Design Model for Integrating Learning Management Systems and Massive Open Online Courses on a Digital E-Learning Platform: Implications for Zimbabwean Universities

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by

Talent Tapiwa Rugube

Main Supervisor	:	Dr. Chibaya Colin
Co-Supervisor	:	Prof. Govender Desmond

Supervisor's Statement

This thesis has been submitted with my endorsement.

3rd December 2019

Dr. Colin Chibaya

Date

3rd December 2019

Professor Desmond Govender

Date

Declaration

I, **Talent Tapiwa Rugube**, student number, **216076156,** declare that:

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Abstract

Available affordances for learning provide opportunities for advanced technology-enhanced teaching and learning. Digital learning environments can make relevant learning content available to students using existing infrastructure. This creates an environment which requires different learning management systems (LMS) to interact with, and exchange information. Increasing use of mobile devices, digital learning platforms, LMS, and massive open online courses (MOOCs), has necessitated integration design approaches. However, ignorance of resources offered and discouragement and frustrations arising from the economic situation in Zimbabwe regarding regulated access to electronic services make automation of teaching processes a great challenge.

In this thesis, a design model for integrating LMS and MOOCs on a digital learning platform is proposed. From an e-learning point of view, the study contributes to the working of e-learning management systems through automation process of uploading content to LMS. From a computer science point of view, the study contributes to software engineering principles where it puts together three different platforms; LMS, MOOCs and digital learning platforms under one design.

Methodologically, the study uses design science research (DSR) framework with software modelling language to address challenges in teaching and learning. This study describes how the Technology Adoption Model (TAM) and Task-Technology Fit (TTF) model can be used together with DSR in relation to design model evaluation. A software modeling language was used to create the logical designs, which were evaluated using experimental design approach. Software engineering experts and lecturers were invited to validate proposed logical designs. The key deliverables of the study include requirements specifications for the design model for integrated learning management systems, as well as the logical designs for the design model. The design model, as per requirements specification and the evaluation thereof, are based on TAM and TTF. The hybrid model proposed was further validated using structural equation modeling via the partial least squares and path modeling. In our views, the interventions of integration work would support decision making, which influences choices made by policy makers when taking decisions about higher education technological infrastructure.

Keywords : Learning Management Systems, Massive Open Online Courses, Integration, Digital e-learning platforms

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Acronyms

BSc	- Bachelor of Science
DSR	- Design Science Research
HTML5	-Hyper-Text-Markup-Language
ICT	- Information Communication Technology
IEEE	- Institute of Electrical and Electronics Engineers
LMS	-Learning Management System
LPRE	-Learning Pathway Rules Engine

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LTI	-Learning Tools Interoperability
MOOCs	- Massive Open Online Courses
MOODLE	-Modular Object-Oriented Dynamic Learning Environment
MSc	- Master of Science
OER	-Open Education Resource
CORDRA	-Content Object Repository and Resolution Architecture
PLS-PM	- Partial Least Squares - Path Modeling
SCORM	-Sharable Content Reference Model
TAM	-Technology Acceptance Model
TTF	- Task Technology Fit

Chapter 1

Introduction

Educational technology is a practice of facilitating learning and improving performance by producing, consuming, and handling suitable technological processes and resources (Umar, Basheer, Isa & Watsilla, 2017). In this study, educational technologies are described as affordances for learning (Leary, 2017) in a learning environment; whether physical or virtual. In my view, this encompasses infrastructure that supports teaching and learning.

Current educational technologies provide opportunities for advanced technology-enhanced teaching and learning (Kirkwood & Price, 2014). Learning management systems designers can consider which software to pick from the many available educational software. This creates an environment which requires the different learning management systems to interact and exchange information (Aboualizadeh Behbahani, 2016). Learning management systems have become ubiquitous in higher education (Arora, 2018; Betul & Dawn, 2014). They support diverse learning methods, provide a central repository of learning material, and help users to organize courses (Dube & Scott, 2014; Gautam, 2010). Individual students access the learning management system and obtain learning content. In this study, learning management systems are defined as interoperable information systems used to plan, store course materials, implement specific learning processes, and assess the same in students (Szabo & Flesher, 2002).

