**Faculty of Computing and Informatics**

**Department of Computer Science**

# DESIGNING A CLOUD BASED ELEARNING IMPLEMENTATION MODEL

# FOR HIGHER AND TERTIARY INSTITUTIONS IN NAMIBIA

Thesis submitted in fulfilment of the requirements for the degree of

**Master of Computer Science**

at the

Namibia University of Science and Technology

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| **Submission Date:** | **February 2017** |

## DECLARATION

I, Shadreck Chitauro hereby declare that the work contained in this thesis presented for the degree of the **Master of Computer Science** at the **Namibia University of Science and Technology**, entitled:

**Designing a Cloud based eLearning platform implementation model for higher and tertiary institutions in Namibia**

is my original work, and that I have not previously, in its entirety or in part, submitted it to any other university or higher education institution for the award of a degree.


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**METADATA**

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## DEDICATION

I am dedicating this thesis to my family.

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## ABSTRACT

Main stream academic institutions are aiming to improve from past trends and venturing into new emerging technologies for quality delivery of teaching and learning. One of these trends that enhance teaching and learning is termed eLearning. ELearning is when teaching and learning is facilitated through the use of information communication technologies. ELearning is highly popular because it is flexible, it supports self-paced learning, and learners can access learning material anywhere, anytime and in the absence of the instructor. The problem with eLearning is that of managing data, ensuring security, limited server space, infrastructure sourcing and expensive maintenance. In addition to these problems, most academic institutions in the developing world are unable to fully finance eLearning systems and the skills for the support of these systems. Higher and tertiary institutions in Namibia which also use eLearning in their day to day teaching and learning activities are faced with slow bandwidth challenges. However, cloud computing can ease the financial burdens and reduce support issues brought about by lack of information technology skills and infrastructure. A qualitative case study at one Namibian tertiary institution was used in which interviews and experiments were used to obtain data. ELearning administrators at the case site were interviewed and it was established that at this tertiary institution the eLearning system also experiences infrastructure problems, support issues due to lack of expertise and insufficient human resources. In addition, their eLearning server reduces performance as the number of concurrent users connecting to it increases. Thus, migrating to a public cloud would solve most of these issues but there was no concrete plan as to how to migrate to cloud. Consequently, this research used design science research to design a cloud based implementation model for higher and tertiary institutions in Namibia so that academic institutions can seamlessly migrate to cloud. An experimental cloud was setup using a cloud based implementation model.  The results of the experiment proved that the biggest challenge being faced by this tertiary institution's eLearning server can be overcome. One of the challenges that could be solved is that the server is slow due to the ratio of RAM on the server, which is not proportionally adequate to the number of users. Most eLearning technical challenges and technical support challenges were solved. The use of cloud computing was proposed as a solution to these challenges.

**Keywords**: Cloud computing, eLearning, ICT in Education, Virtual Machine

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## LIST OF ACRONYMS

AD:         Active Directory

BBB:        Better Business Bureau

CCAUM:      Cloud Computing Adoption and Use Model

CCNA:       Cisco Certified Network Associate

CIDR:       Classless Inter-Domain Routing

CMS:        Content Management System

CPU:        Central Processing Unit

CUS:        Computer User Skills

DHCP:       Dynamic Host Configuration Protocol

DICT:       Department of Information and Communication Technology

GHZ:        Gigahertz

Gig:        Gigabyte

HDD:        Hard disk

HTTP:       Hypertext Transfer Protocol

ICMP:       Internet Control Message Protocol

ICT:        Information and Communication Technology

IPv4:       Internet Protocol Version 4

IPv6:       Internet Protocol Version 6

IT:         Information Technology

ITS:        Integrated Tertiary Software

LTS:        Long Term Support

MB:         Megabyte

NSA:        National Security Agency

OS:         Operating System

PHP:            Hypertext Preprocessor

RAM:            Random Access Memory

SLA:            Service Level Agreement

TAM:            Technology Acceptance Model

TCP:            Transmission Control Protocol

TLU:            Teaching and Learning Unit

VM:             Virtual Machine

vCPU:           Virtual Central Processing Unit

vSwitch:        Virtual Switch

# CHAPTER 1: RESEARCH OVERVIEW

## 1.1 Introduction

The emergence of new technologies has seen the application of different technological applications which improve service delivery. These include virtualisation, social networks and cloud computing. The health sector, agricultural sector, and economic sector have embraced some of these emerging technologies.

This research focused on cloud computing technology. For example, in the agricultural sector, cloud computing is used to keep a lot of information since it offers high data stores. According to Goraya and Kaur (2015), a lot of information which can be stored by farmers on cloud include the type of crops, soil type, pesticides information, market information, etc. Through the use of cloud computing, together with the internet of things, farmers are in a position to monitor moisture levels in the fields and make sure that all fields have the same level of moisture during and after irrigation since the whole process will be monitored and operated electronically (Vatari, Bakshi, & Thakur, 2016). This is possible due to different sensors deployed in the entire farm. Similarly, in the health sector there is a need to keep significant patient information in the cloud. Since the database will be in the cloud, this means that doctors examining patients can access patients' personal health records or profiles and they can assist the patients without asking or asking a few questions from the patients (Hameed, Mohamad, Hamid, & Tapus, 2015). The financial sector also utilises the cloud. This is exemplified by Islam, Islam and Beg (2015), who proposed a system which can be utilised by financial service providers. The system has a common centralised banking system, which can improve on efficiency, and the system includes modular banking, which means that the bank can go closer to people. This is made possible through mobile banks and all is possible if the mobile bank is connected to the main banking system through the cloud.

Moreover, governments are adopting cloud computing through the smart city technology together with the internet of things. Governments are reducing costs and they are able to automate services and improve communication with people (Clohessy, Acton, & Morgan, 2014). At the same time, academic institutions have also made efforts to take advantage of

cloud computing technology. Namibian academic institutions would possibly fully utilise the advantages that cloud technology has to offer but there is no clear existence of a roadmap to follow in order to migrate to cloud. Therefore, this thesis focused on cloud computing technology and how it can be adopted and implemented by tertiary academic institutions in Namibia. This thesis explained cloud computing with a focus on demonstrating how it can be implemented and used by the selected Namibian tertiary institution to improve teaching and learning. The research sought to improve teaching and learning by incorporating eLearning in cloud computing as an emerging technology.

## 1.2 Background

Main stream academic institutions like higher and tertiary institutions are aiming on improving from the past trends and venturing into new trends for quality delivery of teaching and learning (Vivekananthamoorthy, Sankar, Siva, & Sharmila, 2009). This has encouraged the adoption of new teaching and learning technologies. In the past teachers used to be the only source of information and learners were required to attend classes and listen to teachers delivering the lecture. With the aid of technology, learners can nowadays acquire a lot of information from books, libraries and mainly on the internet, and the duty of the teacher is to facilitate learning. With the introduction of eLearning platforms and services, learners are able to start and finish a course without attending classes in a centralized venue.

According to Manochehr (2006), eLearning is an environment which can be used to transfer knowledge through the network, internet and or computers. With this in mind, computer administrators should be able to setup an efficient eLearning platform which can be used by learners throughout their studies. Furthermore, the administrators should be able to deploy the eLearning services in the cloud in a secure and fast manner. Cloud computing is one of the best environments to run these applications and this is so when considering the technological trends (Holt et al., 2011). Learners from different tertiary institutions have problems in accessing the eLearning resources due to a number of reasons and an investigation was carried out to find out if moving these eLearning services into the cloud

would improve the way the learners interact with the system and the way they can access the resources.

### 1.2.1 Overview of IT Resources at the Selected Tertiary Institution

The institution of higher learning under study is located in Windhoek, Namibia. It is a typical higher learning institution, which offers bachelor and postgraduate degrees. Many operations at this institution depend on IT resources. An overview of IT systems can be depicted as shown in figure 1:
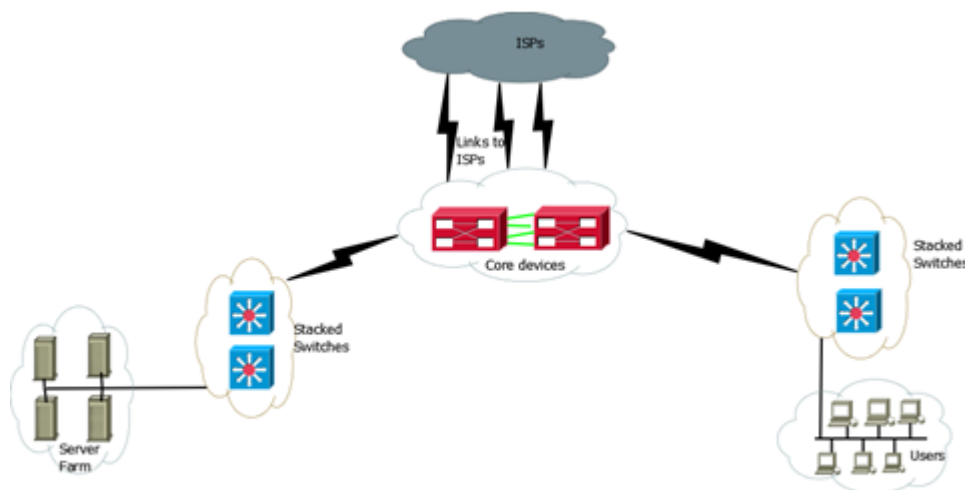


*Figure 1: IT resources distribution*

The IT resources are deployed in a typical IT fashion whereby there are core devices that connect the institution to the internet and connect users to the data centre and services. In this kind of setup, all important services are backed up and all important network links are connected redundantly. All network devices included in the entire network are Cisco products and the network backbone is fibre optic for fast connection. More firewalls are implemented at the edge of every Virtual Local Area Network (VLAN) to protect traffic across subnetworks. In the data centre all servers are virtualised using VMware ESXi 6 software running on Cisco blades. Some virtualised servers include email, webserver, eLearning, and Integrated Tertiary Software (ITS). The ITS is an enterprise resource planning Software. The system is used to manage all activities whether educational or administrative.

The ITS system is a very crucial system at the institution because learner records, staff records, finance, inventory, etc. are stored and managed by this system.

The IT resources at this institution are very current and they are of competitive standards. The institution under study also has state of the art equipment, which is able to efficiently host the technological requirements for an educational institution. In summary, the researcher is stating that the IT resources are not inferior to any other higher learning educational system in the world. In addition to this, the institution provides email services through its intranet services. The current IT resources at this tertiary institution have helped in setting up an Open source platform for eLearning. This is currently running on Moodle. In this thesis, Moodle is used as the eLearning platform. The aim is to assess and demonstrate how the current Moodle environment could be transformed to a cloud based application. The next sections present the research problem, research questions and objectives.

## 1.3 Problem Statement

Academic institutions in developing countries find it difficult to incorporate advanced technologies. This is due to inadequate ICT infrastructure, financial constraints, and lack of technical skills (Gamundani, Kanyangela, & Chitauro, 2015; Alghali & Roesnita, 2014). Most importantly, low internet bandwidth hinders tertiary institutions in Namibia to fully benefit from the modern technologies such as cloud computing (Gamundani et al., 2015; Bhalalusesa, Lukwaro, & Clemence, 2013). In cases where such aspects have been resolved, there is lack of a guiding model to follow on how to adopt modern technologies. In this thesis, there was no standard cloud computing implementation and adoption model that exists for Namibian tertiary institutions to refer to. This causes delays and the need to spend more money for the institutions as they end up getting IT experts which might be expensive. Additionally, there seems to be no research so far in Namibia that has been done to migrate the current eLearning platforms from their current state to cloud-based platforms.

This thesis therefore proposed the introduction of cloud-based services to support the current eLearning environment at the tertiary institution. The motivation for this is the

available supporting IT infrastructure and also the numerous benefits that cloud computing brings to the institution.

Based on the above mentioned challenges and the identified problem, the thesis proposed the following objectives.

## 1.4 Research Objectives

The main objective of this research was to design a cloud based eLearning implementation model for a Namibian tertiary institution. The intention was to have a standardised cloud computing implementation model that can be utilised by academic institutions to improve teaching and learning services. To achieve this objective, the following sub-objectives were undertaken, namely to:

- ✓ Evaluate current eLearning platforms usage and challenges;
- ✓ Assess the current supporting IT infrastructure on eLearning technologies;
- ✓ Analyse current technology implementation models which support cloud computing; and
- ✓ Experiment on cloud based technologies and demonstrate how the current eLearning environment can be transformed to cloud computing.

In order to address the objectives and provide a solution to the problem, the following research questions were proposed:

## 1.5 Research Questions

The main research question was: How can cloud computing be adopted and implemented at academic tertiary institutions in Namibia?

The following were the sub-questions that supported the main research question:

- ✓ What are the current eLearning platforms and challenges faced?
- ✓ What IT infrastructure is available to support existing eLearning platforms?
- ✓ What are the current modern technologies adoption and implementation models?
- ✓ How can the current eLearning environment be migrated to the cloud-based environment?

The mentioned research questions and objectives were meant to support the problem statement and enable the research to provide a possible solution.

## 1.6 Research Methodology

In this research, a qualitative case study research methodology was used. In this methodology, experiments and interviews were used as methods. Interviews were used to understand the current setup of eLearning platforms currently in operation and to gain further information about the challenges being faced by the administrators managing the systems. They were also used to understand the challenges that learners experience when they access eLearning materials from different geographical locations across the continent. Systems administrators and eLearning administrators were interviewed to understand current eLearning technologies at academic institutions in Namibia (one tertiary institution was selected), to gain insight on the infrastructure available to support existing eLearning platforms and to determine current eLearning platform usage challenges. Experiments on cloud based eLearning platforms were carried out to demonstrate how the current eLearning environment could be transformed to cloud computing. Design science was used to design the cloud based eLearning implementation model.

## 1.7 Rationale/Justification

The outcomes of this research may improve current ICT delivery, especially eLearning. By migrating to cloud, academic institutions may reduce IT spending on ICT infrastructure. Moreover, when academic institutions adopt cloud computing, they won't need to deal with technical issues and technical support of IT services that would have been deployed on the cloud. Academic institutions that decide to adopt cloud computing and those that use the cloud adoption model designed in this research may seamlessly transition IT resources and services to cloud without the users' significant downtimes experienced by the users.

## 1.8 Research Limitations

In this research there were some limitations which prevented the researcher from obtaining full representation of data. There are three tertiary institutions in Namibia and one of these institutions is not using eLearning and at the time of this research they were in the process of setting up an eLearning system. One of these tertiary institutions is using an eLearning platform at a small scale. All efforts to contact this institution's only eLearning expert were not fruitful. As such, only one tertiary institution was considered. This limited the sample

size. Furthermore, eLearning experts at the institution that was used as a case site are limited in number. This also limited the interview size population. Based on the above-listed points, this implies that research findings were limited. Moreover, one of the interviewees contacted for this research opted to answer interview questions through email, which consequently prevented the researcher from asking further probing questions.  However, the final implementation model can still be adopted and used in other Namibian institutions. Current literature was considered to assist in developing a model that is applicable in other higher institutions.

## 1.9 Research Scope

ELearning is widely used in different IT sectors. However, in this research focus was on higher and tertiary institutions. There is a lot of eLearning platforms available for use but in this research only Moodle was used. Furthermore, cloud computing can be used to solve IT related problems but in this research cloud computing was used to prove that it can reduce eLearning challenges. Moodle technological challenges were being addressed in this research. Thus, eLearning administrators and systems administrators instead of users were selected to participate in this research, which aimed at solving technical problems associated with eLearning.

## 1.10 Summary of the Thesis

This thesis has seven chapters and each of these chapters has an introduction, the core of the matter and a summary at the end. The first chapter defined cloud computing and where cloud computing is used. In addition, a brief background on the use of eLearning and cloud computing at academic institutions and in particular at the selected tertiary institution was also presented.

Chapter two, which is the literature review focuses on cloud computing models, cloud computing uses, ICTs in education, eLearning, eLearning challenges and how eLearning challenges can be overcome.

Chapter 3 describes the methodology adopted in this research. This research used a case study approach. This entailed the use of interviewing eLearning experts and then using experiments to validate eLearning cloud based platforms.

Chapter 4 presents the findings obtained from the interviews and the experiments that were conducted in this research.

Chapter 5 explains the analysis of the data obtained from the interviews. This chapter also highlights the data that was obtained after the analysis.

Chapter 6 describes how the cloud adoption model for the higher and tertiary institution was designed. The model itself is explained and how the model can be used. Finally, this chapter shows how the cloud adoption model was evaluated.

Chapter 7 concludes the research and it shows the researcher's conclusions and also highlights future directions in which similar research can follow.

## 1.9 Conclusion

In this chapter cloud computing was defined and an overview of cloud computing was presented. This chapter also outlined cloud computing uses of which the education sector was one of the sectors. The same chapter presented the main objective and sub-objectives for the study. A brief description of the selected tertiary institution network and the services managed and the setup of these was explained. The rationale of the study was presented so as to justify the importance of this research. In the next chapter, a detailed literature review eLearning and Cloud computing is discussed.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

Cloud computing is a computing platform that offers computing power for scientists when they are exceeding institutions' local computing capabilities (Armbrust et al., 2009). Cloud computing is a computing environment which has gained significant popularity all over the world due to its nature of operation and the advantages it offers to the public. This environment relies on sharing of computing resources and not individual computers processing the applications. It is being used in the education system to solve problems of ICTs in education. This chapter thus describes ICTs in education, paying more attention to eLearning as an ICT technology. The researcher shows eLearning challenges and how they can be overcome using cloud computing. This chapter also includes cloud computing benefits in eLearning.

## 2.2 ICTs in Education

Information Communication Technology (ICTs) can be defined in many ways, but in our context we can refer to it as the use of technology and its related services to teach and conduct classes electronically through the use of computers, ipads, tablets, unified communications, computer networking and telecommunications (Information and Communications Technology, 2016). The present world we are living in is a digital environment where almost every aspect has a component of ICT. According to Aris and Orcos (2015), it is now difficult to exclude ICT when teachers are teaching learners. Depending on different backgrounds, some learners start school when they are at an advanced stage with ICT tools. Moreover, institutions are integrating ICT when teaching due to the nature of ICT, which can motivate learners to learn at their own pace (Aris & Orcos, 2015). Aris and Orcos (2015) further describe ICT as an important tool in education because it motivates learners. ICT products are used by teachers as an essential tool to educate learners and these tools include CD-Roms, emails, television lessons, and teleconferencing (Raju, Raju, Abbaiah, & Gudavalli, 2016). The same authors list some advantages offered by ICT as follows:

- improves qualities in learners;

- helps lecturers to improve on their knowledge;
- learners can access and interact with the system anywhere and anytime from internet enabled devices;
- encourages learners to participate in group discussions or forums; and
- learners have access to latest technologies.

In the past, lecturers would create slides to be used in classrooms, based on a context from a textbook, and the whole course could be designed following a particular textbook and the teacher and the library were the main sources of information. With the use of technology and the paradigm shift in the 21$^{st}$ century, the mode of instruction has changed from teacher centred to learner centred education, where learners should be responsible for their learning (Yan & Yuhong, 2012). The introduction of ICT in education also allows institutions to offer distance learning, whereby the teacher and the learner are not required to meet in a common place for classes to take place. Yan and Yuhong (2012) identified the following points as the ones blocking teachers from integrating ICT in their courses, using the case of China and this is also corroborated in Namibia by Wambui and Black (2009) who had the following to say:

- Teachers are afraid of integrating technology within their courses
- Teachers lack the skills on how to integrate ICT
- Lack of teacher motivation. Teachers are less motivated when they reflect and check the pass rates of the class.

The use and integration of ICT in teaching is the responsibility of the faculty and their drive to support it should be complemented by continuous training of the lecturers in various aspects of ICTs (Croteau, Venkatesh, Beaudry, & Rabah, 2015). If teachers do not believe in this, they will not integrate ICT in their classrooms.

## 2.3 ELearning

ELearning encompasses all electronically supported learning and teaching whether it be termed computer based training (CBT), Internet based training (IBT) or Web Based training (WBT). What it simply means is that learning is facilitated through the use of the internet and computers. The present researcher defines eLearning as the teaching and delivering of teaching materials through the use of ICT. ELearning can be learner-paced or instructor led

(Alghali & Roesnita, 2014; Bora & Ahmed, 2013). ELearning has gained popularity and it has been adopted by many educational institutions because it provides effective quality education and it is also supported because of the following reasons:

- Ease of access - this means that learners can enrol for training and they are able to access educational resources without being physically present in the instructor's location. This also implies that learning materials and courses can be accessed at the learner's convenience and not at the instructor's local time (Muhammad & Abdulrahman, 2015).

- Group based collaboration – learners interact amongst themselves to brainstorm and share ideas

- Flexibility – joining discussions or bullet boards at any time

- Self-paced learning -  learners learn at their own pace

- Universal dimensions of knowledge

- Improved response to meeting deadlines

Although eLearning has many good elements, it has some disadvantages such as the fact that learners learn in isolation without physical interaction with other learners or the instructor. Furthermore, some practical exercises cannot be done using eLearning, take for example, agricultural lab activities. Moreover, managing eLearning software might prove to be a challenge and it might also be difficult for learners to master.

Most educational institutions have adopted the use of eLearning in their day-to-day teaching and learning activities. This comes with a lot of challenges that are grouped by Alghali and Roesnita (2014), as financial, individual, knowledge management, support, and technological challenges. Under these 6 categories, 24 challenges have been identified (Alghali & Roesnita, 2014).

