learning Centre

The Open and Distance Learning Centre of the University of Patras implemented several aspects of the e-learning dome, especially concerning the communication aspect of the Infrastructure layer. In our opinion, the aspect of content development – especially the development of additional content and the inclusion of external content – needs to be addressed. Other aspects that need to be included are project management, configuration management and fault reporting.

4.7.11 Clemson University Graduate School

Clemson University Graduate School's e-learning environment implemented some of the aspects from the Infrastructure layer of the e-learning dome as well as some evaluation aspects. The environment will be improved, in my opinion, by addressing the development of content, administration and quality assurance. Configuration control and the management of the development process can also be addressed.

4.7.12 The VSAT System

The VSAT e-learning environment of the Indian government successfully implemented the hardware aspect of the Infrastructure layer of the e-learning dome. By addressing the evaluation of the environment, quality assurance and configuration management the environment will, in my opinion, be improved remarkably. Furthermore, the aspects regarding administration of the environment and content development should also be addressed.

4.7.13 Cleveland State University

Cleveland State University successfully implemented a substantial number of aspects of the e-learning dome in their e-learning environment. Aspects that need to be addressed, however, are project management, fault reporting, configuration management and quality assurance.

4.7.14 The National Technical University of Athens

The National Technical University of Athens successfully implemented a number of aspects from the e-learning dome in their e-learning environment, especially configuration management and evaluation of the environment. Other aspects that need to be included, in our opinion, are quality assurance, content development and the infrastructure.

4.7.15 The Universal College of Learning

The e-learning environment of the University College of Learning implemented the quality assurance and evaluation aspects of the e-learning dome very successfully. In our opinion, the aspects of infrastructure, administration and content development need to be included, as well as project management and configuration control.

4.7.16 The Higher Access to Web-based Learning project

The Higher Access to Web-based Learning project successfully implemented the quality assurance and evaluation aspects of the e-learning dome. Aspects that should be addressed, in my opinion, include the infrastructure, project management, configuration management, content development and administration.

Table 13: Summary of comparison between case studies and E-learning Dome elements

	SimulNet	Virtual Campus	UW-Stout ALN	University of Massachusetts	City University of Hong Kong	Boston University College of Engineering DLI	Open University of Catalonia	Purdue University	University of Pretoria	University of Patras ODL	Clemson University Graduate School	VSAT system	Cleveland State University	National Technical University of Athens	UCOL	HAWL
GENERAL REQUIREMENTS																
A modular development approach	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓
Constituent components of an e-learning environment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓
Effective management of an e-learning environment development project																
Subject autonomy	✓	✓					✓	✓		✓		✓				✓
Best possible operational performance		✓				✓										
Effective *quality* control of both the development and operational phases															✓	
System fault reporting mechanisms																
Configuration management mechanisms																
INFRASTRUCTURE LAYER																
Identification of hardware.	✓	✓				✓										
Identification of software.	✓	✓	✓					✓	✓	✓						
Identification of communication technology. Specifically, a distinction was made between synchronous and asynchronous communication technologies.	✓			✓	✓		✓	✓	✓		✓	✓				
Selected components should be evaluated in terms of realistic goals and performance measures.																
The inclusion of effective system fault reporting mechanisms.																
Establishment of configuration management procedures for components on this layer.																
ADMINISTRATION LAYER																
Project management	*															
Configuration management																
Learner registration and finances		✓		✓												
Processing learner submissions				✓												
Managing deliveries to learners				✓	✓								✓			
General administration issues				✓	✓								✓			
CONTENT DEVELOPMENT LAYER																
Appropriate authoring tools	✓															
Additional course development tools if required																
Design of specific content units	✓	✓		✓									✓			
Content delivery and learner interaction mechanisms	✓															
Appropriate assessment procedures	✓	✓	✓		✓											
QUALITY DOME																
Evaluation of quality control aspects														✓	✓	✓
Quality Assurance		✓												✓	✓	✓
Summative		✓		✓					✓				✓	✓	✓	✓
Formative	✓	✓		✓							✓			✓	✓	✓
Usability	*															✓
Flexibility	*			✓											✓	✓
Total Number of Elements included	14	11	4	11	6	3	4	5	5	4	4	4	5	5	6	9

4.8 Summary

In this chapter I looked at a number of case studies of e-learning environments to determine of each of the elements of the E-learning Dome discussed in Chapter 3 can be implemented in real life. I found that most of the e-learning environments in the case studies support a modular development approach, include most of the constituent components of e-learning environments and include one or more communication technologies. There are a number of aspects that were not addressed by any of the case studies. These aspects include fault reporting mechanisms, performance measurement and configuration management. The other aspects are all addressed by at least one of the e-learning environments. I therefore concluded that there is enough evidence that it is possible to use the E-learning Dome to develop a successful e-learning environment.