The opportunities and benefits offered through using learning management systems should potentially expand with the development of massive open online courses. (Barclay & Logan, 2013). Massive open online courses are popular learning tools designed for distance education (Dos Santos, Punie & Castaño-Muñoz, 2016). They have gained attention in education (Yu, 2016).

Massive open online courses are collections of free, up to date, open online resources which can be registered by anyone (McAuley, Stewart, Siemens & Cormier, 2010). They let any student from anywhere register and learn for free as long as the students have devices connected to the internet.

When massive open online courses were first introduced, they underscored open-access in relation to licensing of content (Kazakoff-Lane, 2014). They later closed licenses for their learning materials. Though learning material access is licensed and lack openness, students still access massive open online courses for free (Yuan, Powell & Cetis, 2013; Swinnerton, Morris, Hotchkiss & Pickering, 2017). Massive open online courses' most featured characteristics include; interactivity which strengthens communication in the learning environment (Iniesto & Rodrigo, 2016), and integration with other existing learning platforms (Kalz, Khalil, & Ebner, 2017).

Educators anticipate that massive open online courses, integrated with learning management systems on convenient platforms, will continue to advance. The next generation of the digital learning environment might integrate an e-book application with a course syllabus where the syllabus would connect students to intellectual resources, and affording opportunities for adaptive learning (Dahlstrom, Brooks & Bichsel, 2014). The Zimbabwean context is not an exception in this technological race.

A digital learning platform has been launched by Econet in Zimbabwe on which digital content via mobile devices can be shared (Econet, 2016). The Econet e-learning platform is a digital workspace aimed at stakeholders in a learning environment such as schools, colleges or universities. It gives a central point to accessing information systems of institutions. Architecturally, the digital workspace is emerging as the new end-user computing platform, securely delivering anytime and anywhere access to all applications, services and resources across all devices (Galloway & Waller, 2017). Learning platforms provide secure internet access to learning content in the educational environment (Jewitt, Hadjithoma-Garstka, Clark, Banaji, & Selwyn, 2010).

Despite the benefits offered by learning management systems, massive open online courses and digital learning platforms; users can either accept or reject the technologies (Ambali, 2014; Maduku, 2015). Acceptance in this context is how users engage with technology. When technology is availed, users are expected to show their willingness to use the technology (Oye, Iahad, & Rahim, 2014). However, this is not always the case with learning management systems.

Although availability of learning management systems is quite visible in Zimbabwe's sixteen universities (Mbengo, 2014), evincing improved access to Information and Communication Technology (Kabanda, 2013; Mlambo, 2014), they are not fully utilized as yet. Institutions such as, Harare Institute of Technology, Africa University, Solusi University, Bindura University of Science Education, and Great Zimbabwe University are among the sixteen universities in Zimbabwe (as indicated on each institution's website) that prescribe Modular Object-Oriented Dynamic Learning Environment as the preferred learning management system. This is in line with the national ICT policy's goal to realize growth in the use of ICT in education (ICT, 2014). The other three universities use tailor designed learning management systems, namely: Tsime, used at the University of Zimbabwe (UZ, 2016); Changamire, used at the Midlands State University (Chitanana & Museva, 2012); and Eagle, used at the Chinhoyi University of Technology (CUT, 2014). The National University of Science and Technology uses Sakai and has developed an in-house product used by one of its departments (Dube & Scott, 2014). The other six universities have student portals. The remaining two are still considering platforms to adopt. Probably, the remaining two are still to acquire the resources that can handle a learning management system.