### 2.3.1 Financial ELearning Challenges
Financial challenges as cited by Alghali and Roesnita (2014), and also corroborated by Fernandez, Peralta, Herrera, and Benitez (2012), as well as Kamba (2009) are those of buying and maintaining site infrastructure, the payment for site licences and individual packages. These researchers have argued that there is a need to pay for the support of the software packages and support staff. Alghali and Roesnita (2014), also have also proffered that there is a need to invest in the training of staff and learners to enable them to use the

system. Finally, there is also a need to monitor instructor competency in their use of the eLearning system, which also has cost implications in cases where retraining is needed and in the case where new staff members are to be trained.

### 2.3.2 Individual ELearning Challenges

The five challenges identified by Alghali and Roesnita (2014), under this category are awareness, confidence, culture, leadership and motivation. "We need to have the culture which will embrace eLearning means and build the leadership support for that culture" (Abdelraheem, 2006, p. 4). This means that for eLearning to be successful there must be leadership that spearheads new thinking and learning skills that can embrace eLearning. In some cases, as stated by Mahmud and Gope (2009), there is lack of confidence in the users of the technology. Mahmud and Gope (2009), report that only 3% of Bangladesh learners have very good computer usage confidence levels. In addition, these learners lack eLearning awareness (Mahmud & Gope, 2009). Not only learners lack eLearning awareness but so do academic staff (Bhalalusesa et al., 2013). Some learners are just not interested in using technology and they prefer the traditional face to face learning and thus they have no motivation to use eLearning (Al-Adwan, Al-Adwan, & Smedley, 2013). About 69% of learners in the survey by Mahmud and Gope (2009), did not want to change their learning environments because of technology.

### 2.3.3 Knowledge Management ELearning Challenges

Content, copyright issues, curriculum, eLearning strategy and the pedagogical model are the five challenges listed under this category by Alghali and Roesnita (2014). Abdelraheem (2006) also raised concern about the content of eLearning. Furthermore, parents fear that learners might get access to adult materials whilst using eLearning. In places where citizens would rather access content that relate to their environment this becomes a challenge to convince users that content is safe and it is home grown (Mahmud & Gope, 2009; Abdelraheem, 2006). Abdelraheem (2006), argues that it is vital to have a clear copyright policy on online training, otherwise users might think that it is trivial to copy and use material from elsewhere, ignoring the implications of how easy it is to propagate further online material. The Middle East, Africa and Asia-Pacific contexts where eLearning is still in its development stages have a 59% and 62% average rate of unlicensed software respectively ("BSA Global Software Survey: The Compliance Gap: Home," n.d.).

Abdelraheem (2006) further proffers that successful eLearning implementations require an eLearning strategy that will overcome the problems and complexities that are brought about by implementing eLearning. This is corroborated by Kamba (2009), who found that the lack of good policy implementation is one of the challenges eLearning faces.

### 2.3.4 Support ELearning Challenges

ICT professionals, instructor competency, skills, support for learners from faculty and training are listed as the challenges that fall in this category (Alghali & Roesnita, 2014). Lack of training as mentioned by Frimpon (2012), Abdelraheem (2006), Mahmud and Gope (2009), Wambui and Black (2009), and Bhalalusesa et al., (2013), is regarded as a major challenge in eLearning systems. Both learners and academics are not trained sufficiently for eLearning systems use. In addition, when eLearning is being used there is a need to have ICT professionals that are able to give the necessary support both to the users and also in terms of maintaining systems. It is common knowledge that these professionals in developing countries are rarely available and do not come cheap. This inherently means that academics and learners will lack the proper skills on the use of the eLearning systems. ELearning use forces learners to be able to use the eLearning interface without reference to the learner's capability and experience. This means that eLearning implementers assume that all learners will be able to use the eLearning software despite the fact that it might be true that some learners will not be able to effectively use eLearning interfaces (Mahmud & Gope, 2009). In countries where English proficiency is lacking, learning from eLearning documents is difficult as most eLearning documents are written in English (Mahmud & Gope, 2009).


### 2.3.5 Technological ELearning Challenges

These come in the form of infrastructure, localisation, presentation and interface design, resource management and speed bandwidth as highlighted by Alghali and Roesnita (2014). Alghali and Roesnita (2014), note that local infrastructure is not effectively used because resources are not used to full capacity all the time. Resources are used at full capacity only during certain peak periods like examination times. This means that institutions are investing a lot of money into infrastructure that is not used at full capacity most of the time. This leads to scalability challenges. When there is a need to increase the capacity of the infrastructure, higher education institutions need again to carry the cost implications of the

upgrade. This means that more finance has to be channelled to the eLearning system on top of what was used to be got in the first place, and that is on top of the support financial obligations the institution has to pay on a regular basis. Another technological issue prevalent in developing countries is that of lack of internet connectivity and bandwidth (Mahmud & Gope, 2009; Wambui & Black, 2009; Kamba, 2009; Bhalalusesa et al., 2013). Power supply is also not a reliable commodity (Kamba, 2009; Mahmud & Gope, 2009).

## 2.4 Solutions to ELearning Challenges

"The benefits and potentials of eLearning far outweigh its challenges" (Mahmud & Gope, 2009, p. 1). As such, there are many solutions that have been suggested to overcome eLearning challenges. Some of the recommendations by Wambui and Black (2009), for the tertiary institutions like the one under study and other developing countries are as follows:

1. Tertiary institutions in developing countries should have incentives to encourage the adoption and integration of eLearning academic activities. Also, academicians should develop online portfolios for sharing, recognition and promotion.

2. Team teaching should be encouraged where proficient members of staff team up with less experienced colleagues for a period of 3 to 6 months to gain mastery expertise regarding eLearning systems.

3. ELearning network systems between developed and developing countries should be adopted and instituted for academics from developing and developed countries. Through this mechanism, colleagues from developing countries will be able to receive guidance, mentorship, and support; also, they will be able to discuss and share ideas with colleagues from developed countries for bench marking and best practices.

4. Academics from developing countries should organize and attend eLearning conferences and workshops for increased knowledge management.

5. ELearning change agents should be appointed in institutions of higher learning. These individuals will be responsible for in-house training of lecturers, attending conferences, workshops and engaging in research regarding eLearning.

6. A multi-interdisciplinary approach to designing and implementing a fully functional and user-friendly eLearning system should be streamlined throughout an institution. For instance, a lecturer in Marketing could team-up with a lecturer from Software

Engineering. The lecturer in Software Engineering could provide recommendations for a system's effectiveness and usability.

7. Develop and nurture strategic partnerships where industry and academics collaborate to improve ICT computer access, which includes training and development.

Mahmud and Gope (2009), as well as Bhalalusesa et al. (2013), also stress the importance of recommendations 3, 4, and 6. They also further state that materials used on eLearning systems should have reusable eLearning objects. The recommendations above solve most eLearning challenges such as individual eLearning challenges, knowledge management eLearning challenges, and support eLearning challenges. Financial and technological challenges still persist and to some extent it means that the other problems are still to be considered because these two also have implications on the other challenges stated earlier.

Pocatilu, Alecu, and Vetrici (2010); Fernandez et al. (2012); Muhammad and Abdulrahman (2015); Kasi, Kusuma, and Gupta (2012), and many other researches highlight the fact that to overcome financial and technological eLearning challenges, then eLearning must be implemented on the cloud. In addition to solving financial and technological challenges, implementing eLearning on the cloud brings about support benefits (Maher, Alwi, & Ismail, 2013). That is to say, all technical support of the eLearning system is moved to cloud providers. So what is cloud computing and how does it solve eLearning challenges?

## 2.5 Cloud Computing

### 2.5.1 Overview

The origin of the term cloud is not really agreed on. Some say cloud came the way network diagrams depict the internet (Pocatilu et al., 2010). Some say that cloud originates from when telecommunications companies started to use virtual private networks (Jadeja & Modi, 2012). Whilst Qian, Luo, Du, and Guo (2009) state that the term is a very vague technique that is used in many application scenarios. They state that the term is used for publicity by many companies and as such it takes many different meanings depending on who is using it.

Furthermore, cloud computing is defined by Mell and Grance (2011, p. 2) as follows:

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Whilst Kalagiakos and Karampelas (2011, p. 1), explain that:

Cloud is a metaphor to describe web as a space where computing has been preinstalled and exist as a service; data, operating systems, applications, storage and processing power exist on the web ready to be shared.

Furthermore, Hill (2013, p. 3), states that:

Cloud computing is a means by which computational power, storage, collaboration infrastructure, business processes and applications can be delivered as a utility, that is, a service or collection of services that meet your demands.

From all the definitions of cloud computing given above, we can say that cloud computing is a service that enables individuals or organisations without computing capabilities or infrastructure to rent from a cloud computing service provider the services that they need. Whether the services are hardware, software or platform oriented, they just need to hire from cloud computing service provider(s). This means that computing services are now being accessed in the same manner that we access electricity or water (Neto, 2011; Jadeja & Modi, 2012). Furthermore, the definitions listed above show that access to cloud services is through the internet. This implies that cloud usage is heavily dependent on the availability of an internet connection.

The underlying cloud operations are not visible to the user. As such the user does not understand the underlying technology as it is abstracted from the users. From the users' side, they only need to understand how to use the internet and the service being outsourced from the cloud. Thus, cloud users need not have any specialised IT use and maintenance skills depending on the level of service being outsourced from the cloud.

The term model is explained as "something that a copy can be based on because it is an extremely good example of its type" (Cambridge English Dictionary, n.d., p. 1). If we take this meaning of a model, then inserting it in the definition of Mell and Grance (2011), would translate their definition of cloud computing to an extremely good example for enabling ubiquitous, convenient and on-demand network access to a shared pool of configurable computing resources. From this meaning, we can say that computing is now a resource that is abundantly available to everyone whether they have computing infrastructure, skills or not. This can be attested to by the number of people and organisations that are adopting cloud computing as shown by the graph below.

Based on results from the RightScale (2016), the following is indicated in cloud computing adoption statistics:

*Table 1: Cloud adoption statistics (RightScale, 2016)*

| Year | 2014 | 2015 | 2016 |
|---|---|---|---|
| **Cloud adoption in Percentage** | 58 | 58 | 71 |

Furthermore, the diagram below illustrates cloud adoption statistics from the year 2014 to 2016. These figures are for hybrid cloud adoption, which is both private and public cloud.
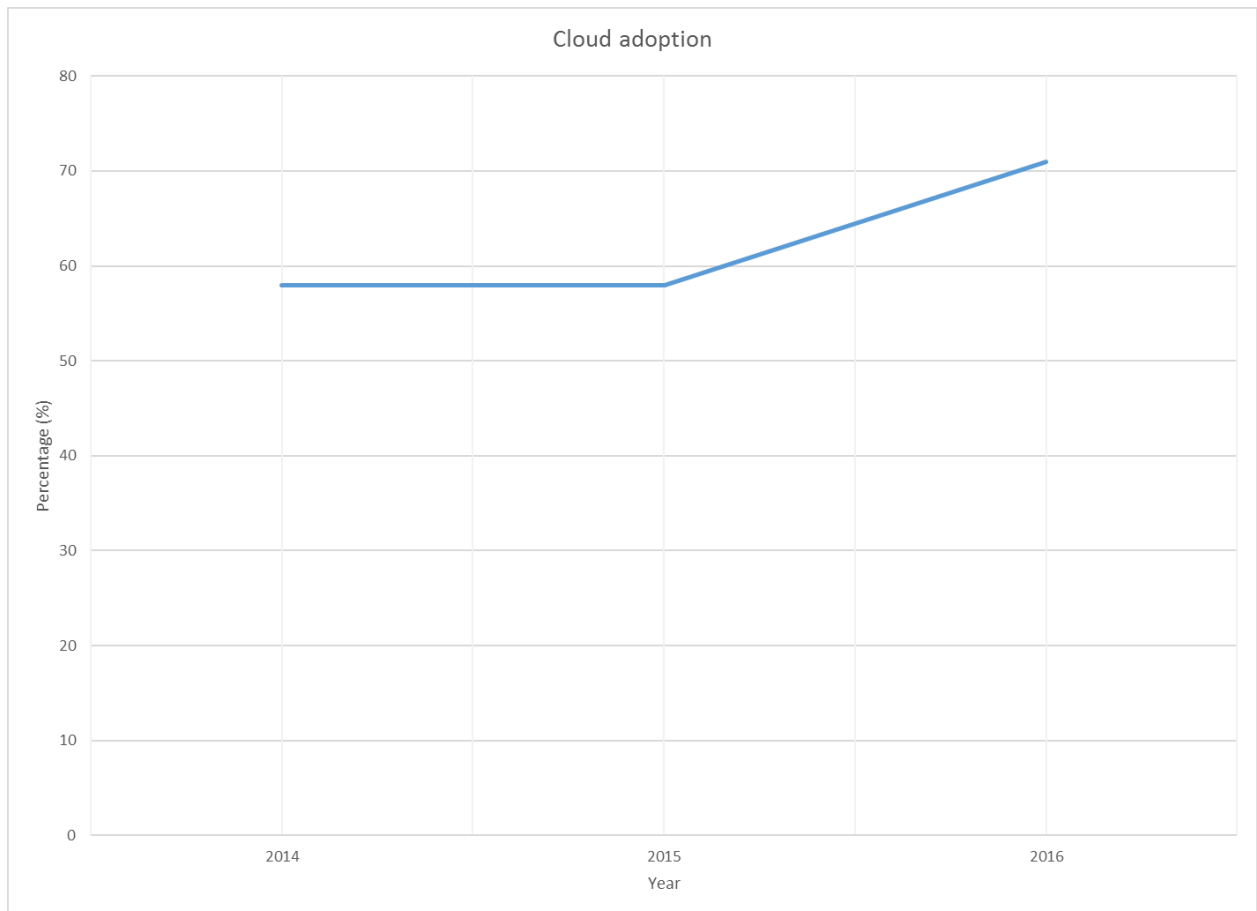
Figure 2: Hybrid cloud adoption

Cloud computing is used across many sectors and education is one of these sectors. Higher and tertiary institutions like the one under study can therefore benefit from cloud computing adoption.

The following section explores cloud computing models, uses, hardware and software.

## 2.6 Cloud Computing Services/Delivery Models

Cloud computing customers can buy any of the infrastructure as a service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). These services are also known as cloud computing service delivery models. The choice of service depends on what the customer needs.

2.6.1 Infrastructure as a Service

In this type of service, the cloud service provider provides all the hardware that the customer needs. The customer will get access to servers, network technology, storage, operating systems, as well as virtualisation of hardware resources from the cloud provider

(Fernandez et al., 2012). This is like getting a very big computer with large storage and computational facilities together with its operating system. Some examples of cloud that provide Infrastructure as a Service (IaaS) are Microsoft Azure, Cisco Metapod, and Google Compute Engine. According to (Microsoft Azure, 2017), "Microsoft Azure is a Microsoft cloud platform used for creating, installing and handling applications through global network of datacenters" (What is Azure section, para. 1).

### 2.6.2 Platform as a Service (PaaS)

In this type of service, the cloud service provider provides all the hardware required by the customer as well as the software that the customer needs to develop applications and for their execution (Fernandez et al., 2012). This will provide Application Programming Interface (API) which will help developers to have a platform which allows them to develop and customize applications without installing additional software for this purpose (Google App Engine, 2016). An example is when the customer needs an email system or database software. They get this service from PaaS vendors. Examples of PaaS providers are Microsoft Azure, Google App Engine, Open Shift and SalesForce. SalesForce offers a Customer Relationship Management (CRM) platform to customers. This would imply that customers will be able to use a specific module of the CRM depending on their needs and they can be billed on which module(s) they are using. This is a convenient environment since customers will not be forced to buy the CRM framework on which they will purchase and install different modules on top of the framework. OpenShift is a PaaS for RedHat platforms which is used by customers for the development of applications and also to host those platforms among other features like the scaling of applications in the cloud.

### 2.6.3 Software as a Service (SaaS)

In this type of service, the user does not need to install any software that he/she needs on the systems. This was one of the earliest implementations of cloud services (Fernandez et al., 2012). Customers require a minimum of a browser on their computers for them to be able to access the software from the cloud provider; as such a thin client can work perfectly for this environment (Gibson, Rondeau, Eveleigh, & Tan, 2012). Examples of Software as a Service are Hotmail, Gmail, Google Apps and WebEx. Customers can use services provided by Hotmail and Gmail, for example the mail server. Companies can outsource email services

for their business from Hotmail or Gmail among other providers for such services. Google Apps is rich in so many applications used by customers to achieve their business needs. For example, if an organisation wants to create an online form to be completed by their customers or employees, they can log in to google apps and design an online form quickly and publish it so that the participants can complete the form online. WebEx is a Cisco application used for creating online meetings and inviting people to listen and participate in Webinars. This tool can be used to deliver distance education where the learners cannot meet in one location for classes.

## 2.7 Cloud Computing Deployment Models

Cloud computing can be deployed using four models, namely public, private, community and hybrid.

### 2.7.1 Public Cloud

In this type of cloud all the services are provided by the cloud service provider, either for free or on pay-per-use. All the infrastructure belongs to the cloud provider hence customers will not buy any software or equipment. Customers can access the services provided by the public cloud via the public internet.

### 2.7.2 Private Cloud

Private cloud offers the same services offered by the public cloud but the services offered are solely for the private company. The private company is responsible for their equipment or infrastructure, and the administration of the cloud. This type of cloud typically functions inside a firewall.

### 2.7.3 Community Cloud

This type of cloud infrastructure is shared by organisations that have the same interests. The cloud may be provided by one of the organisations in the interest group or it might be sourced from a third party.

2.7.4 Hybrid Cloud

Hybrid cloud is a type of cloud which combines the functions of the public, private and or community cloud. This includes in-house providers for the private cloud and third party providers for the public or community cloud.

Kamara and Lauter (2010), state that there are two types of cloud, private and public. If the cloud is completely managed by its users and there is no third party involved, then that is a private cloud. If the cloud has the involvement of a cloud provider, then that means it is a public cloud. Thus a hybrid cloud will be a public cloud and a community cloud could be both public and private depending on who is administering it. If it has the involvement of a cloud service provider, then it is public. If it is completely managed by its users, then it is private.

## 2.8 Cloud Characteristics

Cloud systems characteristics which define how they should provide the services as they are expected are outlined by Mell and Grance (2011), as follows:

- **On-demand self-service**. Customers are able to utilise cloud resources as they want and when they want without interaction with the cloud service provider.
- **Broad network access**. Many devices with internet capabilities and a browser will be able to access the cloud and perform administrative or the normal use of a service. This will not limit the end user devices to only desktop computers or laptops.
- **Resource pooling**. Resources are pooled to customers automatically, depending on customer demand(s). The customer will not have knowledge on where these resources are located in the cloud.
- **Rapid elasticity**. This is a phrase used to describe scalability. Customers may subscribe to services at a small scale but after some time they might need to expand or extend their services. Cloud providers should thus be able to add additional services required by customers without much impact even on the infrastructure.
- **Measured service**. Customers will use the services running on the provider's platform and they are only charged on what they use. Access to cloud services by

customers is metered by the cloud provider so that it will be clear to customers when they are billed on services and the infrastructure they have utilised.


## 2.9 Cloud Hardware and Software

This section will cover an overview of cloud computing hardware and software requirements and how they differ from any enterprise environment and/or the consumer technology. This section will also cover how the resources are managed and allocated in a cloud environment and these resources include the central processing unit, disk for storage and the networking that includes the bandwidth as well. Salam (2014), highlights the following as critical:

- Basic input/output system (BIOS) and Firmware configuration:  In a virtualised environment or in a normal environment, administrators are required to have access to the BIOS as some configurations might affect the behaviour of the system. For example, if virtualisation is not enabled in BIOS when you want to create virtual machines, you will not be able to create 64 bit VMs, which will give problems since 32 bit operating systems will not utilise any amount of Random access memory (RAM) exceeding 3Gb. Considering the cloud environment, customers or clients will not have direct access to BIOS settings for their VMs. However, other cloud providers such as ProfitBricks give the end-user access to BIOS settings. Whereas providers such as Amazon, Microsoft, Oracle and Google do not give direct access to BIOS settings and configurations to customers/clients; clients can only have access to those configurations and settings via a script injection including specialised tools to assist in this regard.
- Memory capacity and configurations: For any computer or VMs to perform optimally it requires enough memory. The more memory you have, the more applications you can run at any given time. Some other cloud providers allow clients to allocate the memory they need to their VMs in a dynamic way. This is a good approach since when more memory is required by VMs it can be allocated dynamically without interacting with any personnel. When VMs are initially created, there should be a cap on the resources soft limit and hard limit. Soft limit can be exceeded but it has

some implications on the cost since the consumers will be paying these resources on a per use environment. Proper orientation is needed to clients so that they will not increase the memory on VMs, which is not really needed. They need to do a thorough investigation on the minimum requirements on VMs and they can only increase memory when it is absolutely necessary.

- Number of CPUs: The processing power of a machine or VMs depends on the CPU. Cloud providers need to manage that resource properly. Flexibility and scalability is one of the cloud characteristics, hence for vCPU, cloud providers offer auto-provisioning that supports dynamic allocation of resources depending on system load. Virtual CPUs depend on the logical cores of the host hosting the VMs and the type of operating system running on the host. If hyper-threading is supported by the CPU, then the logical core doubles the physical cores, and for this to happen the virtual symmetric multiprocessing (SMP) must be supported. Below is a table summarising the limits per licence as presented by VMware vSphere:

Table 2: Vmware Vsphere limits per license (Salam, 2014)

| Edition | vCPUs Supported | Maximum memory per VM |
|---|---|---|
| Standard | 8 | 24 |
| Enterprise | 8 | 32 |
| Enterprise plus | 32 | 48 |

For a customer to increase memory this implies that the customer will have to purchase more licenses. With the support of Vmware 6.0, it supports more specifications as highlighted by Configuration Maximums - vSphere 6.0 - vsphere-60-configuration-maximums.pdf (n.d.). Some of the specifications supported include: a maximum of 480 logical CPUs per host, 1024 VMs per host, 4096 vCPUs per host, and many others (Salam, 2014).