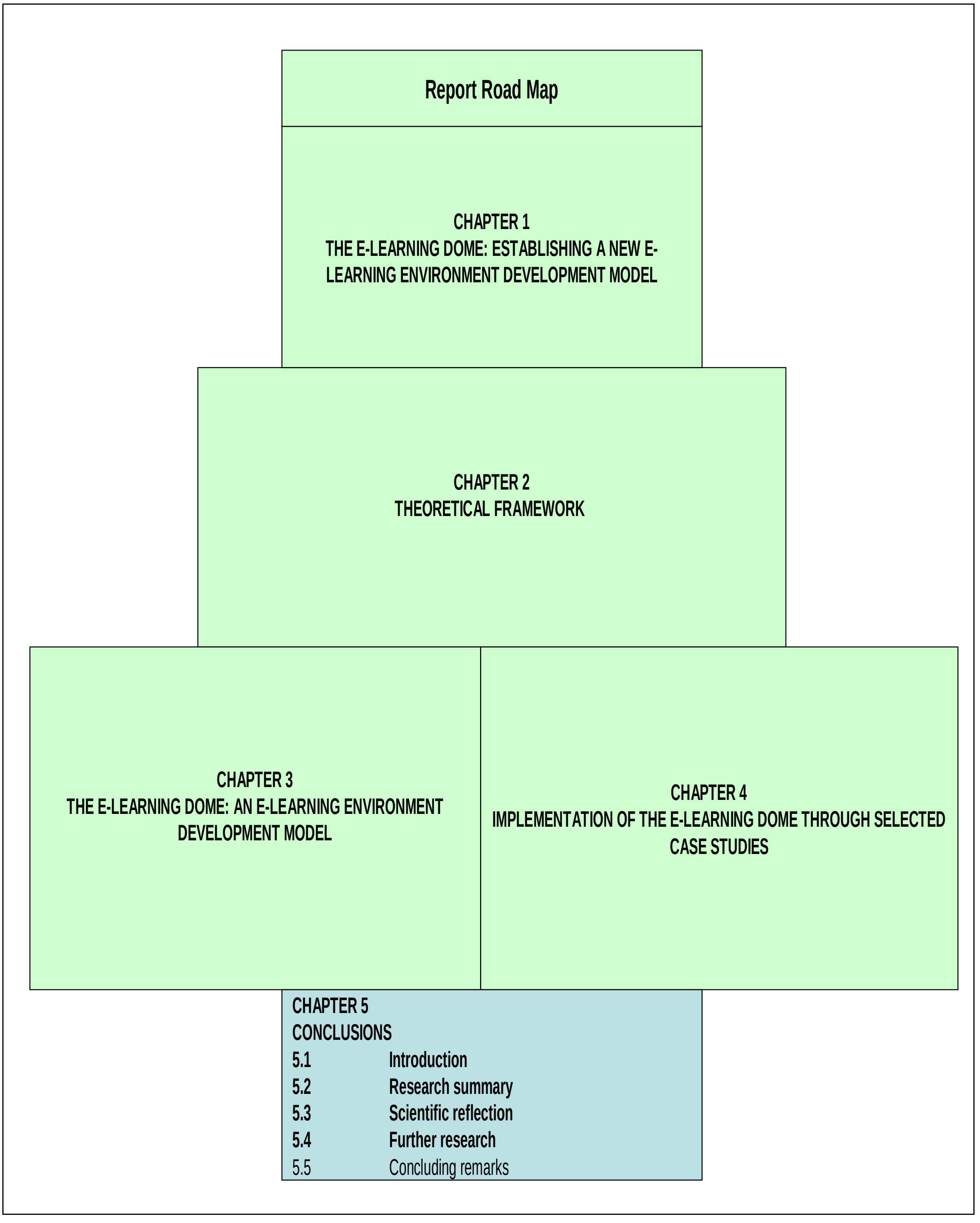

Figure 22: Layout of Chapter 5

5. Conclusions

5.1 Introduction

In this final chapter a summary is given on the research done in this study. Section 5.2 gives a summary of the different issues related to the research questions, followed by a discussion on the contribution in section 5.3. Section 5.4 gives some recommendations for further research followed by some concluding remarks in section 5.5.