A technology acceptance model by Mbengo (2014) showed that lecturers and students in most of these institutions were reluctant to implement digital teaching and learning technologies due to limited skills and ignorance of the resources offered which, in turn, fostered negative attitudes (Dube & Scott, 2014). Reluctance is credited, unofficially though, to discouragement and frustrations arising from the economic situation in Zimbabwe regarding regulated access to electronic services (Rupande, 2014).

As universities implement the use of learning management systems, the selection, uploading, updating and removal of content is the prerogative of profiled administrators and editing teachers of the modules (Bhalalusesa, Lukwaro & Clemence, 2013). As a result, the quality of content exposed to students relies heavily and subjectively on the lecturers' involvement and engagement with new content, and with the learning management system. The lecturers manage all sorts of content and activities deployed on these learning management systems; including the sequencing, importing, and exporting of files and folders.

The usefulness of learning management systems (Stantchev, Colomo-Palacios, Soto-Acosta & Misra, 2014; Conde, García-Peñalvo, Rodríguez-Conde, Alier, Casany, & Piguillem , 2014) has been proven. Universities implement the learning management systems as interactive learning environments, to facilitate teaching and learning (Mupfiga, Mupfiga & Zhou, 2017). Recent findings indicate that there is noteworthy presence of e-learning activities in the Zimbabwean universities, which include uploading of learning content on e-learning platforms and downloading learning content. Moreover, with the increasing acceptance of handheld mobile devices, it is more common for students and lecturers to access intellectual resources using mobile devices like smartphones (Hu, et al., 2016).

In this study, the researcher was particularly inspired by the prospect that freeing lecturers from the responsibility of selecting and managing the content availed to students on learning management systems in favor of automated mechanisms of presenting and sequencing such content, would eliminate subjectivity and enhance quality (Limongelli, Sciarrone & Temperini, 2015). Since some institutions do not exploit all the learning management systems features, this study aims to design a system that automatically feeds into a learning management system, allowing maximum resources available to students. Such a model would likely foster automated content selection and uploading, free from administrators and editing teachers' interventions. It would likely validate content sequencing and automatically verify content pre-requisites for enhanced teaching and learning. Figure 1-1 summarizes the envisioned placement of the proposed model design within the existing contexts.

In this work, the researcher sought to: (a) embrace massive open online courses' introduction into teaching and learning as alternative resources with up to date content relevant in different learning areas. Relevant content in massive open online courses can be filtered using conditional data mining policies and rules. The filtered content is automatically uploaded into learning management systems in specific sequences; (b) explore the design of a software model for integrating a particular learning management system and massive open online courses on a digital e-learning platform which runs on mobile devices (Elletson & MacKinnon, 2015; Tabuenca, Drachsler, Ternier & Specht, 2012; Boga & McGreal, 2014); and (c) investigate ways in which to automate communication between the learning management system and massive open online courses, facilitating appropriate data mining, regular and timely content update, appropriate content sequencing, as well as verifying pre-requisite content and prior knowledge for any topic chosen at that time.