- Network Interface Card, Speed and Configuration: Since the VMs will be accessed by many users or more data moved between the web users and the VMs, it means that speed is required. In a virtual environment, vswitch can be created for virtual networks but eventually traffic has to move from the VM to outside users through the physical NIC. The physical NIC should have more speed so that it can handle huge data traffic. The VMs are bridged to the physical NIC of the machine and one of the

techniques required on the physical NICs is link aggregation where you can bundle the links' bandwidth to increase throughput. Link aggregation requires a minimum of two NICs and a maximum of 8.

- Storage media: In any environment, the storage of information is crucial. The type of information to be stored and how often that information is retrieved will guide the cloud providers with the best storage media to use. Storage tapes are gaining popularity in the cloud environment since they are cheap, they have a long storage life, and they can store a higher capacity. Solid State Drives (SSD) have a longer life span due to non-movable parts; they have a high capacity flash-based storage. Because of this reason, they are used mostly in the cloud environment since their chances of crashing are less compared to normal hard drives with movable parts during operation.

- Licensing: Cloud providers will not afford to run a free version of software since there are some limitations. For cloud providers to offer fully fledged features in a certain service, they need to licence it. Even in the business approach, if the client wants more additional features, the cloud providers charge the client and activate/enable the required feature, but this will not be possible on unlicensed software.

## 2.10 Cloud Computing Uses

Cloud computing is used across many sectors as shown by figure 3, which was taken from Ercan (2010).
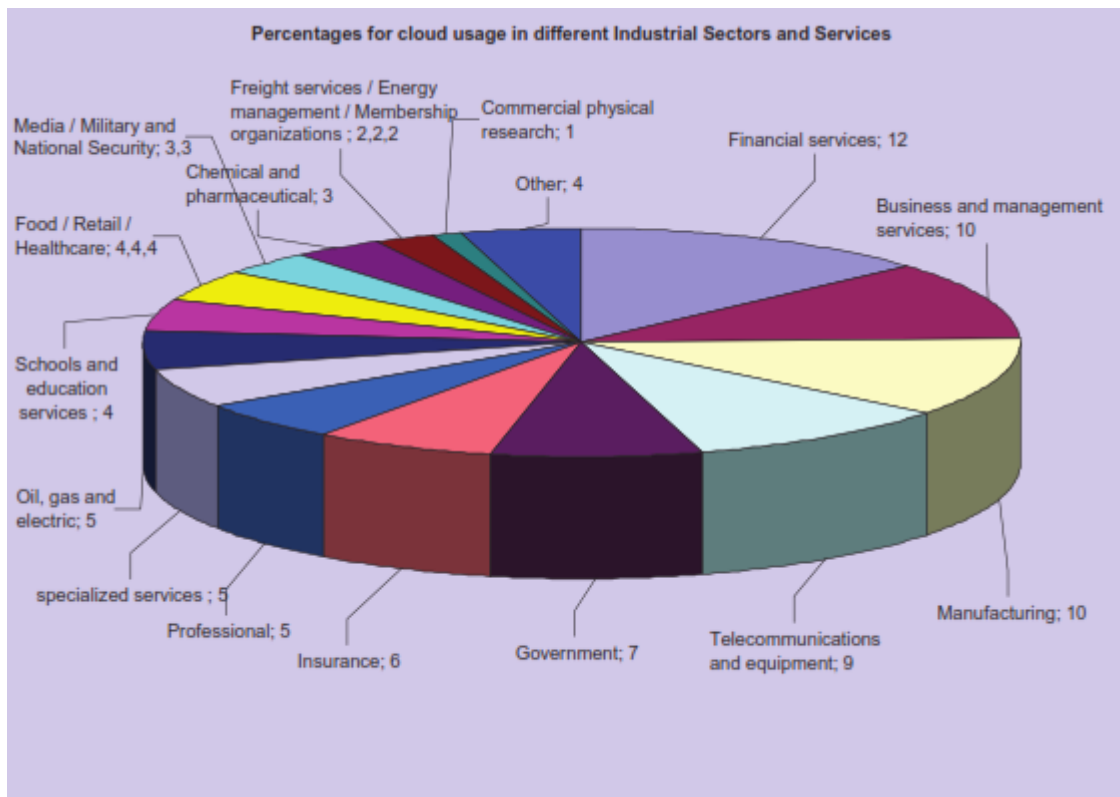


*Figure 3: Cloud computing uses (adopted from Ercan, 2010)*

### 2.10.1 Cloud Computing in the Health Sector

Cloud computing is being adopted by health institutions to provide computing as a service from the cloud providers. Since the health sector keeps a lot of records for patients locally, the sector is migrating to cloud to store their records since cloud providers provide storage as one of the services available. This means that the health sector is no longer investing much in IT infrastructure, but it is rather concentrating on how to deliver health services to customers/users/patients. According to Mgozi and Weeks (2015), in South Africa health sectors are investing more in ICT but the output is less. According to the World Health Organisation (WHO | eHealth, n.d.), eHealth is the use of ICT for health. Examples include treating patients, conducting research, educating the health workforce, tracking diseases and monitoring public health. In some developing nations, for example Nigeria, they are in the process of implementing socialised medicine which allows individuals to track their health personal record, monitor it and also share the record with other friends in the same

category via the use of social media (Ayeni & Misra, 2014). Integrating the records with social media will be granted by the cloud service provider upon signing of service level agreements about the security and privacy of personal health records since this is a major concern with most of the health care centres. Once this is fixed, socialised medicine will reduce the cost of sharing records with other health care providers. Personal health records can be exchanged by owners through some existing platforms as mentioned by Ayeni and Misra (2014):

- PatientsLikeme: online platform which allows patients to share information about their conditions.

- CureTogether: this platform allows different people to compare their health so that they can have a better understanding about themselves.

- TuDiabetes: a social network to exchange ideas, support others suffering from diabetes and some tips on dos and don'ts.

- MoodScope: social platform used to monitor the moods of different patients and draw up conclusions on what can trigger it and how to drop it to normal.

- The leading ones are Google health and Microsoft health vault.

### 2.10.2 Cloud Computing in Business Sector

Organisations conduct their business in such a way that clients approach organisations to conduct business and these organisations in turn contact their existing clients and business partners to conduct business and they in turn also contact their existing clients and business partners to conduct business and so on. In the past businesses used face-to-face interactions to conduct business but according to Wang and Zhao (2016), organisations have started conducting their business through cloud computing and big data. Wang and Zhao (2016) further state that the Chinese government in China is leading in using cloud computing and most enterprises are attracted to cloud computing due to its various ways to conduct business. Many businesses are attracted to the cloud computing environment because of the way that Microsoft Azure and Amazon3 offer storage and retrieval. Amazon3 offers a web interface which is simple to use and Azure can be integrated with services in the cloud as well as outside cloud (Subhashini & Nalla, 2016).  Companies can utilise high computing power offered by cloud from their low computing power, and in addition they

are able to store lots of information that varies in terms of size, starting from kilobytes, megabytes, gigabytes, and terabytes (Subhashini & Nalla, 2016).

*2.10.3 Cloud Computing in Education Sector*

The education sector is a crucial sector for transferring knowledge to learners. Educational institutions are ever trying to improve the way they deliver knowledge to learners. Most educational institutions are using eLearning platforms to teach. These eLearning platforms can be accessed on campus and or off campus. This method is productive if the learners have full access to the internet so that they can be able to access the server hosting the eLearning material (Bora & Ahmed, 2013).

*Table 3: Cloud Computing Models Use in Teaching and Research Activities.*

| Cloud service model | Support for Teaching activities | Support for Research activities |
|---|---|---|
| SaaS | • Learners can use standardized/well-known applications for laboratories. For example, in engineering, learners can use simulation SaaSes to run experimental models. In business, ERP and accounting SaaSes can be used as application platforms for learners to practise. Google Docs can help learners with practising work or spreadsheet processing.<br>• Institutions can jointly establish educational application stores and SaaSes in order to reduce investment costs and to improve collaboration in teaching activities. | • Research applications and tools (e.g. computational simulations, scientific workflows, high performance data visualisations, etc.) can be provided and accessed via SaaSes |
| PaaS | • Particularly useful for computing learners who can use PaaS for learning and practising programming tools and environment. For example, learners can use Google App Engine, Amazon Hadoop or similar PaaSes to practise web programming.<br>• Learners in economics, computational and scientific disciplines can also utilize PaaSes (e.g. MathLab/R computational platform) | • Similar to teaching activities, PaaSes can be used as platforms for developing custom research tools to support research activities. |

| | | |
|---|---|---|
| | to build their custom simulation and analysis tools. | |
| IaaS | • Provide on-demand machines for learner laboratories and personal use. Learners can acquire and design customized virtual machines that may include OS, laboratory exercises, communication and collaboration tools, IDEs, etc., for their course work. From universities' perspective, for exercises that require lots of machines in a short period such as parallel processing, IaaSes can be used to save costs and management efforts. | • Computational requirements for research are usually ad hoc, particularly in computational and scientific disciplines. For some computational models, the resource required can be scaled up to a very large extent only for a short time. IaaSes are good solutions in these cases. |
| DaaS (Data-as-a-service) | • For teaching, DaaSes can be used to store and provide teaching materials such as lecture slides, course contents, exam papers, etc. | • DaaSes can be used as sources of research data and publications and also as means for sharing these resources (Big data analytics). |

## 2.11 Cloud Computing Benefits for Education

Educational institutions without proper IT infrastructure can opt to run eLearning services on cloud due to its benefits. These benefits include reduced costs, security, privacy, scalability, and accessibility (Bora & Ahmed, 2013; Mathew, 2012). For educational institutions, they reduce costs by renting computing resources from a cloud provider and these resources can be increased or reduced on demand. For learners they will be able to access the eLearning platform running in cloud securely from anywhere, provided they have internet access by using an end device capable of going on internet and has a browser installed. This will allow learners to keep on learning either on campus or off campus hence this increases productivity. Chandra and Borah (2012) conducted research to demonstrate how cloud computing can reduce cost, focusing at North Carolina State University. They focused on the reduction of IT employees from fifteen (15) to three (3) and the reduction on the costs for equipment/infrastructure, which includes but is not limited to servers, power and cooling, thin PC, cables, licensing, etc. A cloud model for eLearning was illustrated, access to latest technology tool, and gamification. Gamification is a tool used by learners to play games and in so doing learners will be learning, especially mathematical courses (Veeramanickam & Mohanapriya, 2016). Many research papers have cited that it is possible

to solve eLearning challenges by the use of cloud computing. According to Maher et al. (2013), implementing cloud computing for education will have the following benefits:

- Support
- Availability
- Cost
- Performance
- On-demand
- Pay-per-use
- Broad network access
- Rapid elasticity

*2.11.1 Cost and Pay-per-use*

Muhammad and Abdulrahman (2015), Kasi et al. (2012) and Maher et al. (2013), argue that cloud computing reduces costs. According to Muhammad and Abdulrahman (2015), cost is reduced by reducing costs in initial IT investment. Educational institutions do not need to buy sophisticated IT equipment that is needed to run eLearning systems. Moreover, Fernandez et al. (2012), present that the costs are reduced by reducing hardware and software installation, maintenance, deployment and administration costs. In addition, they Fernandez et al. (2012) further argue that having fewer IT staff that will implement, maintain and support the system results in cost reductions as well. In some instances, software or access to cloud resources is free (Seke, 2015; Pocatilu et al., 2010). In addition, the cost of eLearning software licensing packages are shifted to the cloud service provider side (Maher et al., 2013). Maher et al. (2013) also highlight that costs are reduced on power networking and storage. Another cost reduction brought about by implanting cloud computing in eLearning systems is that of paying for only what you use (Fernandez et al., 2012; Seke, 2015). This is a direct benefit of general cloud computing as this is the default costing model for cloud computing. Furthermore, Chao (2012) asserts that the main benefit for implementing eLearning on the cloud is that of cost reduction. This is supported by the fact that is presented by Cisco (2012), that states that American higher education institutions that have adopted cloud computing have reduced costs by 21%. In summary costs are reduced by:

- Reducing initial IT investment

- Reducing hardware and software installation, maintenance, deployment and administration costs

- Reduction of support costs

- eLearning software licenses will be bought by the cloud service provider

- Less power, networking and storage is required

- Pay-per-use

### 2.11.2 Support

The major advantage here which also has cost implications is that educational institutions that adopt eLearning no longer have to worry about support issues (Muhammad & Abdulrahman, 2015; Kasi et al., 2012; Maher et al., 2013). This reduces overall operational costs as there is no need for support staff because all support requirements for hardware, software and maintenance are transferred to the cloud and thus less problems for the local IT team (Maher et al., 2013).

### 2.11.3 Availability and Broad Network Access

As was mentioned earlier in section 2.8, wide network access is when *many devices with internet capabilities and a browser will be able to access the cloud and perform administration or normal use of a service*. This is echoed by Muhammad and Abdulrahman (2015), Kasi et al. (2012), Alghali and Roesnita (2014), who argue that this is an advantage that cloud based eLearning has over conventional eLearning systems. Cloud based eLearning systems are available for any platform. In a cloud based environment, servers are configured in a cluster based setup in such a way that the nearest server to the client's request will respond. Even if one server goes down, other servers in a cluster will keep on responding to user queries since there will be many redundant links from ISPs to ISPs. Conventional eLearning platforms from institutions will not have this benefit because if the link to their ISP goes down, this means that no one outside the institution will access the service.

### 2.11.4 Performance and Rapid Elasticity

Here educational institutions take advantage of the high performance on cloud where there is enough RAM, storage and CPU. ELearning applications and processes run on the cloud and thus inherit good performance from the cloud (Maher et al., 2013; Kasi et al., 2012).

Scalability is a property of elasticity that brings to the table the ability to scale services according to current demand.

## 2.12 Theoretical Framework

Figure 4 summarises findings from literature reviews in the preceding sections. Section 2.3 discussed eLearning challenges which were grouped under five categories namely financial, individual, knowledge management, support and technology. Section 2.4 discusses how to solve eLearning challenges. Some of the suggested solutions include appointing eLearning change agents, training learners and staff, collaboration and drafting ICT policies to enhance capacity and sustainability. However, these solutions do not address the availability, cost and performance of eLearning systems. Furthermore, section 2.11 discussed how implementing cloud computing can also solve eLearning challenges stated in section 2.4. Section 2.11 highlights how cloud based eLearning can reduce costs, increase availability, as well as support skills, performance and scalability. Thus, figure 4 shows which eLearning challenges can be solved by deploying cloud based eLearning and which eLearning challenges can be solved by general eLearning solutions highlighted in section 2.4.

The highlighted area in red indicates the focus of this study as we seek to use cloud based eLearning services to address the challenges that are still not solved.
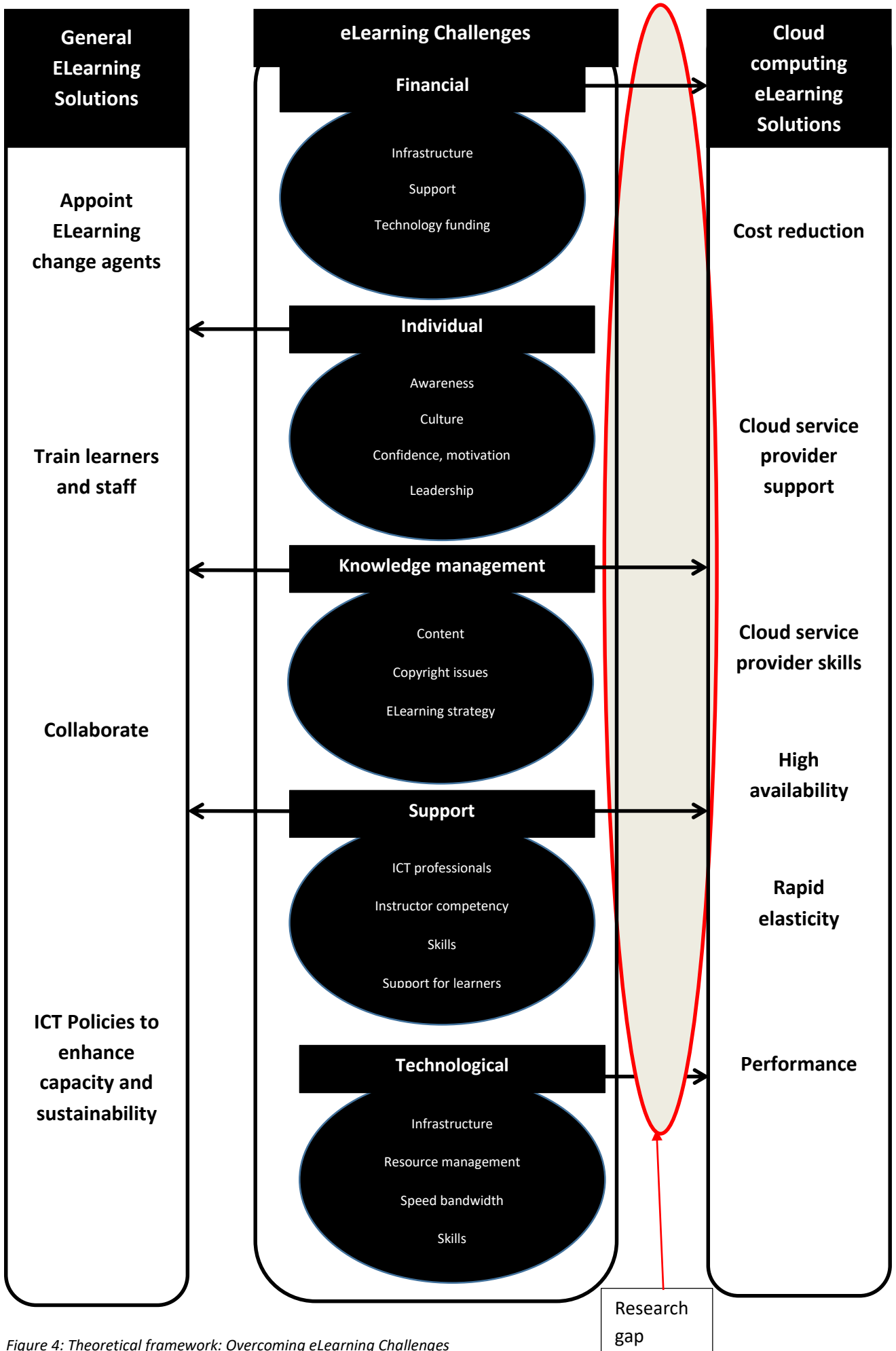
*Figure 4: Theoretical framework: Overcoming eLearning Challenges*

## 2.13 Cloud Implementation Models

Figure 4 and section 2.11 showed how cloud computing can solve some of the eLearning challenges. But the question is: how can an academic institution migrate to cloud? How can an academic institution ensure that it will be worthwhile to migrate to cloud? The researcher recommends that there should be a standard cloud computing implementation model that academic institutions should follow. In this way organisations do not have to hire costly IT experts to migrate their eLearning systems to the cloud. Some of the techniques that have been used to implement new technologies are discussed in the next sections.

Njeh, (2014) studied several studies that were undertaken to establish factors that influence technology adoption. Njeh (2014), proffers that the most widely used is the technology acceptance model (TAM). Njeh (2014, p. 44) criticises the TAM by stating that it "does not address features of modern technology" and thus, Njeh (2014) introduced the Cloud Computing Adoption and Use Model (CCAUM) (Njeh, 2014). CCAUM is an improvement of TAM because it encompasses the TAM and TAM2, and it has been extended to include five additional categories of features that are namely; technology features, economic factors, security and privacy, standards and control. CCAUM is discussed in more detail in the next section.

2.13.1 Cloud Computing Adoption and Use Model (CCAUM)
CCAUM (Njeh, 2014) is an improvement of TAM in that it has features that represent today's modern technologies which TAM is not capable of. CCAUM is depicted in figure 5.
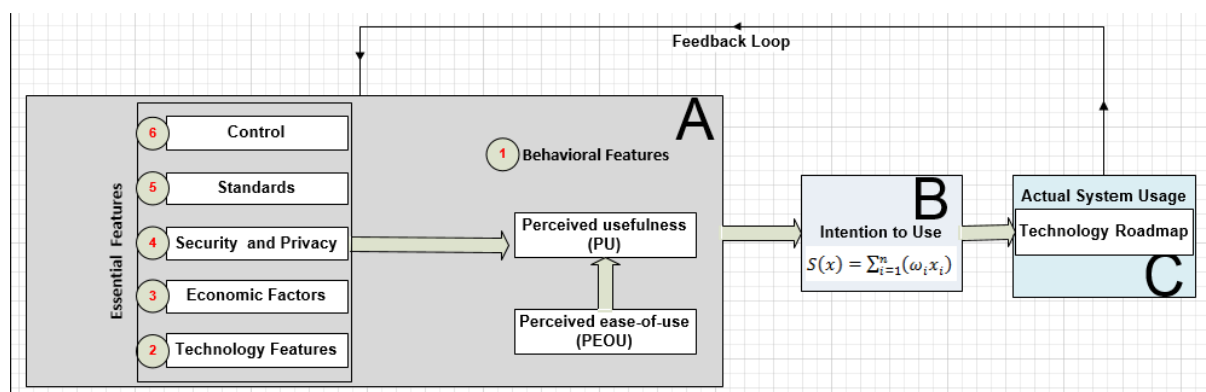


*Figure 5: Cloud Computing Adoption and Use Model (Njeh, 2014)*

Features of CCAUM are listed below (Njeh, 2014):

- Behavioural Features (from TAM)
    - Perceived Usefulness
    - Perceived Ease of Use
- Technology Features
    - On-demand self-service
    - Heterogeneous or broad network access
    - Resource pooling
    - Rapid elasticity and scalability
    - Measured service - pay per use
    - Availability and Continuity
    - Energy consumption - efficiency
    - Quality of Service (QoS)
    - Performance and reliability
    - Maintenance
- Economic Factors
    - Ease of adaption to new markets
    - Global access to a wide customer base due to the broad network access capability
    - Flexible cost model - pay-as-you-go
    - Cost Savings - OpEx is the New CapEx, TCO, ROI
- Security and Privacy
- Standards
- Process and Control

The model is used in three phases. The first phase determines whether the cloud adoption will have the essential technology features that the organisation requires. The second phase involves tasks that determine whether business is ready to adopt a cloud. The third phase has a roadmap which organisations must follow to implement and integrate the cloud. The third phase starts with a clear understanding of the current or as-is environment (which is presumably non-cloud). It consists of a transition from the current environment to the target or end state which is accomplished by applying modernisation projects. It also deals

with the actual use of the technology in use. The third stage "provides a roadmap to guide and provide an industry best-practices method and path to cloud adoption" (Njeh, 2014).