5.2 Research summary

The main research question was defined as - What is the structure of the EEDM? This question was divided into three sub-questions, which are:

1. What are the requirements of a development model?
2. What lack in current development models?
3. What elements are included in the structure of the e-learning environment model?

Question 1 was answered in section 2.2 where the following requirements were established:

- the model should facilitate the effective management of an e-learning course development project,
- the model should recognise the existence of the various constituent components and elements of an e-learning course and should facilitate their generic grouping,
- the model should provide for a modular approach in the selection of the components for an e-learning course,
- the model should ensure subject independence,
- the model should ensure the best possible performance of the e-learning course,
- the model should facilitate effective quality control of the e-learning course development project, and of the implemented e-learning course,
- the model should facilitate system fault reporting, and
- the model should facilitate configuration management of the e-learning course components and elements, both during development and operation.

Question 2 was answered in section 2.4 and 2.5 by discussing five EEDMs and then comparing them with the requirements established in section 2.2. In this comparison the following was significant:

- In the *Electronic Education System Model* no provision is made for project management (requirement 1). Through the different layers and the evaluation plane this model addresses all the elements of an e-learning environment - the second requirement. This model consists of layers that make it a modular system and which facilitates modification to suit different user environments. The use of objects further increases the modularity (requirement 3) of the Electronic Education System Model. This model has generic characteristics that is used to develop e-learning environments over a wide spectrum of subject material (requirement 4). As deliverables of only two layers of the model are evaluated, decisions made concerning the other two layers cannot be evaluated or verified. This only partially fulfills requirement 5, which is performance. No explicit provision is made for quality assurance (requirement 6), and no mechanism is provided to report any system faults (requirement 7). No provision is made for configuration control or management (requirement 8).
- Project management (requirement 1) is included in the *EcoSystem Model* as part of the Learning Design System. This model addresses all the elements of an e-learning environment (requirement 2), except continuous evaluation. This model is modular, because it consists of three different levels, each consisting of different tools, and it can be used in different user environments. This addresses requirement 3. It is possible to use this model to generate an e-learning environment irrespective of the subject material (requirement 4). The evaluation of the model's deliverables is not included in the model, which means that requirement 5 (performance) is not addressed. No explicit provision is made for quality assurance (requirement 6), fault reporting mechanisms (requirement 7) and configuration management (requirement 8).
- No provision is made for project management (requirement 1) in the *E-education Framework*. This model addresses all the elements of an e-learning environment (requirement 2), except continuous evaluation. The model consists of a vertical and horisontal category that forms cells (or modules), which makes it a modular model and thus adheres to requirement 3. This model can be applied on any subject material (requirement 4). Requirements 5 (performance), 6 (quality assurance), 7 (system faults reporting mechanisms) and 8 (configuration management) is not addressed by this model.

- The *Demand Driven Learning Model* makes no provision for project management (requirement 1). The model provides for all the elements that are included in an e-learning environment, by means of layers and the ongoing evaluation activities and so adhere to requirement 2. It also adheres to requirement 3 (modularity of the model) as it consists of three main constructs that are supported by the superior structure and continuous evaluation construct. The model can be utilised to implement any e-learning environment irrespective of the subject matter (requirement 4). Evaluation (requirement 5) is covered by the continuous evaluation construct. Quality assurance (requirement 6) is addressed in the ongoing adaptations and improvement construct of the e-learning environment. The model provides for continual adaptation and improvement, which implies that there should be a mechanism to report faults in the e-learning environment as thus, addresses requirement 7. The existence and detail of such a mechanism are not reported in the description of the model. No configuration management (requirement 8) is included in the model.
- The *ODLIS Model* makes no provision for project management (requirement 1). This model addresses all the elements of an e-learning environment (requirement 2), except continuous evaluation. ODLIS consists of three tiers and three modules, which makes it modular and so adheres to requirement 3. The model is used for the development of an e-learning environment irrespective of the subject matter (requirement 4). No evaluation measures were developed for this model and thus do not adhere to requirement 5. No explicit quality assurance processes (requirement 6), fault reporting mechanisms (requirement 7) or configuration management (requirement 8) are included in the model.