CCAUM assumes that the organisation that uses CCAUM should take note of the following:

- A user governance board – to review and approve technology and related policies.
- A user technical review board – this board comprises of subject matter experts who specify, design, build and maintain technological resources.
- The user is the body that specifies the detailed requirements for any innovation or technology.
- The national or international body specifies standards that can be adopted and used by the organisation.

Another research by Masud and Huang (2012) describes a roadmap that should be followed in order to implement cloud. The roadmap has four stages. In the first stage the organisation which wants to implement cloud must develop knowledge, feasibility and an initial plan for cloud computing. In the second stage they must evaluate the present stage and experiment on cloud usage. The stage involves choosing the cloud computing solution and the last stage is the implementation and the management of the solution.

The roadmap proposed by Masud and Huang (2012) and the CCAUM  proposed by Njeh (2014) are similar.  Although the stages might not be in the same order, they all require that the organisation that wants to migrate to cloud should:

- ✓ Establish the need to migrate to cloud
- ✓ Establish that the cloud will have the necessary features to host their systems
- ✓ Experiment on the cloud usage
- ✓ Choose the right cloud service provider
- ✓ Finally migrate to cloud

The problem with these cloud migration strategies is that they are not tailor made for academic institutions.

## 2.14 Summary

This chapter discussed ICTs in education. ELearning which was also cited as being one of the ICTs in education was defined. ELearning was shown to be very popular because of its ease of access, group based collaboration capabilities, flexibility and self-paced learner learning characteristics. However, despite having many good qualities, eLearning is facing challenges namely knowledge management support, individual challenges, financial challenges and technical challenges. Cloud computing was presented in this chapter as a solution to eLearning challenges. Thus, cloud computing was discussed in the chapter by discussing cloud computing definitions, characteristic service models, deployment models and perceived cloud computing benefits for eLearning. A theoretical framework summarised the eLearning challenges and how they can be overcome. Finally, the chapter presented the cloud implementation strategies that existed before our cloud implementation model.

# CHAPTER 3: RESEARCH METHODOLOGY

## 3.1 Introduction

This chapter presents the methodology used in this research. This research used the qualitative case study approach. The specific methods for data collection were interviews and the verification process used an experiment method and literature review. Interviews were used to get information about current eLearning systems implementation and use. Literature review was used to bench mark cloud based eLearning systems implemented elsewhere, their challenges and successes. Finally, an experiment was used to test a case where an eLearning system is implemented in the cloud and used by a local university.

## 3.2 Overview

This research used the qualitative case study approach. The study was carried out at the selected tertiary institution. The IT department and Teaching and Learning Unit (TLU) participated in the study. A case of Moodle was used. At this tertiary institution, the IT department and the Teaching and Learning Unit are all responsible for the technological infrastructure and the eLearning platform. Moodle was selected and the thesis was written by considering the different stakeholders who are using Moodle.

A qualitative research according to Burton (2000)  focuses on understanding humans from multiple perspectives. Creswell and Creswell (2007, p. 37) state that:

> Qualitative research begins with assumptions and the use of interpretive/theoretical frameworks that inform the study of research problems addressing the meaning individuals or groups ascribe to a social or human problem. To study this problem, qualitative researcher use an emerging qualitative approach to enquiry, the collection of data in a natural setting sensitive to the people and places under study, and data analysis that is both inductive and deductive and establishes patterns or themes.

A qualitative research design has the following characteristics among others (Creswell & Creswell, 2007, p. 37):

- Qualitative research is conducted in a natural setting where the researcher collects data on the site where participants experience the problem. In our case normal eLearning conditions at the selected tertiary institution were considered.

- The qualitative researchers collect their own data from observations and interviews. Interviews were used to gather data.

- Qualitative researcher gathers multiple forms of data which are reviewed and organised into categories or themes. Data gathered in the previous step were grouped and themed (refer to chapter 5).

- Qualitative researcher reports multiple perspectives of the problem, identifying the many factors involved in a situation. Data were gathered from the interviews as well as literature reviews.

The methods used in this thesis are briefly explained below.

### 3.2.1 Observation

When a researcher uses this method the phenomena is observed in its natural setting. Experiences, activities and behaviours and other items of interest are recorded (Sekaran & Bougie, 2010). Environmental factors such as layout are also recorded. The researcher can be a non-participant observer or participant observer. A non-participant observer does not become part of the organisational system. A participant observer becomes a part of the inner circle of group or event being observed (Welman & Kruger, 2001).

Participant observation was used in this research to understand current eLearning behaviour in its current setup. This is because the researcher was in a position to get first-hand information about the eLearning system as they use it in their day-to-day activities.

### 3.2.2 Interviews

Interviews are used to collect data by talking to participants to obtain data about the problem area. Interviews may be structured, unstructured and semi-structured. They may be conducted face to face by telephone or online.

### 3.2.2.1 *Structured Interviews*

The structured interview is conducted with a set of pre-determined questions (Sekaran & Bougie, 2010). Normally the interviewer reads out the questions in their order and records

the responses in a standardised schedule (Saunders, Lewis, & Thornhill, 2009). The researcher reads out pre-coded questions and does not change them during the interview. Structured interviews are normally used to collect quantifiable data (Saunders et al., 2009).

### 3.2.2.2 Unstructured Interviews

Unstructured interviews are those that do not involve pre-planning the sequence of questions. They are also known as in-depth interviews where the interviewee is given a chance to talk freely about events, behaviour and beliefs about the topic at hand (Saunders et al., 2009). The questions posed to the interviewee in an unstructured interview aim to find out views and opinions from the participants (Creswell, 2014). This type of interview will have follow-up questions.

### 3.2.2.3 Semi-structured Interviews

In a semi-structured interview, the interviewer has a list of questions that serve as a guideline on the themes and questions to be covered. As such additional questions are added during the interview to explore further the themes that come up during the interview. Saunders et al. (2009), state that some of the pre-coded questions might not even be asked during the interview and that the conversation will be recorded by an audio recorder.

Semi-structured interviews were used in this research because they enabled the researcher to get an in-depth understanding of current eLearning system problems and user experiences. The semi-structured interviews were chosen to explore views and opinions from eLearning administrators and users.

### 3.2.3 Case Study

A case study is "an empirical inquiry that investigates a contemporary phenomenon in-depth and within its real-life context" (Yin, 2014, p. 16).  A case study is useful when the researcher believes that the comprehension of the case involves critical issues important to the case. The case study technique is most likely to use triangulation. Triangulation is the use of different data collection techniques within one research. According to Yin (2014), there are two case study designs; single case and multiple case, which can either be holistic (single unit of analysis) or embedded (multiple units of analysis).

*3.2.3.1 Single Case Design*

Yin (2014), proposes that a single case design can be used if it suits any of the following five rationales. The first one is a critical case, which means that the case is critical to the researcher's theory or theoretical propositions. This means that the single case is used to prove the theoretical proposition. The second rationale is that of an extreme/unusual case where the case is a rare occurrence or the case deviates from normal occurrences. The third rationale is the common case where the researcher captures the case in its natural circumstances and conditions of everyday situation. The fourth rationale is when the case was in the past inaccessible and not available for enquiry and it is called a revelatory case. The fifth rationale is the longitudinal case where the researcher studies the same single case at two different points in time.

A single case design was used in this research because the researcher believed that studying an eLearning system in its real life context outside of the cloud would make the researcher understand critical issues in eLearning systems that are not cloud based.

## 3.2.4 Experiments

"An experiment seeks to determine if a specific treatment influences an outcome" (Creswell, 2014, p. 13). In an experiment the researcher seeks to discover relationships between variables (Saunders et al., 2009); that is, to measure whether the change in an independent variable produces changes in two or more dependent variables (Saunders et al., 2009). In this research, the researcher wanted to find out the relationship between a cloud based eLearning system and performance. This means that deploying a cloud based eLearning system is the independent variable and performance is the dependent variable. As such the experiment was supposed to outline what happens to an eLearning system performance after it has been deployed to the cloud in comparison to when it is deployed on local servers.

## 3.2.5 Literature Review

The main purpose of the literature review is to get an in-depth understanding of relevant previous research and trends that have emerged in the subject area (Saunders et al., 2009). If the literature review is used to identify theories and ideas used for testing data, then this is a deductive approach (Saunders et al., 2009). In the inductive approach the literature

review is used to frame the problem (Saunders et al., 2009; Creswell, 2014). A literature review has a number of purposes some of which are that it:

- Helps refine research questions and objectives
- Helps to avoid repeating work that has been done
- Helps to identify some gaps in other previous researches
- Helps to identify opinions and trends and current understanding

## 3.3 Research Techniques

The main objective of this research was:

> To design a cloud based eLearning platform that can be utilized by Namibian tertiary institutions

To achieve this goal, the researcher had to:

- Determine the current eLearning platforms usage challenges
- Assess the current supporting IT infrastructure on eLearning technologies
- Analyse current technology adoption/implementation models which support cloud computing
- Experiment on cloud based technologies and demonstrate how the current eLearning environment could be transformed from non-cloud based to cloud based.

Thus, qualitative research with the use of a case study was chosen for this research because:

- It enabled the researcher to collect data about eLearning platforms in their natural setting, that is to say as they are currently installed and configured;
- interviews were going to be used to find information from experts that use the systems and those that implement the system(s); and
- the problem issues that were going to be derived from the participants.

A case study of a Namibian university's Department of Information and Communication Technology (DICT) and Teaching and Learning Unit (TLU), was chosen because the researcher wanted to get an in-depth understanding of eLearning systems in their real life

context. A single case was chosen for the rationale that it suits a common case of eLearning implementation.

## 3.4 Selection of Participants

The researcher interviewed the eLearning administrators and systems administrators since they are the ones that interact with the eLearning system on a daily basis for administration purposes. They were composed of one systems administrator and two were eLearning administrators. Only one class with fifteen learners participated. All learners in this class participated during the testing of a cloud based eLearning platform. The researcher was involved with this class and it was convenient in terms of the time to involve these learners.

## 3.5 Research Process

To find out about the available cloud based eLearning models, the literature review was used. Information was collected from journal articles, conference proceedings, the internet and books. From this exercise the researcher was aiming at getting information about:

- A general understanding of cloud based services;

- ICTs in education (teaching and learning);

- Advantages and disadvantages of cloud based services in different sectors such as health, business and education;

- Trends in cloud based services;

- Technologies in tertiary education (ICT applications for tertiary institutions such as Moodle, claroline, A tutor, black box, and so on); and

- Hardware and software requirements for cloud based system.

After this, the next objective was to find out information from IT experts from the tertiary educational institution that use and implement backend of eLearning systems performance. It was also important to find out from the learners that use the eLearning systems for their classes and off campus learning. However, it was decided to exclude the learners from the data collection process because of time limitations which forced the researcher to only concentrate on the data provided by IT experts. This is because the main objective of the research was to influence the adoption of cloud services for eLearning systems.

Initially all three tertiary institutions in Namibia were supposed to be included in the data collection process. University one was not able to participate because they don't extensively use eLearning systems. University two indicated that they were in the process of implementing a new eLearning system and as such they were not in a position to give feedback about how the eLearning system operates.

To actually collect the data about the current eLearning systems, semi-structured interviews were used. The following people were interviewed; senior systems administrator, head instructional technology, and the instructional technology designer. These people were selected based on their roles as technical implementers of the eLearning system and administrators of the eLearning system. The technical implementer is responsible for creating, managing, carrying out backups, assigning additional disk space, CPUs and RAM on Virtual Machines running on ESXI VMware server. The eLearning platform at the institution was running on a virtual machine hosted on the ESXI server. The role of the eLearning administrator at the chosen institution was to manage the backend platform of the eLearning system. It included the backups of the database where all course content was stored as well as users (lecturers, tutors, learners). The administrator was also responsible for adjusting or adding memory allocation to the eLearning service, optimizing MySQL database for best performance, and creating users directly into database tables. Instructional designers had some limitations to backend access; they concentrated on content layout of all course content as well as the general appearance of the eLearning site. Some of the roles overlapped with those of the head of instructional technology.

The questions that were asked initially are listed below:

1. Do you have an eLearning platform?
2. I understand you are using Moodle, can you describe its setup in terms infrastructure and technical requirements as well as users feedback, and the tools required by learners to access the platform. Size of space per user. Any comments for CUS411S since it is the biggest group?
3. What are the major challenges (technical) faced with the current platform?
4. Any plans to transfer the application to cloud?

5. Do you need to change/acquire (sufficient infrastructure) (if any) to migrate the current Moodle to cloud?

6. Any benefits from the current setup to cloud? Can your current setup support cloud environment, especially bandwidth?

The interviews were recorded and transcribed. Three senior administrators were interviewed at this tertiary institution and their roles were Senior Systems Administrator (Department of Information and Communication Technology), Head Instructional Technology and an Instructional Technology Designer, both from the Teaching and Learning Unit (TLU). In general, the interviews took approximately one hour per interviewee.

The questions listed above were general guidelines on the aspects that the interview needed to cover. They were answered by the Head Instructional Technology as they are because it was not possible to find an appropriate time for the interview so the interviewee opted to answer the questions as they are. For the other two, the questions listed above served as the guidelines but they were additionally asked other questions as listed below:

The actual additional questions posed to the Senior Systems Administrator are as follows:

1. What are the current specifications on the eLearning server?

2. The allocation of size to users, who is responsible for this? Is it from your side or that of the Head of Instructional Technology?

3. What are the major challenges in terms of the technical side?

4. On another note, what are the tools (e.g. computers) or infrastructure required by the learners to access the eLearning platform? Does Moodle support the use of mobile devices such as cell phones or tablets?

5. I understand this tertiary institution has remote campuses and learners are supposed to connect from those remote sites to the eLearning platform. Were there any challenges from those remote sites in terms of speed and bandwidth issues?

6. Just pointing out on some server slowness I have observed during orientation week or vacation schools when all the labs are fully used and the traffic to the server is high, the server response is slow. I actually thought that the backbone bandwidth locally was increased. Any comment on that issue?

7. Do you have any plans to migrate or transfer the current platform (Moodle) to cloud?

8. I understand the networking department was running a project of implementing private cloud locally. How far with the project and how far are you in moving the Moodle platform to that private cloud which will be under your administration here?

9. Since there are no plans to go the cloud route and considering the current infrastructure, do you think it can support cloud; considering bandwidth issues and other factors you might think of.

10. If we go the public cloud many stakeholders are sceptical about it. But when you go cloud you will sign SLA confidentiality documents so that your information will be secure. What are your comments about that?

11. On the issue of backup, you are responsible for backing up the whole system or individual courses because as of now if I log on to Moodle I can see a course I taught 2 years back. For the sake of space do you have a separate backup server or it is up to the administrators of the system (Moodle)?

12. If there is need for space for any virtual machine, you can add/increase the space as required. Within your policies do you have a cap or limit to say we cannot go beyond a certain size?

13. I understand you are implementing single sign-on; may you give a comment on how far is the project focusing particularly on integrating Moodle on the project?

14. We have come to the end of the interview. Any comments/suggestions?


The actual additional questions posed to the Instructional Technology Designer are as follows:

1. I understand you are running Moodle. Can you describe the setup of Moodle in terms of infrastructure, the technical requirements and the tools which are required by the learners or users to access Moodle?

2. Any knowledge about the size you allocate to users? All courses at this institution are created on Moodle and any comment about CUS411S course challenges in particular?

3. So the technical challenges I can find out from DICT?

4. When it comes to backup, how does the backup work; how do you back up the system? I can see some courses I taught two years ago and I am still seeing them appearing? Do

you have a backup server of the main system or you backup course by course and leave it accessible.

5. Are there any plans to migrate the current Moodle you are running to cloud?

6. So there are no plans to go cloud? Let us maybe suggest that you want to move to cloud; do you think that with the infrastructure we have already we can be able to access our server from the cloud or we need to supply or add more equipment, bandwidth and other aspects?

7. When it comes to bandwidth I have observed that when we have orientation or when most of the users are running tests or when the system is overloaded the server would become slow, and some of the concerns we have are with regards to the bandwidth and the server issue. Locally the networking department has done a lot to increase the backbone bandwidth so what makes the server to be slow locally and even when not going out of the institution?

8. Thank you very much for your input. Are there any comments about the eLearning server which we did not ask but which you feel are important and we need to be aware of?

To evaluate the performance of a cloud based eLearning system the researcher setup an eLearning system on a public cloud. Moodle was the eLearning platform which was set in the cloud and it was chosen since it is the one currently being used by the selected tertiary institution and many other tertiary institutions when delivering eLearning education. Other eLearning platforms were available for use like Claroline, ATutor, DotLRN, Dokeos, Ilias. Moodle was chosen because it is the one that is used at this tertiary institution and for comparison of cloud based eLearning and non-cloud based eLearning performances, the platform had to be the same. The cloud based eLearning system was setup on a public cloud provided by XON running on OpenStack technology, which is an open source software used when creating either private or public cloud(s). Cloud provided by XON is called Wingu. Wingu was used because XON provided free access to the cloud for educational purposes on agreement. Other clouds considered were expensive to get access and for the other ones there were administrative difficulties to getting access.

One course was selected and created on the Moodle platform running on the cloud. The course chosen was the Cisco Certified Network Associate because this was the course that the researcher normally taught and as such course administration was relatively easy.

The following table summarises the methods used and why.

*Table 4: Summary of objectives and methods*

| Objective | Method | Reason |
|---|---|---|
| Examine cloud based implementation models available and examine if they can assist in proposing the new model | Literature review | To identify opinions and trends and the current understanding about cloud based models |
| Identify current cloud based technologies and challenges | Literature review, case study, semi-structured interviews | To identify the current hardware and software of cloud based technologies<br><br>To determine the current eLearning challenges<br><br>To get an in-depth understanding of eLearning systems in their real life context<br><br>To collect data from eLearning system administrators |
| Carry out experiments on cloud based eLearning platform | Experimental case study | To assess cloud based eLearning performance |

## 3.6 Research Ethics

To conduct the research at the selected tertiary institution an ethical clearance request was submitted to the management of the tertiary institution. The letter is appended as Appendix A. The letter explained how data gathered would be disseminated. It explained that participants would not be forced to take part and that even if they participate they can withdraw anytime.

During the interviews consent was sought from the participants. The researcher clearly explained that participation was voluntary and that if the respondents were not comfortable they could withdraw anytime. For the experiments, the researcher also informed the learners that participation was voluntary and that their identities would not be published with the results. They were also informed that they could withdraw anytime. A consent email was forwarded to the DICT director to seek consent to disseminate data that the DICT department publishes to the selected tertiary institution community about ICT operations at the tertiary institution, which sometimes includes the eLearning server. The letter is shown as Appendix B.

## 3.7 Summary

In this chapter the researcher highlighted the research process in which the research was conducted. The research took a qualitative approach with the use of a semi-structured interview, single case, case study and the use of an experiment to validate cloud-based eLearning technologies.

The next chapter discusses findings obtained from the literature reviews, interviews and system performance of Moodle setup on cloud based system.

# CHAPTER 4: FINDINGS OF ELEARNING USAGE AT THE INSTITUTION UNDER STUDY

## 4.1 Introduction

The findings from the data collected in the previous chapter are presented in this chapter. The information presented here is the actual data that were collected. The first section shows findings from the interviews and subsequently findings from the experiment.

## 4.2 Semi Structured Interview

To collect the data about current eLearning systems, semi-structured interviews were used. The following people were interviewed; senior systems administrator, head instructional technology, and instructional technology designer. These people were selected based on their roles as technical implementers of the eLearning system and administrators of the eLearning system.

Data were collected using semi-structured interviews from the senior systems administrator, head instructional technology and instructional technology designer. The questions asked to the senior systems administrator and the responses are listed below:

1. *Question: What are the current specifications on the eLearning server?*

Senior systems administrator: 16 Gig Memory, one core 8 sockets, 3.2 Ghz Intel Xeon, 600Gig HDD, Production and training servers.

2. *Question: The allocation of size to users, who is responsible for this? Is it your side or the Head Instructional Technology?*

Senior systems administrator: It is the Head Instructional Technology. I just provide the server (The Virtual Machine) and the necessary software required including backup of the VM. Basically I build the server (container) with the necessary requirements. I provide the username and password for the VM so that the Head Instructional Technology and his team can install the OS, and anything to do with Moodle it will be the Head Instructional Technology, including installation and other configurations related to Moodle.