Table 14 gives a summary of what lack in each model and it can be concluded that only one evaluated model adheres to requirement 1 (project management). All the evaluated models adhere fully or at least partially to requirements 2 (elements of e-learning) and 3 (modularity). All but one model adheres to requirement 4 (subject independence). Only two evaluated models adheres to requirements 5 (performance) and 6 (quality assurance) and only one to requirement 7 (system fault reporting). None of the models adhere to requirement 8 that deals with the configuration management of e-learning environments.

Table 14: Summary of what lack in each model

	Project management	Elements of e-learning	Modular system	Subject independence	Performance	Quality assurance	Report system faults	Configuration management
EESM	×						×	×
EcoSystem					×	×	×	×
E-education Framework	×				×	×	×	×
DDLM	×							×
ODLIS	×			×	×	×	×	×

Question 2 was further addressed in section 2.3 and the basic structural elements, or *building blocks* were established:

- the *Infrastructure Building Block*, which addresses the hardware and system software infrastructure of the e-learning environment;
- the *E-learning Tools Building Block*, which addresses the specific tools, mechanisms, services, media, and support software that are used to develop and present the e-learning environment;
- the *Administration Building Block*, which addresses all administrative matters related to developing, implementing, and managing an e-learning environment;
- the *Instructional Interfacing Building Block*, which addresses the incorporation of the instructional material into the e-learning environment, and the methods and procedures of enabling effective interaction between the e-learning environment and the e-learner; and
- the *Quality Assurance Building Block*, which addresses matters related to the continuous evaluation and quality control of the e-learning environment.

Question 3 is answered in chapter 3 where I developed a new EEDM called the E-learning Dome, which incorporates all the building block given above.

In chapter 4 the feasibility of implementing the E-learning Dome is tested by looking at how each of its elements was implemented in existing e-learning environments.

5.3 Scientific reflection

In answering the research questions I suggested an EEDM that consists of three layers and a dome encompassing these layers. A graphical presentation of the model can be seen in Figure 23.

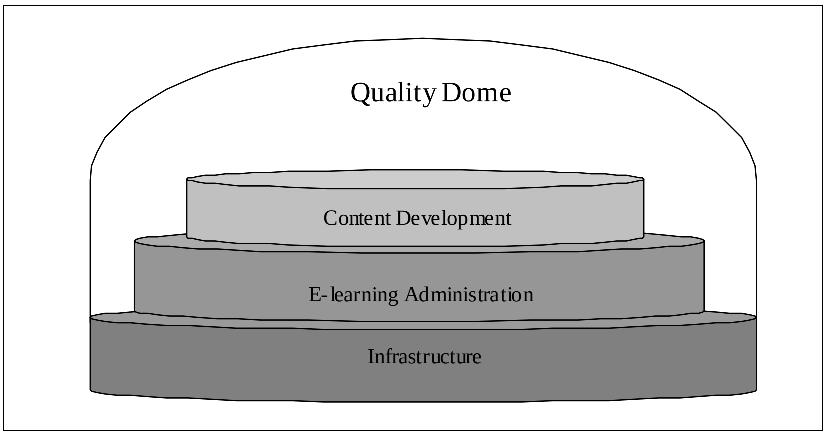

Figure 23: The E-learning Dome

The first of the three layers are the Infrastructure layer that includes the identification of relevant hardware to be used, the identification of relevant software to be used, and the identification of required communication technology. The second layer is the E-learning Administration layer that address management and administrative matters such as the application of project management procedures during the development of the e-learning environment, the application of configuration management procedures during the e-learning environment, the overseeing of the learner registration process, the establishment of procedures for submissions by learners, the establishment of procedures for the delivery of assignments to learners, and the definition of procedures to manage finances related to the e-learning environment. The third layer is the Content Development layer that includes the development of e-learning course content and the development of assessment procedures for the specific course. The Quality Dome include the application of quality control measures both during the development and operation of the e-learning environment, the development and application of system fault reporting procedures, and the development and application of procedures to take corrective actions.

The feasibility of each of these components where determined by looking at case studies of e-learning environments that are already developed. The results are shown in Table 15. From this it can be established that none of the e-learning environment looked at included a component for project management, configuration management, performance measurement and the reporting of system faults.

My contribution to the scientific body of knowledge is two-fold: firstly, it is the identification of the characteristics that should be included in an e-learning environment and secondly, the identification of a feasible EEDM called the E-learning Dome.

Table 15: Summary of feasibility study

	SimulNet	Virtual Campus	UW-Stout ALN	University of Massachusetts	City University of Hong Kong	Boston University College of Engineering DLI	Open University of Catalonia	Purdue University	University of Pretoria	University of Patras ODL	Clemson University Graduate School	VSAT system	Cleveland State University	National Technical University of Athens	UCOL	HAWL
GENERAL REQUIREMENTS																
A modular development approach	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓
Constituent components of an e-learning environment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓
Effective management of an e-learning environment development project																
Subject autonomy	✓	✓					✓	✓		✓		✓				✓
Best possible operational performance		✓				✓										
Effective *quality* control of both the development and operational phases															✓	
System fault reporting mechanisms																
Configuration management mechanisms																
INFRASTRUCTURE LAYER																
Identification of hardware.	✓	✓				✓										
Identification of software.	✓	✓	✓					✓	✓	✓						
Identification of communication technology. Specifically, a distinction was made between synchronous and asynchronous communication technologies.	✓			✓	✓		✓	✓	✓		✓	✓				
Selected components should be evaluated in terms of realistic goals and performance measures.																
The inclusion of effective system fault reporting mechanisms.																
Establishment of configuration management procedures for components on this layer.																
ADMINISTRATION LAYER																
Project management	*															
Configuration management																
Learner registration and finances		✓		✓												
Processing learner submissions				✓												
Managing deliveries to learners				✓	✓								✓			
General administration issues				✓	✓								✓			
COURSE DEVELOPMENT LAYER																
Appropriate authoring tools	✓															
Additional course development tools if required																
Design of specific content units	✓	✓		✓									✓			
Content delivery and learner interaction mechanisms	✓															
Appropriate assessment procedures	✓	✓	✓		✓											
QUALITY DOME																
Evaluation of quality control aspects														✓	✓	✓
Quality Assurance		✓												✓	✓	✓
Summative		✓		✓					✓				✓	✓	✓	✓
Formative	✓	✓		✓							✓			✓	✓	✓
Usability	*															✓
Flexibility	*			✓											✓	✓
✓ = component address successfully * = component partially addressed																

5.4 Further research

During development of the E-learning Dome, I focused on the broad elements that should be included in a comprehensive EEDM. I did not include the in-depth processes to implement each element in the model. This is further research that can be conducted. Another issue that can be researched is the configuration management of e-learning environments. Configuration management for software and hardware is not a new concept, but I could find very little about the configuration management process for e-learning environments. Two other aspects that can be addressed by further research are fault reporting and the standardization of e-learning environment.

5.5 Concluding remarks

The hypothesis for this study was defined in Chapter 1 as: *the current e-learning environment development models are not sufficient to support an e-learning environment and that a comprehensive e-learning environment development model can be established.*

This hypothesis is confirmed in this study where a list of characteristics was defined to identify the shortcomings in existing e-learning development models. A comprehensive e-learning environment was established and measured against the list of characteristics, which confirms the hypothesis that a comprehensive e-learning environment development model can be established.