3. *Question: What are the major challenges in terms of the technical side?*

Senior systems administrator: During peak sessions especially when all learners are busy uploading assignments or when there are a lot of classes or during orientation period when they are all accessing the system, the system won't behave. However, the Head Instructional Technology has done some tweaking on MySQL database so that it can improve performance during those peak sessions. If we find a solution, we always communicate. The space issue is another challenge; we had to increase 300Gig for storage to make it 600Gig and currently the usage is at 53% (20/08/2015).

Sometimes after the infrastructure maintenance when we power up all servers, the Moodle server will not start as expected. It is a challenge if you provide the platform and someone is administering the server because he or she sets up the system the way he/she wants.

Sometimes after setting up the VM the person operating it might not be running the correct configurations as it should and in that case it can present a challenge for those hosting.

4. *Question: On another note what are the tools (e.g. computers) or infrastructure required by the learners to access the eLearning platform? Does Moodle support the use of mobile devices such as cell phones, tablets?*

Senior systems administrator: Yes, the Moodle system is customized to use cell phones; but I am not very sure, I stand to be corrected. Learners can access the system using a browser from their computers and obviously they should have internet access. So accessing the site off campus is possible.

5. *Question: I understand* this tertiary institution *has remote campuses and learners are supposed to connect from those remote sites to the eLearning platform. Were there any challenges from those remote sites in terms of speed and bandwidth issues?*

Senior systems administrator: No, the connection we have currently is good, we haven't had any problems. The only challenge is when we changed network equipment or providers and

most of the centres were not able to connect to servers and it was the task of the network team to open the necessary ports required for the connection and also to create/add routes to specific servers. Apart from that there was no problem. Like every system it is dependent on the main leased line we have and there are so many services provided to learners and the community through the same line. When it is that time of the year when learners are busy retrieving their results you would find that accessing Moodle will be probably slow. So it is dependent on different factors.

6. *Question: Just pointing out on some server slowness I have observed during orientation week or vacation schools when all the labs are fully used and the traffic to the server is high, the server response is slow. I thought that the backbone bandwidth locally was increased. Any comment on that issue?*

Senior systems administrator: The slow response is due to resources on the server hosting the Moodle platform. We have increased the memory to 16Gig since the initial allocation was too little and we increased the CPU after the Head Instructional Technology informed us that the load on the CPU was always high. For a server/systems being accessed by many learners, it is my suggestion to work on how to handle multiple concurrent connections. After experiencing the same problem with our ERP system, we had to split the load on different servers and it helped a lot. I know that the Head Instructional Technology is busy working on optimizing multiple access to MySQL database because the read and write process will present some challenges as well.

7. *Question: Do you have any plans to migrate or transfer the current platform (Moodle) to cloud?*

Senior systems administrator: Currently there is no plan. I had a look at the google eLearning platform that they provide for schools. The Moodle we are running was implemented two years ago and before that it was Chisimba and I don't see us moving to another platform/product soon. If we are to go cloud it would be best to explore learning platforms supported by google and considering the large number of learners. Technical

knowledge will not be an issue. I am aware of several cloud solutions and I was checking about moving the email sever to google authentication so that users will not spend time trying to figure out things or fixing them.

8. *Question: Just for clarity, I was considering moving Moodle as a service on the cloud and you and other systems administrators keep on administering it. You will not be worried about hardware and physical infrastructure.*

Senior systems administrator: No we haven't looked at that. We had discussions about cloud but the feedback which came out of those meetings is that we can actually expose ourselves to nsa snooping, nsa intercepting data and other attacks. Most of the managers pointed that we will be risking ourselves so that route was shot down. Going cloud - not anytime soon unless we have a radical change in the management.

9. *Question: I understand the networking department was running a project of implementing private cloud locally. How far have they gone with the project and how far in moving the Moodle platform to that private cloud which will be under your administration here?*

Senior systems administrator: It is not the networking department per se; we as a department would build our cloud including the networking aspect, the virtualization aspect and all of them; so it is not the networking department but all sections under DICT were involved.

10. *Question: Since there are no plans to go the cloud route and considering the current infrastructure, do you think it can support cloud? Considering bandwidth issues and other factors you might think of.*

Senior systems administrator: To be honest with you I don't think we are ready to go cloud. From my terms, how I understand cloud is when we provide the necessary service to our

learners from anywhere, everywhere seamlessly. Currently we are not at the same scale like Google, amazon; we are far away from that but we can offer what we call mini cloud with the services we provide like accessing ITS, accessing eLearning, accessing our website, accessing documents online. We can say to some extent we are providing cloud services already; obviously most of our services are running from private cloud and we are accessing them from within.

11. *Question: If we go the public cloud way, many stakeholders are sceptical about it. But when you go cloud, you will sign SLA confidentiality documents so that your information will be secure. What is your comment about that?*

Senior systems administrator: My comment on that is simple; yes you will have SLA, SLA with learners since we have to be accountable to learners since they are the ones keeping us employed here. For example, if a learner wants to upload an assignment the system needs to be available and SLA existing and if SLA is broken somehow there will be some penalties. That's the same you will get with cloud service providers like amazon, google, Microsoft. So if we decide to go that route we will be forced to have SLA in place.

12. *Question: On the issue of backup, you are responsible in backing up the whole system or individual courses because for now if I log on to Moodle I can see a course I taught 2 years back. For the sake of space, do you have a separate backup server or it's up to the administrators of the system (Moodle)?*

Senior systems administrator: We have backup in two stages. The Head Instructional Technology backs up the database (MySQL) and us as systems administrators are responsible for the VM; we do a backup of the whole system even if the database was backed up already. Our backup is effective since it will compress the backup so that it will not use more space. We haven't discussed with the Head Instructional Technology as to who does what when it comes to backup. There will be discussions with him to determine what we are supposed to do and whether backup should be implemented per course by course.

*13. Question: If there is a need for space for any VM you can add/increase as required. Within your policies do you have a cap or limit to say we cannot go beyond a certain size?*

Senior systems administrator: Currently we do not have a policy stipulating that and we should develop one. In some systems there should be a guiding document that has to be followed when setting up, for example Active Directory (AD) but with Moodle we didn't receive one from the Head Instructional Technology indicating specifications. Currently those contact people managing different virtual machines can detect that they need more space after their VM reports 95% full and then we can add more space. Last year the Head Instructional Technology was using 300GB and he requested more space since the system was at 95% full and we added 300Gig more and now it's at 53% and that space can last for the next two years. So the space is allocated in an ad-hoc manner.

*14. Question: I understand you are implementing single sign-on, may be just a comment on how far is the project, focusing on integrating Moodle on the project.*

Senior systems administrator: Our system analyst discussed this with the Head Instructional Technology because we did a preliminary investigation to see if we can integrate Moodle with AD. We recently finalized learners' active directory services. I am not sure when we are going to have a road map as to which service can we move to single sign-on. From the staff some of the internal websites we need to integrate with AD so it's still a work in progress. Integrating Moodle with AD will require more stages than many people thought. For example, if a learner forgets the password for Moodle who will reset the password for him/her. So now we are still busy finalizing the foundation and the other stuff can fall in place.

*15. Question: We have come to an end. Any comments/suggestions?*

Senior systems administrator: To be honest I don't really work on the platform. I don't know how Moodle looks like now. Moodle is used by thousands of universities in the world. The suggestion is to have better communication between the Head Instructional Technology and us to see what are his needs, future plans for the system and where does he want to move? We are just sitting in an island providing services. You find learners asking systems administrators questions relating to Moodle itself and those questions should be directed to the Head Instructional Technology or Instructional Technology Designer. I am suggesting a central learner's helpdesk where they can be helped with any query even not Moodle related.

Below are the questions which were asked to the Instructional Technology Designer and his answers:

*16. Question: I understand you are running Moodle. Can you describe the setup of Moodle in terms of infrastructure and the technical requirements and the tools which are required by the learners or users to access Moodle?*

Instructional technology designer: Moodle is an open source CMS. A lot of activities found in Moodle are developed either using html or php; they are running off the database. It is CMS that is customized to suite learning purposes. Infrastructure wise at this tertiary institution we are running virtual servers and the Senior systems administrator will be able to highlight technical details about those servers, for example hard disk size, memory, processor. Myself I'm not too technical. In terms of learners it's a web-based platform and they require any browser that supports html. In terms of the content that we develop its flash-based and the learners would end up being required to install a lot of add ins to their browser e.g. Java should be enabled, cookies, flash player is required. Learners require accounts to use and the profiles together with emails that can be used for reference purposes for most of the changes done on user profiles.

17. *Question: Any knowledge about the size you allocate to users? All courses at this institution are created on Moodle and any comment about the CUS411S course challenges in particular?*

Instructional technology designer: User space allocation can be found from the Head Instructional Technology but currently we don't have a policy for allocating user space, memory etc. Currently we are running with default settings on the server and the other challenge we are having is that the infrastructure is not managed by us. It's like we are outsourcing to DICT. No leeway to define our requirements hence we use the default settings options which come with the Virtual server. When it comes to CUS administration of the course, this is a challenge considering that we have categories like tutors/lecturers, coordinators, and learners. For the learner's side, teaching and learning is a challenge since most learners are not well-prepared for this type of learning; internet based learning. Basically this is distance learning where time management is key and our learners are not yet ready for this. Course administration challenges, the allocation of learners to tutors and on the system; the same configurations are done so that tutors can create activities for his/her group and be able to interact with the group. Groups are set as we go, it is not defined before the beginning of the semester and we keep on identifying learners not allocated to any group even up to the end of the semester and the learners complain that none of the assessments were marked. That is not a platform related problem or learner's problem; that is where the role of course coordinators should come into play.

18. *Question: So, the technical challenges I can find out from DICT?*

Instructional technology designer: Yes, they are running virtual servers. We could not setup our infrastructure and setup our system on top of other duties, we have to use existing infrastructure and I think it was a wise decision. For the allocation of space in Moodle itself, the Head Instructional Technology will be able to give the details.

*19. Question: When it comes to backup. How does the backup work, how do you backup the system? I can see some courses I taught some years ago, I am still seeing them? Do you have a backup server of the main system or you backup course by course and leave it accessible.*

Instructional technology designer: We have two backups. One is the backup of the server (entire system) and that runs twice daily and this backs up individual courses. Some departments have courses that are used for supporting the learners only. We add learners at the beginning of the semester and remove them at the end of each semester, those types of courses we don't create any backup. There are some courses where learners take tests, quizzes, participate in forums, assignments or any form of assessment(s). We create a backup at the end of each semester and leave it open to lecturers not learners when the semester is over. Lecturers would want to review what happened in the past and each backup will have a label; for example the year and semester when the course was offered for easy referencing. We are looking at separating the content/data of the system and the front end system so that it will be easier when doing backups and upgrading since we won't upgrade the whole servers. This helps when archiving but all this is up to DICT to offer that service; so far we cannot run and manage the whole platform on our own.

*20. Question: Are there any plans to migrate the current Moodle you are running into cloud?*

Instructional technology designer: No plans at the moment mainly because it comes to bandwidth issues. Let us start with the networking infrastructure he have. From the network side we deal with the Network manager. The support we had so far is high uptime for our server, so moving on to the cloud doesn't necessarily offer any immediate advantages. We wouldn't be so driven to the cloud. Moving to cloud also helps us in terms of infrastructure - the hardware on the ground; that is the biggest advantage if we move to the cloud but our challenge is the infrastructure that exists and even when it comes to the budget. Management seems to want to only prioritize any infrastructure we might need so from that aspect we don't have an administrative push for us to consider the cloud. There will be other advantages in that it will be much easier to manage the server and far much easier even when the ownership moves into our hands than to liaise with the department handling the servers since they have other servers they are managing. We always get priority when it comes to our server or the infrastructure we might need. The institution invests in our needs so we are not driven to go cloud.

*21. Question: So there are no plans to go cloud. Let us maybe say that you want to move to cloud; do you think the infrastructure we have already is able to access our server from the cloud or we need to supply or add more equipment, bandwidth and other aspects?*

Instructional technology designer: I think we have to definitely work on bandwidth if we are to move to cloud because the constraints we have actually is bandwidth. The DICT side is constantly negotiating for better rates when it comes to bandwidth and most of the time we get the short stick of it all. We are not really in a position where we are able to handle the growth in the usage of the platform with regards to some of the services we want to put on the platform e.g. we want to put the plugins for WebEx. So the same server very soon will be supposed to handle video conferencing as well. When it comes to WebEx on its own, without our eLearning services it requires more bandwidth and it will be a bottleneck. If we consider the numbers, for example CUS has 500 learners and for the first semester there will be 2500 and upwards if all of these learners for one subject start making use of the video conferencing - we will face some embarrassment. I think they need to look in that direction. In terms of hardware I don't think we have big challenges; they have shown us room for expansion and room to add more hard drives, so we are not worried about hardware or software but bandwidth.

*22. Question: When it comes to bandwidth I have seen that locally when we have orientation or when most of the users are running tests or when the system is overloaded we have discovered that the server becomes slow and as a result some of the concerns we got are with regards to the bandwidth and the server issue. Locally the networking department has done a lot to increase the backbone bandwidth so the question is: what will make the server to be slow locally without us not going out of the institution?*

Instructional technology designer: Cache memory allocation is one of the reasons although we tend to increase it as the need arises. Most of the time we end up upgrading after we have seen the need.  So, here and there we tend to respond a bit slowly because we don't foresee certain usage on the server but that is mainly because there is cache and virtual memory. That is what we need to be more vigilant in upgrading and I think that this should be the responsibility of the Senior systems administrator or Head instructional technology. Bandwidth locally should be sufficient except memory (cache & virtual) and we haven't sent out an announcement or apology if we are to consider the public relations side. Since we upgrade as need arises because there are virtual servers, they cannot allocate too much

space to us if the need hasn't arisen so they rather prioritize other services e.g. ITS, and they handle our request as a request rather than giving us more virtual memory.

23. *Question: Thank you very much for your input. Are there any other comments or what you feel about the eLearning server which we did not ask but that you feel is important and we need to be aware of that?*

Instructional technology designer: With the integration of technology which is being done in phases and also the single sign on, I am hoping that it will reduce the user profile management. You can find cases like a learner coming to change the profile settings because initially it was linked to a certain girlfriend or boyfriend but they broke up and now they cannot request for password change since it will go to the person they broke up with. By default, all learners' accounts are linked to learner's email. We hope that once the single sign on is completed everything from the administration side will be smooth and running.

The questions that were supposed to be asked to the Head Instructional Technology were not asked in the form of an interview. Instead the interviewee opted to type the answers because they had no time for the interview. The questions and the answers he provided are listed below:

24. *Question: Do you have any eLearning platform?*

Head instructional technology: Yes, this tertiary institution has one.

25. *Question: I understand you are using Moodle; can you describe its setup in terms infrastructure and technical requirements as well as users' feedback, and the tools required by learners to access the platform. Size of space per user. Any comments for the Computer User Skills (CUS) course since it is the biggest group?*

Head instructional technology: The institution deployed Moodle, which is a renowned World-class virtual learning environment system and it is currently in use. Currently more than 13,000 are registered on the eLearning platform. We designed an instrument (online survey) to assess users' satisfaction and this instrument will be implemented starting from 01/10/2015. Other mechanisms to collect user (especially learners) satisfaction are within individual courses.

*26. Question: What are the major challenges (technical) faced with the current platform?*

Head instructional technology: There are no major challenges for the platform; it is working as expected. The challenges mostly come from the network aspect when there are a bigger number of users connected from the same entry-point to access the platform; this is not common. The system will need more memory in the near future. Content within courses grows rapidly; internal memory should be added in the near future to accommodate the rapid growth of users and content, including multimedia, such as videos, simulations, etc.

We are currently busy designing a cluster deployment of Moodle and this will possibly start next year and this will greatly increase the speed of the overall eLearning system.

*27. Question: Any plans to transfer the application to cloud?*

Head instructional technology: No plan so far, none of I know about. Due to the size of the system and the traffic on the system, shifting to cloud may result in serious financial implications that we need to evaluate compared to the current cost.

*28. Question: Do you need to change/acquire (sufficient infrastructure) (if any) to migrate the current Moodle to cloud?*

Head instructional technology: Basically you shift to cloud because you don't have or you don't want to have specific IT infrastructures that this tertiary institution possesses already. Current infrastructures are more than enough for a cloud deployment at this tertiary institution.

*29. Question: Any benefits from the current setup to cloud? Can your current setup support the cloud environment? Especially bandwidth.*

Head instructional technology: Cloud services are suitable for organisations that are not planning to get IT infrastructures on their own; this reduces considerably the cost of IT operations. These organisations rent services already deployed by cloud service providers. This tertiary institution is currently running above 50 servers for various web-based services. Taking only the eLearning system on the cloud will not present any benefit for the institution because the required infrastructures are already in place; this will definitively cost more money because the institution will rent services that are already available locally. Shifting eLearning to cloud will be beneficial if the institution does not have the technical and financial capacity; this is not the case today.

What I can add here is that the institution is not running only Moodle when it comes to technology integration in teaching, learning and assessment. We have other technology solutions, such as ePortfolio, virtual classroom system (WebEx, even Better Business Bureau (BBB)), online survey system and we are busy deploying an Intelligence Artificial system for marking purposes. I am not sure if it is financially viable to deploy these systems.

This tertiary institution is making use of virtualisation already to maximise the efficiency to its solutions; I don't see the benefit of virtualisation at this stage.

## 4.3 Steps to Setup Cloud Based eLearning Platform

This section presents the technical setup process of the cloud server which was used to host the Moodle eLearning server. In this research the researcher wanted to find out the relationship between a cloud based eLearning system and performance. This means that deploying a cloud based eLearning system is the independent variable and performance is the dependent variable. As such the experiment was supposed to outline what happens to an eLearning system performance after it has been deployed to the cloud in comparison to when it is deployed on local servers.
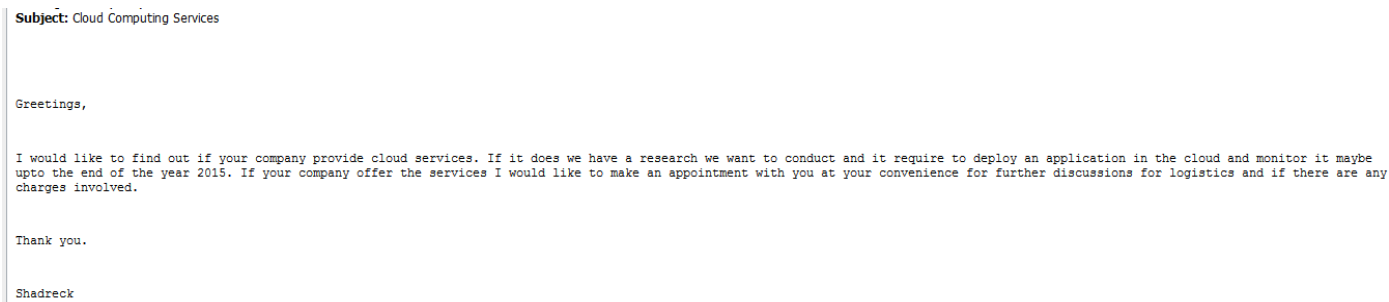
## 4.3.1 Obtaining Cloud Service Provider

After the interview process the researcher was triggered to implement or setup the Moodle on the cloud. The researcher started searching for cloud service providers in Namibia and the following were identified:

- XON Namibia
- Dimension Data Namibia
- Business connexion
- Microsoft
- Salt Essential IT

The researcher approached three different cloud providers namely Dimension Data Namibia, Microsoft and XON Namibia and efforts to contact Microsoft were not fruitful.

Dimension Data was contacted and they were willing to provide a 14-day trial account. All efforts were made to make sure that the researcher would finish the registration process using a coupon code provided. However, there was a challenge in the registration process. The process required the credit card details and unfortunately the researcher did not have a valid credit card at that period. Credit card details were needed so that after the 14-day trial was over then the billing system would automatically bill from the credit card. As the researcher tried to finish the registration process without credit card details the system refused and one of the online Dimension Data support personnel picked it up and contacted the researcher so that the registration process could be finished in a step-by-step guided manner. This process did not materialize since the details of the credit card were required. Figure 6 and 7 are some of the emails exchanged between the researcher and Dimension data personnel in trying to have a cloud based server.



**Subject:** Cloud Computing Services

Greetings,

I would like to find out if your company provide cloud services. If it does we have a research we want to conduct and it require to deploy an application in the cloud and monitor it maybe upto the end of the year 2015. If your company offer the services I would like to make an appointment with you at your convenience for further discussions for logistics and if there are any charges involved.

Thank you.

Shadreck

*Figure 6:Email sent to Dimension Data asking for a Cloud Server*

*Figure 7: Email from Dimension Data Technical Team*

The credit card challenge was not solved, thus, the researcher approached another cloud service provider called XON Namibia.

XON Namibia was contacted and the representative forwarded the request to the XON technical staff based in South Africa. XON was willing to provide a trial cloud server since it is a partner to this tertiary institution. XON Namibia is a networking systems integrator that specialises in solutions for service providers that offer cloud computing services among others. A similar email like the one sent to Dimension data was sent to XON.

The researcher was instructed to visit the XON website and register for a cloud account and the challenge was the same as the one faced with Dimension Data, credit card details were required. After some conversation with XON personnel they managed to grant the researcher permission to finish the registration process without the credit card details and the registration was done. An account was created based on an email address and the password that was provided by the researcher. After the registration process was done the next stage was to setup the first Linux server in the cloud. The next step was to setup a Linux cloud server.

### 4.3.2 Cloud Server Setup

The researcher was using a computer from work as well as a home computer. Below were the specifications and the environment that was used to setup a Linux Server on Wingu cloud. Wingu is a Swahili word which means cloud. Wingu is the name of XON cloud.