6.References

1. Al-Sharhan, J. 2002. Education and the satellite: possibilities for Saudi-Arabia? International Journal of Instructional Media. 27 (1). Pp. 1 – 5.
2. Anido, L, Llamas, M, Fernández, MJ, Caeiro, M, Santos, J, & Rodríguez, J. 2001. A component model for standardized web-based education. Paper presented at WWW10. Hong Kong.
3. Anon. 1999. Savings with satellite: "real time" knowledge yields valuable commodities. Communication News. Pp. 54 - 56.
4. Anon (b). 2003. Preparing school computers for online learning. Apex Learning.
5. Baker, RK. 2003. A framework for design and evaluation of Internet-based distance learning courses. Online Journal of Distance Learning Administration. 6 (2).
6. Banks, B & McGrath, K. 2003. E-learning content advisory paper. FD Learning.
7. Berge, ZL. 1999. Interaction in post-secondary web-based learning. Educational Technology. Pp. 5 - 11.
8. Bouras, Ch, Destounis, P, Garofalakis, J, Gkamas, A, Sakalis, G, Sakkopoulos, E, Tsaknakis, J & Tsiatsos, Th. 2000. Efficient web-based open and distance learning services. Telematics and Informatics. 17. Pp. 213 – 237.
9. Brackett, JW. 1998. Satellite-based distance learning using digital video and the Internet. IEEE Multimedia.
10. Brusilovsky, P & Nijhavan, H. 2002. A Framework for adaptive e-learning based on distributed re-usable learning activities. World Conference on E-Learning in Corp., Govt., Health., & Higher Ed. 1. Pp. 154 – 161.
11. Calitz, AP & Cowley, NL. 2003. A 2-D MPEG-4 Multimedia authoring tool. ACM SIGGRAPH. Pp. 151 – 160.
12. Carliner, S. 2000. Build a business case for online learning projects. Learning Circuits.
13. Claassen, P. 1994. Address to University of Pretoria interest group on interactive television.
14. Cloete, E. 2000. Quality issues in system engineering affecting virtual distance learning systems. COMPSAC'2000 Proceedings. Taiwan.
15. Cloete, E. 2001. Electronic education system model. Computers and Education. 36 (2). Pp. 171 – 182.

16. Cloete, E & Kotze, P. 2002. Reusable and usable environment for the digital courseware domain. Science + IT Education Conference. Cork, Ireland.
17. Cloete, E & Schremmer, CS. 2000. Addressing problems in virtual learning through collaboration. SAICSIT-2000. Cape Town.
18. Cloete, E & Van der Merwe, M. 2001. The position of e-learning systems in 2001. Proceedings of the 25th Annual International Computer Software and Applications Conference.
19. Colace, F, De Santo, M & Vento, M. 2002. Models for e-learning environment evaluation: a proposal. Scuola Superiore G Reiss Romoli 2002 S L'Aquila.
20. Crosby, LS & Schnitzer, M. 2003. Developing online courses: A College-sponsored approach. Online Journal for Distance Learning Administration. 6(2).
21. Cronje, JC. 1996. How to make interactive television interact. Paper presented at the Forum on Telecommunications for Tertiary Education. CSIR, Pretoria.
22. Cronje, JC & Clarke, PA. 1999. Teaching 'Teaching on the Internet' on the Internet. South African Journal of Higher Education. 13 (1). Pp. 213 - 226.
23. Cuhadar, A, Hlynka, D, Jackson, A, Mcleod, B. 1999. Web-based course delivery: A case study for the implementation of Engineering courses. Business and Work in the Information Society. New Technologies and Applications. EMMSEC. Cheshire Henbury. Pp. 394 – 400.
24. Daradoumis, T, Marquès JM, Guitert, M, Giménez, F & Segret, R. 2001. Enabling novel methodologies to promote virtual collaborative study and learning in distance education. Proceedings of the 20th Conference on Open Learning and Distance Education.
25. Daugherty, M & Funke, BL. 1998. University faculty and student perceptions of web-based instruction. Journal of Distance Education. 13 (1). Pp. 21 – 39.
26. Dean, C. 2002. Technology based training and online learning. Department for Education and Skills.
27. Deming, WE. 1994. The new economics. Second edition. USA: Massachusetts Institute of Technology Centre of Advances Educational Services.
28. De Villiers, C. 2000. Using HCI techniques to evaluate electronic commerce sites. Proceedings of the Human Computer Interfaces Conference (CHI-SA'2000). Pretoria, South Africa.
29. Donello, JF. 2002. Theory & practice: Learning content management systems. E-learning magazine.
30. Downes, S. 1997. Web-based courses: The Assiniboine model. Proceedings of the NA Web '97 Conference.

31. Draves, WA. 2000. Teaching online. LERN Books. Wiscinsin. Pp. 85 - 93.
32. Dyson, MC & Campello, SB. 2003. Evaluating virtual learning environments: what are we measuring? Electronic Journal of e-Learning. 1 (1). Pp. 11-20.
33. Edelstein, S & Edwards, J. 2002. If you build it, they will come: Building learning communities through threaded discussions. Online Journal of Distance Learning Administration. 5(1).
34. Feldman, B. 2001. Communication - The essential factor for a successful e-learning environment. Scuola Superiore G Reiss Romoli 2001 S L'Aquila.
35. Freeman, MW, Grimes, LW, & Holiday, JR. 2000. Increasing access to learning with hybrid audio-data collaboration. Education Technology and Society. 3(3). Pp. 112 – 121.
36. Garson, GD. 1999. The role of technology in quality education. Social Science Computer Review.
37. Garvin, D. 1988. Managing quality. New York: MacMillan.
38. Goggin, NL, Finkelberg, ME & Morrow, JR. jr. 1997. Instructional technology in higher education teaching. Quest. 49 (3). Pp. 280 – 290.
39. Govindasamy, T. 2002. Successful implementation of e-learning: Pedagogical considerations. Internet and Higher Education. 4. Pp. 287 - 299.
40. Gustafson, D. 2002. Software engineering. McGraw-Hill. P. 102.
41. Harwood, JT & Miller, GE. 2001. A common e-learning environment for Penn State: The report of the e-learning environment committee.
42. Heberling, M. 2002. Maintaining academic integrity in online education. Online Journal of Distance Learning Administration. 5(1).
43. Hicks, S. 2000. Evaluating elearning: Training and Development. Pp. 77-79.
44. Holland, J. 2000. The University of Wisconsin-Stout asynchronous learning network case study options: Using technology to remove learning barriers.
45. Holt, D & Segrave, S. 2003. Creating and sustaining quality e-learning environments of enduring value for teachers and learners. Proceedings of the 20th Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE). Adelaide, Australia.
46. IEEE 1987, 1990a, 1990b.
47. Ismail, J. 2002. The design of an e-learning system: Beyond the hype. Internet and Higher Education. 4. Pp. 329 – 336.
48. Johnson, J & DeSpain, BC. 2001. Policies and practices in the utilisation of interactive television and web-based delivery models in public universities. Online Journal of Distance Learning Administration.

49. Johnson, SD & Aragon, SR. 2002. An instructional strategy framework for online learning environments. TM Egan and SA Lyman (Eds.) Proceedings of the Academy of Human Resource Development Conference, Honolulu, HI.
50. Karoulis, A, Polyxenidou, A & Pombortsis, A. 2002. On expert-based evaluation of the usability and learnability of web-based open and distance learning environment. Workshop on Computer Science and Information Technologies. CSIT'2002. Patras, Greece.
51. Kerka, S. 1996. Distance learning, the Internet, and the World Wide Web. ERIC Digest. ERIC Clearninghouse on Adult Career and Vocational Education Columbus OH.
52. Khan, BH. 2001. A framework for e-learning. E-learning Magazine.
53. Lawhead, PB. 1997. A model for the creation on online courseware. ITICSE '97. Uppsala, Sweden.
54. Leedy, PD. 1993. Practical research planning and design. 5th edition. Orlando:Harcourt Brace College Publishers.
55. Leung, EWC & Li, Q. 2001. Agent-based approach to e-learning: An architectural framework. Proceedings Human Society and the Internet. Internet-Related Socio-Economic Issues. First International Conference 2001. Pp. 341 – 353.
56. Luca, J & McMahon, M. 2000. Factors influencing the selection of e-learning environments. We-Bcentre.com – Working with E-business.
57. MacDonald, CJ, Stodel, EJ, Farres, LG, Breithaupt, K & Gabriel, MA. 2001. The demand-driven learning model: A framework for web-based learning. Internet and Higher Education. 4. Pp. 9 – 30.
58. Macpherson, A., Elliot, M, Harris, I & Homan, G. 2002. E-learning: reflections and evaluation of corporate programmes.
59. Markel, SL. 2001. Technology and education online discussion forums: It's in the response. Online Journal for Distance Learning Administration. 4(2).
60. McAlister, MK, Rivera, JC & Hallam, SF. 2001. Twelve important questions to answer before you offer a web-based curriculum. Online Journal for Distance Learning Administration. 4(2).
61. McGraw, KL. 2001. E-learning strategy equals infrastructure. Learning Circuit.
62. McIntyre, DR & Wolff, FG. 1998. An experiment with WWW interactive learning in university education. Computers and Education. 31 (3). Pp. 255 – 264.
63. Meyen, EL, Tangen, P & Lian, CHT. 1999. Developing online instruction: Partnership between instructors and technical developers. Journal of Special Education Technology. 14(1). Pp. 18 – 31.
64. Miles, MB & Huberman, AM. 1994. Qualitative data analysis: An expanded sourcebook. Sage: Thousand Oaks, CA.