*4.3.2.1 Work Environment*

One desktop computer with 8Gig of RAM, one Terabyte hard disk space, Intel(R) Core(TM)2 Quad CPU operating at 2.67GHz with Work internet speed; windows 7 Professional 64bit with Firefox and Internet explorer browsers.

*4.3.2.2 Home Environment*

One desktop computer with 8Gig of RAM, one Terabyte hard disk space, Intel Core i3 processor with internet speed of 512kb/s and windows 10 Professional 64bit with Firefox and Internet explorer browsers were used.

To setup the Linux server on Wingu, the researcher followed a tutorial guide provided by Wingu Network Solutions (2016). Access was granted after logging with the credentials set during the registration process.

After successful login the researcher was presented with a Dashboard with different options depending on what one wants to do. The screenshot in figure 8 indicates a sample dashboard:
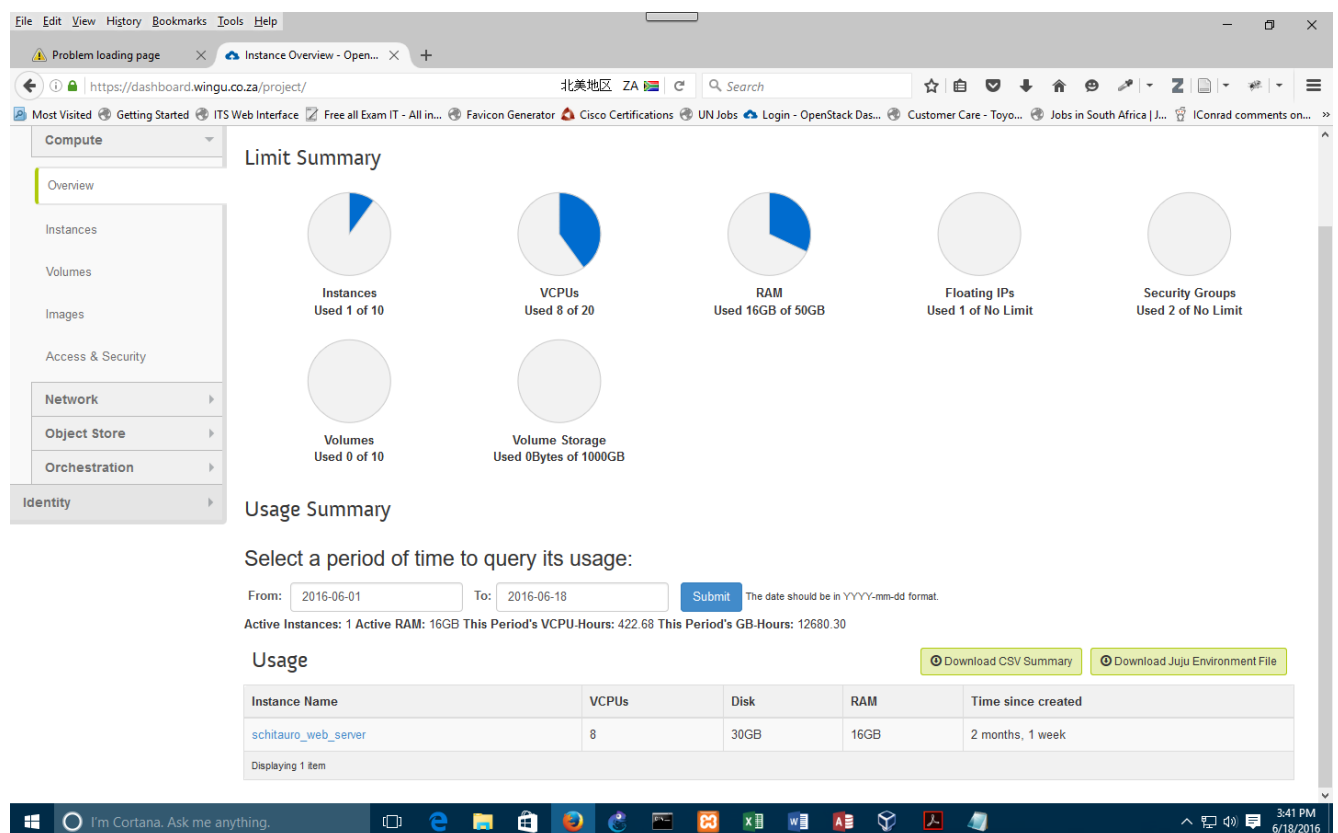


*Figure 8: Wingu dashboard after logging in*

From the dashboard the researcher started by creating a secure shell key pair which was needed for authenticating servers. This was done through the compute tab → access and security option → key pairs option → create key pair. The page for naming the key popped up and the researcher gave it a name called **schitauro_first_key.pem**. The file was created and the researcher downloaded and saved the file so that it can be used when you want to log in remotely through secure shell.

The next step taken was to create a network within the Wingu cloud which will be linked to the server. This was done by selecting network tab → network topology tab. After that a screen with a single public network shows. The researcher created a private network to attach the server by clicking on the create network tab and a popup screen appeared with fields to enter the network name and the subnet. **Chitauro_first_network** was used as the network name. The next step was to populate networking information. The researcher was left with a choice to choose an address space in the private range and a default gateway to be associated with the network name created as **Chitauro_first_network**. At this stage the cloud provider assumed that the person who will be configuring this platform must have networking knowledge so that the person can choose a proper private IP address space; private IP addresses are not routed on the internet. A private IP address of 192.168.10.3 with a subnet mask of /24 (255.255.255.0) and a default gateway of 192.168.10.1 was selected. The Wingu platform supported both the Internet Protocol version 4 and 6 (IPv4 and IPv6) addressing, but for the purpose of the research an IPv4 address was used since the researcher's machine was using IPv4. The researcher clicked next and left the default options for Dynamic Host Configuration Protocol (DHCP) server which indicates that any new server in the range defined above will get a dynamic IP from the cloud DHCP Server. The next stage was to click on the create button and the screen changed from showing one public network to two networks, one public and **Chitauro_first_network**.

The next step was to create a router between the two networks, that is the internal network and the external network. The purpose of the router is to allow access to internal servers from the internet. At this stage the provider assumed that the implementer should have knowledge on networking and routing to understand some sections. After adding the router, the internal servers had internet access for software updates and software packages installation but were not accessible from outside. From the network topology the

researcher selected 'create a router' and the router was named **chitauro_first_router** and it was created. The router icon appeared between the two networks but they were not connected to any network. To connect to these two networks, the researcher moved the mouse pointer to the router icon and options popped up to add interfaces on the router. From the options which popped up, add interface was selected and another dialogue box showed up where the researcher selected the network name created earlier and an internal gateway address was entered on the IP address field. After adding the interface on the router an option to add a gateway to the external network appeared. Two options were set, that is, the external network was selected as public and the router name which was created earlier was selected under router name. After this stage the network diagram was showing connections from the internal server to the public network.

Every server defined must be associated with a security group which defines the type of access and in which direction. Wingu emphasized that they take security very seriously and as such they force the creation of security parameters. A security group was created by clicking compute → access and security option → security groups. The default security permitted the server to communicate with the public but no inbound connection was permitted unless if there is a corresponding outbound match. Since Moodle was going to be used through the browser, the researcher was required to permit the TCP port 80 for http services. The security group was created as **chitauro_web_servers** and the description was left as a basic web server access rule. After creating the security group, the next step was to manage rules by creating a rule through the add rule tab. From the next screen under rule, HTTP was selected and remote CIDR (Classless Inter-Domain Routing) was selected and the add button was clicked to add the rule. The rule was created showing a summary of the rules. The rule which was added was an ICMP rule that enabled the researcher to ping the server for troubleshooting purposes. Figure 9 shows the rules created:



| | Direction | Ether Type | IP Protocol | Port Range | Remote | Actions |
|---|---|---|---|---|---|---|
| ☐ | Egress | IPv6 | Any | - | ::/0 (CIDR) | Delete Rule |
| ☐ | Egress | IPv4 | Any | - | 0.0.0.0/0 (CIDR) | Delete Rule |
| ☐ | Ingress | IPv4 | TCP | 80 (HTTP) | 0.0.0.0/0 (CIDR) | Delete Rule |
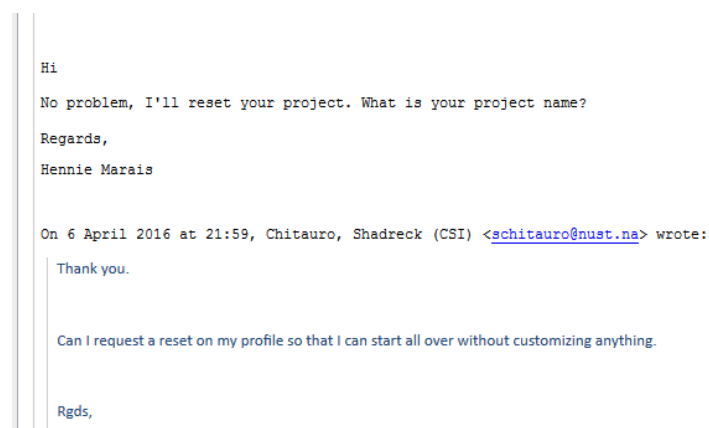
Displaying 3 items

*Figure 9: Security rules created on Linux Wingu server*

The next stage was to create the web server running on the Linux Ubuntu server version 14.04. This version was selected since the researcher wanted to use the same operating system and as well as the Moodle version as the one for the tertiary institution. To achieve this, the researcher selected compute tab → instance →launch instance. Under the availability zone, any availability zone option was selected and under the instance name **My_Web_Server** was entered, under flavour an option which gave 16Gig of RAM, 8 CPU cores and 30GiG hard disk was selected, the instance boot source was left with the image option and Ubuntu 14.04 (Trusty) amd64 was selected. There was an option to add or upload any image one wishes to install. Under the access and security tab the first secure shell key pair defined at the initial setup was selected and under security groups, **chitauro_Web_Server** was selected. From the Networking tab under selected networks, **chitauro_first_network** was selected. Under post-creation the following customized script was used to inject the password and set the password to no expire:

> **#cloud-config**
> **password: mysecret**
> **chpasswd: { expire: False }**
> **ssh_pwauth: True**

The script set the password to **mysecret**. Initially the researcher changed the password to a customized one but the system failed to login. The researcher then tried to restart the system, contact the support staff but with no luck and eventually the researcher requested the technical staff to reset the instance and use the default password specified in the script and it worked. Figure 10 gives a summary of when the researcher requested the resetting of the researcher's instance.

```
Hi

No problem, I'll reset your project. What is your project name?

Regards,

Hennie Marais


On 6 April 2016 at 21:59, Chitauro, Shadreck (CSI) <schitauro@nust.na> wrote:

    Thank you.


    Can I request a reset on my profile so that I can start all over without customizing anything.


    Rgds,
```

*Figure 10: Email sent to XON support team requesting instance reset*

When the researcher requested a profile or Wingu instance resetting, the support staff tried to give advice on what to check for and then try again. Part of the conversation is shown in Figure 11. The researcher tried to do so but to no avail and eventually the resetting process was taken.



Subject: Re: Cloud Server Assistance

Hi Shadreck

There is no need to reset your setup, I believe you're just missing one or two things. At most you might have to terminate your current instance, fix a couple of things, and then launch a new instance.

The script that sets a password (if you do decide to use it) gets executed after the instance is fully up and after a short delay, so it's possible that you can have a login screen and not be able to login shortly after the instance is created. Just wait a minute or 2 and it should work.

In terms of being able to SSH in, did you create a security group that allows inbound SSH connections and associate it to the instance? You'll need to do this in order to be able to SSH to it.

Let's also just double check your networking setup as everything I've described so far will only work if it's correct setup. Please go through the following and make sure you covered everything:

1. Did you define a network with subnet details (range, default gateway, DNS)?

2. Did you create a router?

3. Did you set the gateway for the router?

4. Did you create an interface on the router in your network?

Regards,

Hennie Marais

*Figure 11: Advice from Wingu technical team not to reset instance*

The next stage was to launch the instance to start the Linux Server. The last stage was to assign a public IP address to the server so that it can be accessed from anywhere as long as the client accessing it has an internet connection. From the instance windows, the researcher clicked on the drop down menu of the instance created before and selected the associate floating IP address option, the project had to be assigned an IP address before allocating the public IP address. When allocating the public IP address under the pool section, Public was selected and the system allocated the next available public IP address of 168.253.217.37 and then clicked on associate. This completed the setup.

Towards the end of 2016 an email was sent to notify the Wingu trial account holders that their instances were going to be terminated since they were upgrading Wingu cloud platform to version 2.0. This meant that all the cloud setups were removed since it was for free trial purposes. Following this statement, an email supporting this paragraph is inserted in figure 12:

Dear Shadreck,

We will need to terminate your trail account on our Wingu Cloud platform.

We are moving to the new Wingu 2.0 platform this month and need to deactivate all trial users.

Trust all in order.

Have a safe and blessed holiday season.

Kind regards,

*Figure 12:Trial accounts termination notification from Wingu*

### 4.3.3 Moodle Server Setup on the Cloud

After the Linux Server was set on Wingu cloud, the researcher downloaded Moodle version 3.0 as a zipped or compressed file on a client machine from the Moodle official site (https://download.moodle.org). The zipped file was uploaded to the cloud server through the use of a secure shell. The setup guide from the Moodle site was followed to configure Moodle. The following are the steps which were followed:

Moodle is a web based content management system used for teaching and learning. Since users of Moodle access the platform via the browser, it follows that a webserver has to exist to support web access of the platform through a browser. Apache2 was used as the web server service running on Ubuntu 14.04 LTS and php since the application was developed using php scripting language. Moodle required a database to keep its tables, users, and course information. One of the database which was recommended and which was installed was MySQL and this was also done to match the one that has been implemented at the tertiary institution under study. Before the installation of any applications one command was required: **apt-get update**. This command scans through all the possible repository mirrors which can be used during installation, and preferably the closest mirrors are used. The following applications were installed since they were required by Moodle (positive dependencies).

**Installed applications**: apache2, mysql-client, mysql-server, php5, graphviz, aspell, php5-pspell, php5-curl, php5-gd, php5-intl, php5-mysql, php5-xmlrpc, php5-ldap, clamav.

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Clamav was installed as an antivirus so that it can scan all the contents being uploaded to Moodle. Aspell was necessary for spelling checks especially when instructors are creating documents (tests, quiz, assignments, etc.)

After the installation, apache2 service was restarted using the **sudo service apache2 restart.** A temporary folder was created and the compressed file for Moodle was extracted into the temporary folder. After this process, all the contents inside the temporary folder were moved to the **/var/www/html** folder which is called the **DocumentRoot** folder. This folder is the default folder used to host any content to be accessed by clients via web browsers in **apache2** and **httpd**. A folder called **/var/moodledata** was created for temporary and cache information. The owner of **/var/moodledata** was changed to www-data through the use of the **chown** command. **www-data** is a system account.

Full permissions were granted to all three categories (owner, group and others) to the **/var/moodledata** folder. Permissions on **/var/www/html/moodle** were changed to owner=read, write and execute permissions; group=read and execute permission; others=read and execute permissions. The following lines were added to MySQL configuration under [mysql] basic settings.

> **default_storage_engine = innodb**
> **innodb_file_per_table = 1**
> **innodb_file_format = Barracuda**

MySQL service was restarted to effect the changes.

Connection to the MySQL server was made using the command: **mysql  -u  root  -p**

A database called Moodle was created and a user called Moodle was created with a specified password. The Moodle user was granted full rights on the Moodle database and any tables inside the database. The command **quit;** was used to exit from the MySQL command line. To complete the setup process the researcher accessed the Moodle platform via the web browser by typing the following url:   http://168.253.217.37/moodle and the rest was completed using the graphical user interface. After the installation the researcher logged in and created two courses and enrolled a few users to CCNA 1 course. Figure 13 shows a screenshot of the working Moodle deployed in cloud.
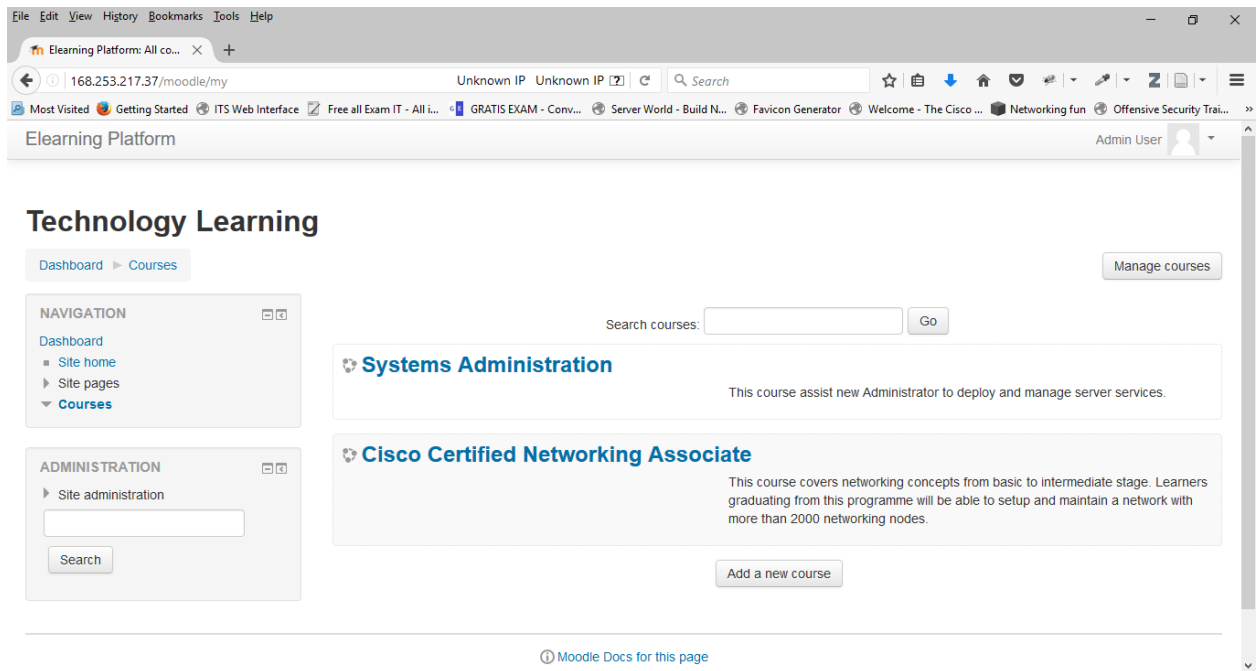
*Figure 13: ELearning interface running on Wingu Cloud*

Much of the administration was done through the site administration tab and site administration of a specific course. Participants from one class were asked to test the cloud based eLearning platform. The researcher uploaded one file for learners to download and answer the questions according to specified instructions. Learners managed to upload the answered file. However, they were not able to upload a video file more than one gigabyte in size. Although the researcher was able to adjust the size for uploads on **Moodle** and **php_upload** parameters, the learners failed to upload a big file (more than 1Gig) due to the bandwidth.

### 4.3.4 Findings from Experiments

1. From the client side only a computer with a browser and internet connectivity was required.

2. There are several cloud service providers in Namibia which offer cloud services. For example, Business Connexion, Dimension Data, XON and Microsoft. An experiment was carried out on XON Wingu cloud.

3. To get cloud service access you need a valid credit card.

4. Setting up the cloud server can be done by the cloud service provider or clients can set it up following technical guidance provided by the cloud service provider.

5. In Cloud, the hard disk space, RAM and CPU allocated to the researcher was sufficient and could be used to host the cloud based eLearning platform without problems. In the case of this research, the researcher's trial account had access to three different categories with different sizes of 8Gig, 16Gig and 30Gig. In a normal scenario, the disk space that you get depends on the amount you pay.

6. Cloud service providers enforce security when setting up their cloud based servers.

7. Support is readily available at any time because at any given time there will be technical staff waiting to solve client queries.

8. ELearning can be successfully implemented on cloud systems.

9. Access by all fifteen learners to the ELearning cloud environment was possible; they could access their course, upload content, view documents, take assessments, participate in chat forums and see instructions from the instructor.

10. The instructor could also upload content, create assessments, create chat topics, etc.

### 4.3.5 Conclusion

The setting up of the Wingu cloud server was possible and very easy to accomplish because of the guide provided by the cloud service provider. Additional technical knowledge was required. By following the technical guide very few questions were posed to the Wingu technical support staff. The same applies to the technical guidance that was provided for Moodle installations. In general, the setting up process was relatively easy and it was done within a short space of time. Accessing of the eLearning material was fast either using high speed bandwidth or low speed bandwidth.

## 4.4 Findings from Literature Reviews

Literature reviews were used to determine current eLearning platform usage challenges and to determine cloud infrastructure and cloud platform usage.

1. ELearning challenges are knowledge management support, individual challenges, financial challenges and technical challenges.

2. Cloud computing can solve the eLearning challenges.

3. A theoretical framework (figure 4 section 2.12) summarises the eLearning challenges and how they can be overcome.

4. CCAUM which was derived from TAM is a model that is used for cloud adoption.

## 4.5 Summary

This chapter highlighted the data that was gathered from people who implemented the eLearning systems and those who managed the virtual machines in the data centre for the institution running on VMware ESXI server. An experimental cloud based eLearning system which was implemented in the cloud was also stated. Findings from the experiment were also highlighted. Following these discussions from the experiments, some brief findings from the literature review were also discussed. For detailed literature reviews findings refer to chapter 2. The next chapter will analyse the data obtained from interviews.

# CHAPTER 5: RESULTS ANALYSIS AND DISCUSSION

## 5.1 Introduction

This chapter reports on the data extracted from the interviews discussed in chapter 4. Chapter 4 highlights what the interviewees said verbatim. At first the researcher went through the interviews and jotted down their initial thoughts about the data. The researcher went on to look at the data in detail, jotting down notes about what they thought data was representing. The researcher summarised the data into themes that were common across the data. It is important to note that the interviews were used to address the objective of identifying the challenges and current usage of eLearning platforms. From the literature reviews done in chapter 2, eLearning challenges in other eLearning systems had already been identified. As such, the researcher analysed the data, looking for information pertaining to the already identified challenges and any other interesting points on how the eLearning system is being used at this tertiary institution. After these interpretations were presented in a table they were then analysed to identify how the eLearning system is used and the challenges being experienced.

5.1.1 Results Analysis Roadmap

The analysis of the information was done following the steps below:

1. Overview of data was done to get preliminary insights on what the data contains.

2. A list of the challenges that were identified in literature reviews was compiled. Since the researcher was addressing the objective of finding the challenges on current eLearning systems, the challenges identified in literature reviews served as a good basis for grouping the found information. The challenges were categorised as financial, technological, individual, knowledge management, support, plan to migrate, security and other interesting facts.

3. Find challenges at this tertiary institution's eLearning system and any other recurring information. At this stage the researcher;
   a. Identified the challenge under which the data fell into.
   b. Listed the interpreted challenge in table 4.

4. Make a comprehensive deduction of what the interpreted data really means to the researcher.

## 5.2 Data Analysis

This was done following the four steps of the result analysis roadmap above. The researcher recorded the interviews conducted. The recordings were then transcribed and then the categories of challenges were listed based on the literature reviews.

### 5.2.1 Initial Thoughts

After going over the data for the first time these were the researcher's initial thoughts about what was contained in the interviews.

- There is low bandwidth at the tertiary institution for eLearning activities.

- There is a lack of policies (what should be included in the backup, how to integrate Moodle with an active directory for single sign on, quota allocation, memory, CPU and HDD allocation, resource allocation in general)

- There are no plans to go cloud as long as management cannot support the move or drive. But respondents cite some benefits of migrating to cloud including resource additions/removal on demand.

- Sometimes the findings by eLearning administrators are not clearly communicated to the system administrators.

- The eLearning platform not given preference when it comes to resource allocation.

- There is a need to separate services on the eLearning server so that not all services will run on the same server (e.g. user front end, database, Moodle system)

After this initial observation then step number 2 was taken and the identified challenges are the ones listed in the introduction section for this chapter.

### 5.2.2 ELearning Challenges

There were no financial and knowledge management challenges based on the data collected through interviews. It was noted that the implementation of Moodle at this tertiary institution brings about financial support obligations when there is a need to increase system memory, storage space. However, all the interviewees clearly stated that this is not an issue as eLearning has been given priority such that whenever they need to upgrade they can do so. As indicated in chapter 2, the knowledge management challenges that other eLearning systems face are that of having no policies to manage the training of users and copyright issues.  The other challenge with knowledge management is that there must be an

eLearning strategy to overcome problems and complexities brought about by eLearning. This also was never highlighted by the interviewees as things that might either cause problems or not. The rest of the challenges and data from the interviewees is listed in table 5.

*Table 5: Findings from interviews*

| TECHNOLOGICAL CHALLENGES | |
|---|---|
| Question Number | Findings |
| 1 | Storage (600Gig), Memory (16Gig), Virtual CPU (one core 8 sockets, 3.2GHz intel Xeon) |
| 1 | Two servers are used: one for production and one for training |
| 2 | Storage |
| 2 | Security: systems administrators give eLearning server support staff the required credentials to access the Virtual machine hosting the eLearning platform. |
| 3 | The storage capacity of the eLearning server is increased when required |
| 3 | ELearning databases reduce performance when there are too many concurrent users |
| 4 | Tools needed by users to connect to the Moodle platform - browsers |
| 4 | Mobile devices can be used to access Moodle |
| 5 | The eLearning server reduces performance as the number of users connecting increases |
| 6 | The eLearning server reduces performance as the number of users connecting increases |
| 6 | Staff members responsible for the Moodle server have a skill to optimize database access |
| 14 | They do not have the skills to integrate eLearning in the existing security framework |
| 16 | Technical specifications required from the user side; browser with html support, java, cookies, flash player |
| 26 | The eLearning platform reduces performance when there are too many concurrent users on the network |
| 26 | They foresee a future need to increase resources due to the growth of the content and the services to be integrated with Moodle |
| INDIVIDUAL CHALLENGES | |
| Question number | Findings |
| 17 | Learners are not ready for eLearning |
| SUPPORT CHALLENGES | |
| Question | Findings |

| | |
|---|---|
| 3 | The eLearning server support staff lack skills to ensure that the eLearning server powers up after maintenance |
| 3 | There is no proper communication structure between the eLearning server support staff and the eLearning server content staff |
| 6 | Staff members responsible for the Moodle server have the skills to optimise database access |
| 12 | Backup is done in two stages - the database MySQL and the actual VM including anything in it |
| 12 | No coordination between the Head instructional technology and system administrators for backups |
| 13 | Not enough human resources to manage too many learners |
| 15 | No communication between system administrators and eLearning administrators |
| 17 | No coordination between system administrators and TLU (Moodle administrators) |
| 19 | The TLU staff is responsible for optimising the eLearning system |
| 22 | The TLU staff is not able to foresee needed resources, and this makes the server to be slow and they only react once it becomes slow |

## PLAN TO MIGRATE

| Question number | Findings |
|---|---|
| 7 | The tertiary institution's DICT has plans to migrate to google educational services and email services |
| 8 | The tertiary institution's DICT has no plan to migrate Moodle to public cloud |
| 9 | The private cloud already exists |
| 10 | Local services are running from private cloud |
| 20 | There are no plans to migrate to cloud since they were given high uptime and priority for infrastructure acquisition from DICT |
| 21 | There is no plan to migrate but this is not because everything is good - they just do not have the plan. This is also inferred from the previous question (20) where they clearly state that they do not want cloud because everything is good but in this question interviewees highlighted bandwidth problems with the current eLearning system |
| 22 | There is no plan to migrate but not because that everything is good, they just do not have the plan. This is inferred from previous questions (20 and 21) where they clearly stated that they do not want cloud because everything else except bandwidth is good, but in these questions interviewees highlight resource(s) problems with the current eLearning system, for example memory. In addition, the interviewee stated that other services are given priority like ITS. |
| 27 | There is no plan to migrate. If they migrate there might be serious financial implications incurred |
| 28 | There is no plan to migrate because the infrastructure they have is sufficient |

| 29 | They do not want to migrate to cloud but they are running a cloud already with more than 50 virtual servers and they do not foresee any benefits by migrating to cloud |
|---|---|
| **SECURITY CHALLENGES** | |
| Question number | Findings |
| 8 | Security fears as a result of migrating to cloud |
| 14 | ELearning is not included in current security policy |
| 14 | they don't have the skills to integrate eLearning in the existing security framework. |
| **OTHER INTERESTING FACTS** | |
| Question number | Findings |
| 11 | If cloud is adopted then they will get SLA |
| 13 | There is no policy for the allocation of the VM size. The space is allocated in an ad-hoc manner. |
| 16 | Assuming that learners properly know how to install the required browser add ins. |
| 16 | Learners require accounts linked to their emails so that they can receive notifications about profile changes |
| 17 | There is no policy for user size allocation |
| 23 | Learners use boyfriends' and girlfriends' emails on their profiles so when they break up they cannot request for password change |
| 25 | There are more than 13000 registered users on the current Moodle platform |

The researcher can deduce the following from the information obtained:

5.2.3 Technological Challenges

The tertiary institution has an eLearning server that has over 13000 registered users and the following specifications; storage hard disk space of 600Gigabytes, 16Gigabytes of RAM, apache webserver, one core 8 socket virtual CPU with 3.2GHz of intel Xeon type and the database being used together with Moodle is MySQL. The eLearning servers are setup in such a way that one is for production and the other one is for training purposes. The recommendations for Moodle are; 160MB free (minimum) but realistically it is 5Gig, 256Mb of RAM (min) but every 10 to 20 concurrent connections require 1Gig. This means that on a day when we have the biggest group (approximately 2500 learners) running an online test, then the eLearning server will be operating way below optimum conditions of 125Gig of RAM. The researcher can only imagine how strained the server will be on that day, where by

coincidence half of this tertiary institution's population is connected and working from the eLearning platform.

For learners to connect to the eLearning server they need any device with an installed browser which supports html, java, cookies and flash player. Mobile devices are included as well. Learners' accounts are linked to their email so that they can receive notifications about profile changes. All the learners are expected to know how to install the necessary add ins to their browsers. This might be a wrong assumption as was shown by interviewee two (2) who stated that learners are sometimes not ready for eLearning and some learners use their boyfriends' and girlfriends' emails on their profiles. This clearly means that they do not understand the implications to accessing eLearning courses in the case when they break up and they cannot request for a password change. Furthermore, assuming that learners know how to install add ins and necessary plugins is also an improper assumption because you need to assess the level of computer literacy the learner has.

In addition, the eLearning database reduces performance when there are too many concurrent users working on the eLearning platform. This point was raised as a major concern by all three interviewees as they all highlighted this as a major problem. One of the reasons for such behaviour on the server as explained above is that the RAM is not enough for the number of users. The other reason for such a kind of behaviour is that the bandwidth is insufficient. Although interviewee two (2) said that they are given high uptime, it can be inferred from the subsequent answers that there really exists a bandwidth problem.

### 5.2.4 Support Challenges

Systems administrators give eLearning server support staff the required credentials to access the Virtual machine hosting the eLearning platform. That is normal practice in any system setup. This will increase security because not every eLearning user will have access to the actual Virtual machine's configurations and setup.

Furthermore, backup is done in two stages: the database (MySQL) backup and the VM backup including anything in it. The backup of the database is done by eLearning administrators and the VM backup is done by systems administrators. The backup of the

database is replicated because system administrators backup all the VM and everything stored on those VMs. This would imply wastage of storage resources since two copies of the database backups are created. ELearning administrators have the responsibility and also the knowledge on how to optimise the eLearning database for performance improvement especially in the case where there are too many connections at the same time. This is a good skill to have at this tertiary institution's eLearning team. However, sometimes after maintenance they are unable to ensure that the eLearning server powers up so that users can access it. In addition, they are unable to integrate eLearning in the existing security framework and sometimes they are not able to foresee the needed resources which make the server to be slow and they only react once the server is slow. The separation of the eLearning system and the database is a good administration practice. In the event that the eLearning system experiences a problem, this will not affect the database because the two are separated. To improve the skills required for the system to run seamlessly then the institution needs to hire more skilled personnel or train the current eLearning support team. However, this would mean that they have to increase the financial resources required for the eLearning system. It also came out that the human resources are not enough to support the big number of learners and staff enrolled on eLearning at this tertiary institution. To improve on this, they need to hire more personnel, which also has some cost implications.

Moreover, there is no coordination and communication between the systems administrators and the eLearning administrators although they are working on the same system with the same goal. All of the involved carry out their tasks disregarding the other players, thus, there are double backups of the database and improper server configurations. In addition, there is no central management to manage the implementation and maintenance of the eLearning system. This is why there is no policy for VM size and for user size allocation.

5.2.5 Financial Challenges

ELearning administrators foresee a future need to increase resources due to the growth of the content and the services to be integrated with Moodle. In addition to this, they are running other technologies to enhance teaching and learning such as ePortfolio, virtual classroom system, WebEx, online survey system and better business bureau. They are in the

process of deploying an intelligence artificial system to be used for marking only. This has financial implications but in the case of the institution under study this is not really a problem because they have been given priority as was stated earlier on in the chapter. Although the financial resources are there, this means that they still invest more money towards the resources for upgrades or boosting.

5.2.6 Plan to Migrate to Public Cloud
The institution under study does not have plans to migrate to cloud because:

- They have high uptime

- They have a high institutional priority for infrastructure acquisition

- They fear higher financial obligations

- The infrastructure in place is sufficient

- They fear security implications of migrating to public cloud

On further enquiry, it came out clearly that they are already running local services from a private cloud and they have no plans to migrate, not because everything is good but simply because they just do not have the plan. This can be inferred from interviewees one (1) and two (2) where they clearly stated that they do not want to migrate to cloud because everything else except bandwidth is good but in these questions interviewees highlighted resource(s) problems with the current eLearning system, for example memory. Interviewee two (2) even went further to state that other services are given priority like ITS over the eLearning system. It was also mentioned that they are looking into migrating into google educational services and email services. This to the researcher means that they are experiencing bandwidth problems as well as resources problems.

## 5.3 Summary of Challenges
Challenges identified above can be summarised as follows:

1. Based on the number of users on the eLearning server, the RAM on the eLearning server is not the recommended size and this makes the server to be slow when there are many users connected on the server at the same time. This is made worse by the fact that they have low bandwidth.

2. Learners are not properly trained on how to use the eLearning system.

3. In the future this tertiary institution will have to invest in upgrading the eLearning system. This means that there will be cost implications.

4. Sometimes the findings by eLearning administrators are not clearly communicated to the system administrators.

5. There is a lack of technical skills to maintain the eLearning system, to include the eLearning system in the current security framework and the inability to foresee the needed resources in the future.

6. Replicating backup of eLearning database.

7. MySQL database reduces performance when there are many users connected to the database.

8. Not enough human resources to support large group of learners.

9. To improve skills, they have to train current personnel or hire an already skilled personnel, which has financial implications.

10. There is no centralised management to manage, implement and maintain the eLearning system.

11. There is no policy to govern the implementation and maintenance of the eLearning system.

12. No plan on how to migrate to cloud.

## 5.4 How Migrating to Cloud Solves the Tertiary Institution's eLearning Challenges?

The identified challenges can be solved by migrating to public cloud in the following manner:

1. The challenge that the eLearning server at this tertiary institution is slow due to the ratio of the RAM to the number of users is solved by migrating to cloud. The cloud has high performance and enough RAM storage and CPU. In addition, cloud has elasticity properties, which means that capacity increases on demand. This was highlighted in chapter 2 section 2.8. The bandwidth challenge cannot be solved completely by migrating to cloud. This is because if the upstream bandwidth for this tertiary institution is not increased then users who will be accessing the eLearning platform from this tertiary institution's network will still experience eLearning server bottleneck issues. Those users accessing the eLearning platform from outside the

tertiary institution's network might benefit depending on their bandwidth on the links they are using to access the platform.

2. The issue that learners are not properly trained on how to use the eLearning system will not be solved by migrating to cloud.

3. Costs implications as a result of the tertiary institution investing in upgrading the eLearning system in the future will be reduced since all the system and hardware upgrades will be done by the cloud provider.

4. The problem of no coordination between eLearning administrators and the systems administrators will not be resolved by cloud but they will be trained on proper organisational information sharing policies.

5. The lack of skills required to maintain and give support can be solved by migrating to cloud since cloud providers will be responsible for VM support, providing security and they should also be in a position to foresee future needed resources for the eLearning system.

6. The problem of replicating eLearning database backup can be solved by migrating to cloud. This can be the responsibility of the cloud provider depending on the SLA between this tertiary institution and the cloud provider.

7. The challenge of MySQL database reducing performance when there are many users connected to the database can be solved in much the same way as in number one.

8. The challenge of not having enough human resources to support a large group of learners will be greatly reduced since all technical issues will now be on the cloud provider side and the eLearning staff will now be solving user support issues.

9. If the skills being improved are those required to solve technological issues, then these costs will be reduced because they don't have to worry about technical skills as they will be the responsibility of the cloud service provider.

10. The issue of having no management and no policies to manage the eLearning system cannot be solved by migrating to cloud but the policies can be drafted.

11. Since this tertiary institution has no plan to migrate to cloud they can follow the cloud adoption model that was designed in chapter 6.

## 5.5 Conclusion

This chapter highlighted the results, analysis and discussion from the interviews done with the eLearning administrators and systems administrator at the tertiary institution. The findings show that the eLearning system at this tertiary institution has over 13000 users and that they experience same technical, support and individual challenges. In addition, they have no plan to migrate to cloud and they fear that they might have security problems when they migrate to cloud. It was also highlighted how most of these challenges can be minimised by migrating to cloud. It was also shown how some the challenges cannot be solved by migrating to cloud. All the solutions to all these challenges were drawn from the theoretical framework in figure 4 in chapter 2.

# CHAPTER 6: DESIGNING A CLOUD BASED IMPLEMENTATION MODEL

## 6.1 Introduction

This chapter focuses on the actual processes followed when designing a cloud based eLearning implementation model. The actual components included in the model were derived mainly from the results analysis in this research and from the literature reviews. The proposed cloud based eLearning implementation model is presented at the end of the chapter. The chapter explains why the model was designed and it also explains how the model components relate.

## 6.2 Model Justification

Literature reviews have shown that implementation plans when migrating to cloud involve a holistic approach that looks at many elements like technology features, process and control, standards and behavioural features. For example, this is illustrated by the CCAUM discussed in section 2.13.1. Findings from this research show that the lack of bandwidth limits tertiary institutions in Namibia to fully benefit from modern technologies. Findings also show that besides the bandwidth issue, tertiary institutions face other technological challenges such as not having enough infrastructure and inadequate technical support. Thus, to improve teaching and learning it is vital to have the eLearning platform run seamlessly and this can be easily achieved by migrating these eLearning platforms to the cloud. This was shown by the experimental eLearning platform hosted on Wingu Cloud (section 4.3). For an organisation to quickly make a technical decision to migrate to cloud, the cloud based eLearning implementation model was designed. This model is used to make a technical baseline to migrate to cloud.

The cloud that is most suitable for academic higher and tertiary institutions that are suffering from the challenges discussed in this research would be a public cloud. The researcher recommends a public cloud for academic tertiary institutions because in this deployment model, all the services are provided by the cloud service provider either for free or on pay-per-use. All the infrastructure belongs to the cloud provider hence customers will

not buy any software or equipment. Customers can access the services provided by the public cloud via the public internet.

If all services are provided by the service provider then academic tertiary institutions are not responsible for the technical support, infrastructure requirements, and software licenses. This model also offers to academic institutions pay-per-use features, which means institutions pay for what they have used. Security is enforced by the cloud service providers thus any concerns about cloud security should be addressed in the service level agreement between the academic institution and the cloud service provider.

## 6.3 Cloud Based ELearning Implementation Model Design Process

The cloud based eLearning implementation model was designed using design science. According to Hevner, Ram, March, and Park (2004), the design science paradigm solves wicked problems that can be characterised by "a critical dependence upon human cognitive abilities (e.g., creativity) to produce effective solutions" (p. 7). In this case the problem at hand required the researcher to create a solution for technical challenges that the tertiary institution was experiencing. Design science research proposes seven guidelines for use when solving a research problem (Hevner et al., 2004). The seven guidelines are:

(i) **Design as an artefact** - Design science research must produce a viable artefact in the form of a construct, a model, a method, or an instantiation.

(ii) **Problem relevance** - The objective of design-science research is to develop technology-based solutions to important and relevant business problems.

(iii) **Design evaluation** - The utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods.

(iv) **Research contributions** - Effective design science research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies.

(v) **Research rigor** - Design science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.

(vi) **Design as a search process** - The search for an effective artefact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.

(vii)          **Communication of research** - Design science research must be presented effectively to both technology-oriented and management-oriented audiences.

In the case of this research:

(i)  A model was designed.

(ii) The technology based model was aimed to solve the problem.

(iv) The model only considers technical aspects and the design process encompassed literature review, findings of the research, engagement of stakeholders, experiments, benchmarking with other models and components identification.

(v) Extensive research was done on the subject of cloud computing and eLearning challenges as shown in chapters 2, 4 and 5.

(vii) The research results we presented as conference papers and also to the tertiary institution's management.

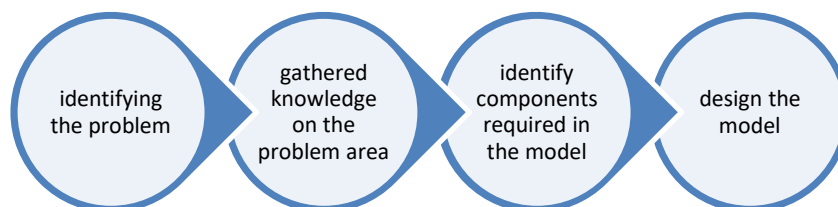The steps that were followed are shown in figure 14 (Hevner et al., 2004):



*Figure 14: Steps to design the cloud based eLearning implementation model*

## 6.4 Cloud Based ELearning Implementation Model Components

Components of the Cloud Based ELearning Implementation Model were deduced from the data gathered in the literature reviews which resulted in the theoretical framework (figure 4, section 2.12). Most of the components that we deduced from literature reviews were corroborated by the results analysis from interviews and experiments (sections 5.2-3 and 4.3 respectively). The whole process was guided by design science theories. The components were mainly derived from eLearning challenges. It must be taken into consideration that this model only addressed technological challenges because it clearly came out in the literature reviews (section 2.4) that migrating to cloud computing only effectively solves technological and financial eLearning challenges. The rest of the challenges can only be partially solved by migrating to cloud computing. Although it is important that these other challenges be resolved, this research only provides a solution from the technological aspect. The components in the Cloud Based ELearning Implementation Model are namely financial requirements, technical support, hardware and software requirements and cloud computing security.