65. Montgomery, A & Little, JK. 1997. Creating and supporting online learning communities: A Model for distance education. PhD. Thesis. University of Tennessee.
66. Moore, GA. 1995. Crossing the chasm: Marketing and selling high-tech products to mainstream customers. Harper Business Publication.
67. Moore, GS, Winograd, K & Lange, D. 2001. You can teach online: Building a creative learning environment. McGraw Hill. New York. Pp. 6.2 – 6.11.
68. Motiwalla, LF. 2000. An E-education framework for training in the next generation enterprises. Proceedings Academia/Industry Working Conference on research Challenge ’00. Next Generation Enterprises: Virtual Organizatons and Mobile/ Pervasive technologies. Pp. 139 – 146.
69. Myers, MD. 1997. Qualitative research in information systems. MISQ. Discovery. 2.
70. Nguyen, D & Kira, DS. 2000. Summative and formative evaluations of internet-based teaching. Distance learning technologies: issues, trends and opportunities. Pp. 22 – 38.
71. Nichols, M. 2002. Development of quality assurance system for e-learning projects. ASCILITE 2002 conference proceedings.
72. Oakes, K. 2002. E-learning. LCMS, LMS – They’re not just acronyms but powerful systems for learning. TD.
73. Oliver, M. 2000. Evaluating online teaching and learning. Information Services and Use. 20. Pp. 83 – 94.
74. O’Rielly, M & Newton, D. 2002. Interaction online: Above and beyond requirements of assessment. Australian Journal of Educational Technology. 18 (1). Pp. 57 – 70.
75. Paulsen, MF. 2002. An analysis of online education and learning management systems in the Nordic Countries. Online Journal for Distance Learning Administration. 5(3).
76. Peach, RW. 1994. The ISO 9000 handbook. CEEM Information Services. Virginia. USA. P.19.
77. Polyson, S, Saltzberg, S & Godwin-Jones, R. 1996. A practical guide to teaching with the World Wide Web. Syllabus Magazine. Pp. 12 – 16.
78. Psaromiligkos, Y & Retalis, S. 2002. Configuration management for web-based instructional systems. 2nd International Workshop on Web Oriented Software Technology. Malaga, Spain.
79. Rack, M & Cantu, D. 2000. Under the magnifying glass. Satellite Communications. Pp. 32 – 36.
80. Rashty, D. 2000. Elearning processes models. Addwise.
81. Ross, V. 2002. Offline to online curriculum: A case-study of one music course. Online Journal for Distance Learning Administration. 4(4).

82. Schach, SR. 2002. Object-oriented and classical software engineering. Fifth Edition. McGraw-Hill Higher Education. New York. Pp. 148 – 149.
83. Schafter, A. 2001. Software round-up: LMS shopping. TD. Pp. 97 – 100.
84. Sharma, S. 2000. Interactive distance education for in-service teachers in India. Education Media International. 37(1). Pp. 68 – 72.
85. Smart, C & Holyfield, S. 2001. The higher access to web-based learning (HAWL) project for the Community University. Report delivered to Community University of North Wales.
86. Stevens-Long, J & Crowell, D. 2002. The design and development of interactive online graduate education. In KE Rudestam and J Schoenholts-Read (Eds.) The Handbook of online learning: Innovations in higher education and corporate training. Thousand Oaks, CA: Sage Publications, Inc.
87. Strother, J. 2002. An assessment of the effectiveness of e-learning in corporate training programs. International Review of Research in Open and Distance Learning. 3(1).
88. Van der Merwe, AJ & Cloete, E. 2000. Structures and techniques used in a virtual distance learning implementation. In Proceedings International Conference on Technology and Education. Potchefstroom, South Africa.
89. Williamson, DM. 1999. A template for web-based interactive distance learning. 6th AC on Information Systems. Pp. 960 – 962.