### 6.4.1 Financial Requirements

It was shown in the literature reviews and results analysis that eLearning suffers from financial challenges such as buying and maintaining site infrastructure, paying site licences and individual packages, and paying support staff. The problem is that the budget allocated to the specific department is exceeded by the actual amount required. It is also important when making a decision to migrate to cloud to have management support. In this instance, management is responsible for ICT policies that support the migration to cloud. Management should be able to make financial decisions like deciding on the professional training budget and selecting the appropriate cloud based business models to follow. As such when one is making use of the Cloud Based Implementation model, they must decide as to whether the eLearning budget is being exceeded by the actual cost and whether management will undertake the financial implications of migrating to cloud, which should be less than the current. Thus the attributes of this component are:

- Costs exceeding the budget for:
  - buying and maintaining site infrastructure
  - paying site licences and individual packages

- o  paying support staff
- Management support
  - o  Management agrees to pay the cloud provider service fees
  - o  Agrees to draft cloud computing support policies
  - o  Management sets aside a professional training budget
  - o  Identifies the right cloud based business model suitable for the organisation

### 6.4.2 Technical Support

Technical support also needs to be considered when making a decision on whether to migrate the eLearning system to cloud because it is one of the problems eLearning is facing as was shown in the literature reviews as well as the results analysis. Problems highlighted were that the ICT support skills are not adequate (support skills are there but not enough), lack of the required ICT support skills (skills are not available within the personnel) and the support staff not being available. To make a decision based on this component then, the user of the model must make an assessment of the technical support available. The attributes to consider are whether eLearning has the support personnel, and if the support personnel is there, are they able to provide adequate support. Thus, one should decide whether to implement cloud if any of the following factors are applying in their context:

(i)     They do not have enough technical support staff,

(ii)    They do have enough technical support staff but they are not adequately skilled to give the necessary eLearning technical support

(iii)   Cloud implementation policies have been drafted

(iv)   Training programs have been designed

### 6.4.3 Hardware and Software Requirements

This is a very important element to include in the model as most of the problems that eLearning encounters at this tertiary institution as shown in the results analysis and also in the literature review emanate from this element. It was shown in section 2.3 that eLearning is implemented because of ease of access and this is tempered with if hardware is not up to par. The problems that are a result of hardware and software requirements are: storage not being enough, server RAM not sufficient, bandwidth not sufficient, server processor not

powerful, software licences are expensive and software installations are complicated for the local staff. Thus the user of the model should make a baseline decision with regards to optimal requirements in the eLearning system under use. That is to say, they must check using a checklist (like in the case of Moodle) in table 6 to make a decision.

*Table 6: Hardware checklist*

| Hardware attributes | Optimum Specifications | Available specifications | Is it affecting operation(s) |
|---|---|---|---|
| RAM | | | |
| Ratio of RAM to number of users | | | |
| CPU | | | |
| Storage | | | |
| Operating system | | | |
| Bandwidth | | | |

After populating a table like this, if the last column is full of negative responses then make a decision to implement cloud. In order to migrate to cloud, there must be an understanding of the hardware and software requirements that the organisation needs to have in place in order to implement cloud based solutions. It was shown by the literature reviews in section 2.6.3, 2.8, 2.11 and the experimental results in section 4.3.4, that the minimum hardware and software requirements to access and use cloud services are a computer with internet connectivity and a browser. This greatly reduces infrastructural investments.

### 6.4.4 Cloud Computing Security

Making a decision on whether to implement a cloud or not is also influenced by the security provided by the cloud service provider. This was shown in the results analysis as well as in the experiments carried out where it was not possible to start using the cloud without setting up security parameters. From the findings, it was also clear that when organisations make a decision to migrate, they are not confident about the cloud security. Therefore, when an organisation decides to implement cloud they need to do a check on the available security options to make sure that they will suit their requirements. To enforce the security requirements, they must draft a security policy that clearly outlines the security services

required from the cloud service provider and this must be enforced by making sure that the specifications required are part of the SLA. They must also make sure that the cloud service provider supports cloud security standards so that they can transition from one service provider to another and it makes it easier for them to integrate security technologies with cloud service provider (Cloud Standards Customer Council, 2016).

## 6.5 Proposed Cloud Based ELearning Implementation Model

**Technical Support**

- support staff skills adequacy
- support staff inavailability
- policy documents
- training program

**Financial requirements**

- cost exceeding budget
- cloud implementation management support
- professional training budget
- cloud based business models

**Hardware & Software requirements**

- server RAM not sufficient
- server processor not powerful
- bandwidth not sufficient
- software licenses expensive
- other

Cloud Based eLearning Implementation Model

**Cloud Computing Security**

- Service Level Agreement
- security policy
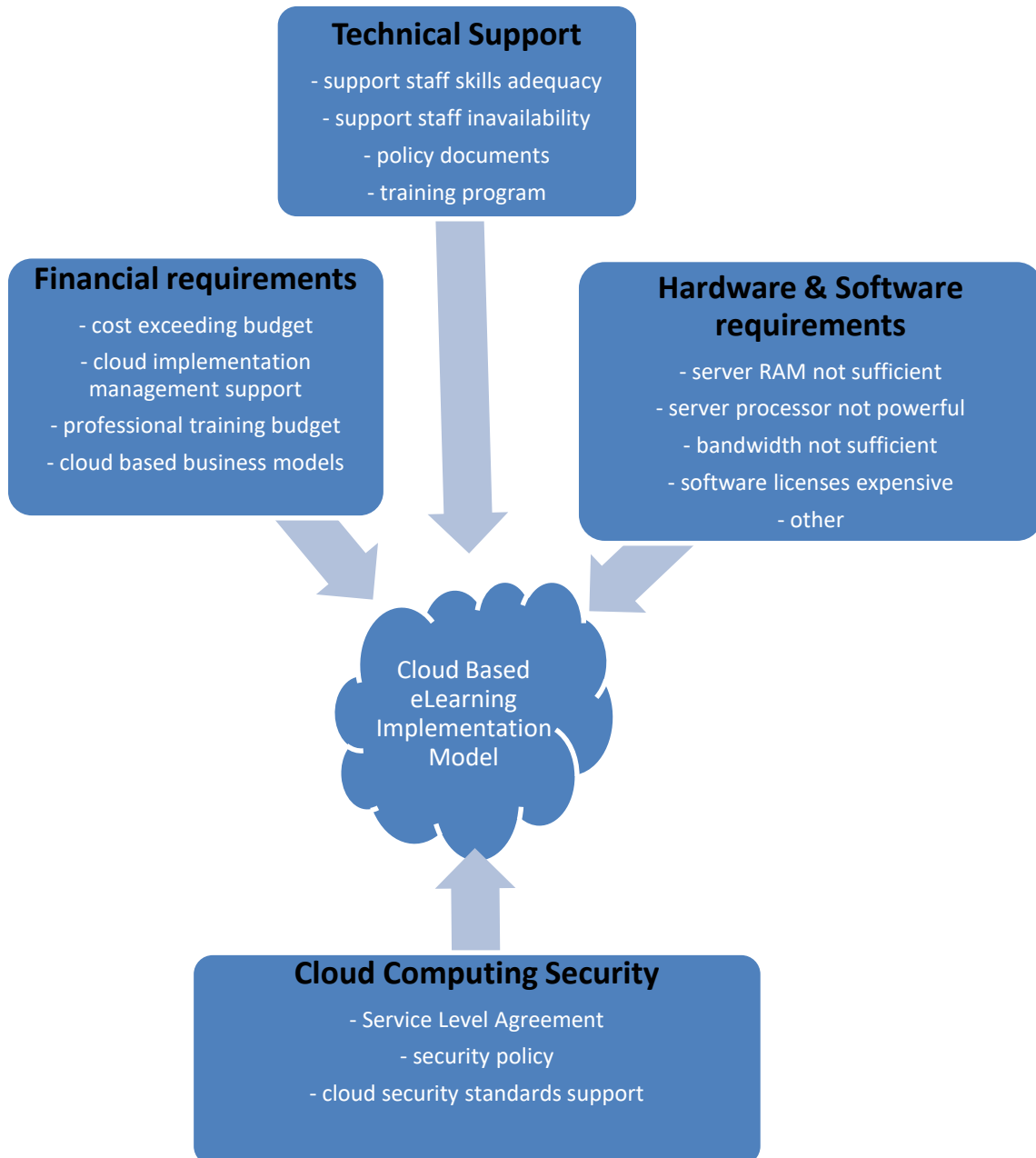- cloud security standards support

*Figure 15: Proposed Cloud Based ELearning Implementation Model*

The Cloud Based ELearning Implementation Model depicted in figure 15 on the previous page is the proposed model that can be used to make a decision to implement the cloud based ELearning solution. The components which are shown surrounding the cloud in figure 15 and the attributes to consider for those components are bulleted.

This model should be used when one needs to make a technical decision on whether to implement a cloud solution or not. To use this model, the researcher proposes that one should consider all the components individually. This means that they have to follow the methods described in sections 6.1-4 which are summarised below:

1. Financial requirements

    a. Are costs exceeding the budgets?

    b. Is there management support to migrate to cloud?

    c. Is there a professional training budget?

    d. Are there any cloud based business models?

2. Technical support

    a. If technical support staff is available, are the skills adequate?

    b. Technical support staff availability?

    c. Are there cloud implementation policy documents?

    d. Is there a training program designed?

3. Hardware and Software requirements

    a. Is the server RAM sufficient?

    b. Do you have a powerful server processor suitable for your eLearning server?

    c. Is the available bandwidth enough?

    d. Are software licences expensive?

    e. Are other hardware requirements met?

4. Cloud Computing Security

    a. Are your security considerations addressed in SLA?

    b. Is there a Security policy?

    c. Which Security standards are supported?

## 6.6 Summary

Chapter 6 discussed the reasons to design a cloud based eLearning implementation model. It was established that there was no technical strategy that one can use to make a decision as to whether to implement a cloud. Furthermore, the chapter outlined the design science processes that were followed in the design stages of the model. Thus, the problem was identified followed by gathering information about the problem domain through literature reviews and interviews, identifying model components and finally designing the model. Financial requirements, technical support, hardware and software requirements and cloud computing security were the identified components that need to be in the model. Finally, the chapter discussed how the model can be utilised to go cloud.

# CHAPTER 7: RESEARCH SUMMARY, RECOMMENDATIONS AND CONCLUSION

## 7.1 Introduction

This chapter highlights how the research objectives were met and the answers to the research questions. The research findings are also outlined in this chapter. In addition, this chapter gives an account of how the research process was conducted and finally an account of which direction future research should follow.

## 7.2 Research Achievements

Firstly, the problem was identified. The problem is that there was no technical strategy to use when one needs to establish if the technical conditions in their environment warrants implementing a cloud based eLearning solution. This was discussed in Chapter 1. To solve the problem, a qualitative approach was used. This involved the use of interviews, experiments, literature reviews and the whole process as discussed in Chapter 3. Results from the literature reviews, interviews, and experiments were highlighted in Chapter 4. Chapter 5 outlined the analysis process and the actual results of the research which led to chapter 6. Chapter 6 described how the cloud based eLearning implementation model was designed, components of the model and how the model can be used. The model was the solution to the problem of not having a technical strategy when migrating to cloud.

## 7.3 Research Objectives and Results

The main objective of this research was to experiment and design a cloud based eLearning implementation model for Namibian academic tertiary institutions. To achieve this objective, the following sub-objectives were undertaken, namely to:

(i)   Evaluate current eLearning platform usage and challenges

(ii)  Assess the current supporting IT infrastructure on eLearning technologies

(iii) Analyse current technology implementation models which support cloud computing

(iv)  Experiment on cloud based technologies and demonstrate how current eLearning environment could be transformed to cloud computing

The following sections will discuss how the objectives were met.

### 7.3.1 Main Objective

The researcher addressed this objective by designing a cloud based eLearning implementation model. The model which was designed using the design research science can enable users of the model to identify that there is a need to implement a cloud based eLearning solution. By following this model one should be able to conclude that current eLearning settings are not adequate and one should implement a cloud based solution in order to gain all the eLearning cloud computing benefits which are discussed in section 2.11.

### 7.3.2 Determining Current ELearning Platform Usage Challenges

In order to come up with an effective solution, it was important to determine the challenges that current eLearning platforms face. To determine what these challenges are, literature reviews were conducted and interviews of experts that are currently administering the eLearning system at this tertiary institution were conducted. From both these methods it was established that the current eLearning system faces financial, individual, knowledge management, support and technological challenges. Financial challenges are in the form of buying and maintaining site infrastructure, paying site licences and individual packages and paying support staff. Awareness, confidence, culture, leadership and motivation are the individual challenges in eLearning systems. Knowledge management challenges were outlined as content issues, copyright issues and the lack of an eLearning strategy. Lack of technical support was also identified as an eLearning challenge. It was established that ICT support skills are not adequate, there is a lack of ICT support skills that are required and support staff not being available. The final eLearning challenge which was determined is technological. This implies that there are infrastructural issues, resource management issues, bandwidth issues and technical skills issues.

### 7.3.3 Assessing the Current Supporting IT Infrastructure on eLearning Technologies

To address this objective several questions were asked in the interviews conducted. The questions which were asked are:

- What are the current specifications on the eLearning server?

- The allocation of size to users, who is responsible for this? Is it your side or the head instructional technology?

- What are the major challenges on the technical side?

- On another note what are the tools (e.g. computers) or infrastructure required by the learners to access the eLearning platform? Does Moodle support the use of mobile devices such as cell phones?

- For the sake of space do you have a separate backup server or it is up to the administrators of the system?

- If there is need for space for any VM you can add or increase as required. Within your policies do you have a cap or limit to say that you cannot go beyond a certain size?

- When it comes to backup. How does the backup work? How do you backup the system? Do you have a backup server of the main system or you backup course by course and leave it accessible?

Answers to these questions are highlighted in section 4.2 and analysed in section 5.2-3 and these can be summarised to say that the current eLearning infrastructure at this tertiary institution suffers from bandwidth issues and support issues. It was also noted that storage space and CPU are up to standard. It is just the memory that needs to be upgraded. Not having enough memory impedes the eLearning server's performance.

### 7.3.4 Analysing Current Technology Implementation Models which Support Cloud Computing

This was addressed by doing literature reviews, the results of which are found in section 2.13 and it was established that CCAUM was designed in 2014 and it was an improvement of the TAM model. The roadmap that CCAUM and other studies propose when adopting cloud were considered when designing the cloud based eLearning implementation model. This model takes into account many factors that affect cloud adoption but for the purposes of this research only the technological aspects were considered.

### 7.3.5 Implementing ELearning Cloud Based Technologies

The experiment which was conducted was described in section 4.3. The experiment established that eLearning can be successfully implemented on cloud systems. Having established this, it was also proven that learners still managed to access their course, upload content, view documents, take assessments, participate in chat forums and see instructions from the instructor. The instructor could also upload content, create assessments, create chat topics, etc. The only drawback was that the learners were not able to upload big files due to the current bandwidth.

## 7.4 Cloud Based ELearning Implementation Model Limitations

The Cloud Based ELearning Implementation Model that is presented in this thesis should work in instances where one only considers the technological aspects to make a decision to implement cloud based eLearning systems. Considerations of the model by technical management at an academic tertiary institution would yield the proper direction to follow but as was revealed by literature reviews and interview findings, eLearning systems are not only affected by technological challenges. They also face financial, individual, knowledge management and support challenges. In terms of this discussion of the limitations that the model has, the researcher is referring to non-technical financial and support challenges. The researcher believes that all these other challenges must be addressed in order to implement a fully effective cloud based eLearning system. Thus, even though it was revealed that implementing cloud based solutions would only solve financial and technical eLearning challenges, there needs to be a way of solving all the challenges and incorporating them into the decision for cloud implementation.

The experiment that was carried out on the cloud involved different participants than the ones who were interviewed. The interviewees only managed to carry out a few tasks on the cloud based system like performing backups. They were not fully involved in the whole process because they had other commitments and they could not afford the time to do the experiments. This might have affected the results that were obtained and eventually used to design the cloud based eLearning implementation model.

Learners that participated in the experiment were quite few compared to the actual number of learners currently enrolled on this tertiary institution's eLearning system. This was because the researcher only involved learners in one of the groups because of time limitations. The time required to carry out a full scale investigation was not available to the researcher. Therefore, results might have been affected.

Another limitation resulted from the fact that one of the interviewees opted to answer the interview questions via email. This limited the researcher from probing for more information or posing follow up questions that could have revealed more information which would have been used in the model design process.

Finally, the limited bandwidth meant that the users of the eLearning system did not get a feel of how the eLearning system would actually perform when the bandwidth is high. If the participants had experienced performance of the eLearning system at peak bandwidth, then they would appreciate that eLearning systems on the cloud have better performance.

## 7.5 Recommendations for Future Research

To advance knowledge on cloud based eLearning platforms, future research work can be recommended as follows:

- Only Moodle was considered in the experimental environment but to get a clearer picture of how cloud based eLearning systems perform on the cloud, work should be carried out that involves more than just one eLearning solution.
- The researcher believes that more participants should be included in the experimental process. This implies that future research should have more participants.
- Administrators that use the eLearning systems should be the ones involved in the experimental process since they have a better appreciation of the system.

## 7.6 Research Conclusion

Section 2.3 established that eLearning is an ICT that is vastly implemented across the world in academic tertiary institutions. This is because it offers features like ease of access, group

based collaborations, flexibility, and self-paced learning among other advantages. Despite these advantages, eLearning is faced with financial, individual, knowledge management and support challenges and these impede eLearning systems performance. Section 2.4 brought out the fact that although eLearning systems face these challenges, the benefits of using eLearning systems outweigh the challenges encountered. This inherently means that implementers of the eLearning systems use eLearning systems to gain the advantages and try as much as possible to minimise the effects that result from the challenges. One way to reduce eLearning challenges is by implementing a public cloud based eLearning system. Since this is a somewhat emerging technology, eLearning implementers need a strategy that helps them to make a decision as to whether to implement a public cloud based eLearning solution. To address this problem, the cloud based eLearning implementation model was designed to assist eLearning implementers to make an informed decision from a technological point of view.

The cloud based eLearning implementation model provides the technological means that can be utilised to evaluate whether implementing a cloud based eLearning solution would be worthwhile.

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# APPENDICES

## Appendix A

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**Faculty of Computing and Informatics**

Department of Informatics

**26 January, 2016**

To:  Whom it may concern

From:  Dr Nobert Jere

**Re: Permission to carry our research in selected Tertiary institutions in Namibia**

This serves to confirm that Mr Shadreck Chitauro – student Number (201001003) is a registered Master of Computer Science student at Namibia University of Science and Technology within the Computer Science Department.

Mr Chitauro is carrying out a Masters research on the topic: **Designing a Cloud Based eLearning platform implementation Model for Higher and Tertiary Institutions in Namibia**. The research problem is based on the following: Academic institutions in developing countries find it difficult to incorporate advanced technologies. This is due to other important issues to consider such as construction of lecture rooms, student accommodation and payment of staff. Most importantly lack of enough internet bandwidth limits tertiary institutions in Namibia to fully benefit from the modern technologies such as cloud computing. In cases where such aspects have been resolved, there is lack of a guiding model to follow on how to adopt modern technologies.  The research intends to address the following questions:  The main research question is: **How can cloud computing be adopted and implemented at academic institutions in Namibia.**

The following are the sub-questions that the thesis focuses on:
- ✓ What challenges do existing eLearning platforms experience?
- ✓ What are the current eLearning technologies at academic institutions in Namibia?
- ✓ What IT infrastructure is available to support existing eLearning platforms?
- ✓ What are the current modern technologies adoption and implementation models?
- ✓ How can the current eLearning environment be migrated to cloud-based environment?

**The research Objectives include:**

The main objective of this research is to experiment and design a **cloud based eLearning implementation model for Namibian academic institution**. The intention is to have a standardised cloud computing implementation model that could be utilised by academic institutions to improve teaching and learning services. To achieve this objective, the following sub objectives were undertaken:

- ✓ Determine current eLearning platform usage challenges.
- ✓ Assess the current supporting IT infrastructure on eLearning technologies
- ✓ Analyse current technology adoption/implementation models which support cloud computing.
- ✓ Experiment on cloud based technologies and demonstrate how current eLearning environment could be transformed to cloud computing.

As, the research supervisor, I am kindly asking for your permission to allow Mr Chitauro permission to carry out his research. He intends to engage tertiary institutions and their respective IT support department and eLearning departments. And also engage the students. Purposive sampling will be used to selce the administrators and students will be randomly selected. Interviews and document review will be the main methods used to reach the participants.

The success of his research relies on your support and participation in this research. All the findings and information collected during the research will be used for academic purposes and only for related academic publications. The participation in the research is voluntary and no one is forced to participate. Kindly support Mr Chitauro for him to achieve his dream as he proposes a solution that will benefit those involved.

Feel free to contact me if there is need for any clarification. Thank you.

**Dr Nobert Jere**
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Senior Lecturer (HOD)
Informatics
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## Appendix B

Then I agree, subject to your undertaking to remove all references to #### and / or any of its official or system, and to remove any other reference that could be used to identify #### or any of its officials or system.

LE?

**Appendix C**

**A CLOUD BASED ELEARNING IMPLEMENTATION MODEL FOR HIGHER AND TERTIARY INSTITUTIONS IN NAMIBIA**

**ELearning for higher and tertiary institutions**

1. Do you have any eLearning platform?

2. I understand you are using Moodle, can you describe its setup in terms of infrastructure and technical requirements as well as users feedback, tools required by learners to access the platform. Size of space per user. Any comments for CUS411S since it's the biggest group

3. What are the major challenges (technical) faced with the current platform?

4. Any plans to transfer the application to cloud?

5. Do you need to change/acquire (sufficient infrastructure) (if any) to migrate the current Moodle to cloud?

6. Any benefits from current setup to cloud? Can your current setup support cloud environment? Especially bandwidth.