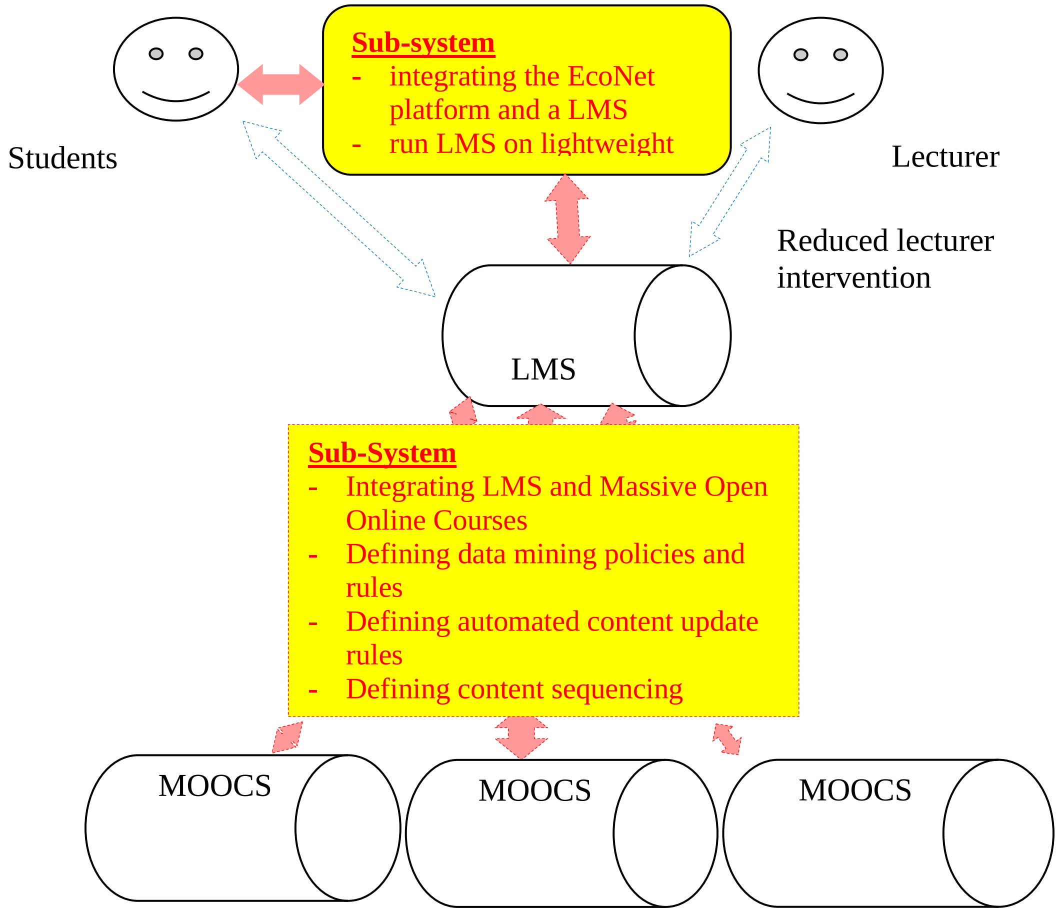

Figure 1-1 Proposed Model

Although the design of the proposed model requires us to consider advanced software engineering paradigms outside the field of education, the implications of a successful software model design to teaching and learning in general, outweigh the technical efforts expended.

The proposed software model infers an improved teaching and learning space which adapts to students' needs and contexts as digital natives, reducing the common challenges of lack of resources that are always pinpointed in many studies.

1.1 Statement of the problem

Zimbabwe universities have embraced the learning management systems concept (Chimhenga, 2017; Dube & Scott, 2014). Consequently, integrating learning management systems with other platforms is essential for providing intellectual resources for teaching and learning. Improved access to Information and Communication Technologies in Zimbabwean institutions of higher learning has enabled learning management systems to be visible (Mutanga, Nezandonyi, & Bhukuvhani, 2018). The use of mobile devices with facilities and access to the internet is now common among students (Elletson & MacKinnon, 2015; Dewa & Mutula, 2014). Such opportunities for integrating learning management systems, massive open online courses, and mobile technologies (Tabuenca et al., 2012; Boga & McGreal, 2014), are partially exploited to further expand access. The launch of digital e-learning platforms (Econet, 2016), which enable access to educational websites and globally-recognized massive open online courses further motivates the need for exploring such opportunities.

In past research (Alario-Hoyos, Estévez-Ayres, Sanagustín, Leony, & Kloos, 2015; Navarro, Cigarrán, Huertas, Rodríguez-Artacho & Cogolludo, 2017), learning system models have been proposed. However, sharing data and integrating different learning management systems is a challenge that requires attention when designing learning management systems (Masud, 2016). Accordingly, integrating learning management systems could be a promising strategy for providing adequate learning resources and allowing innovative methods of using e-learning tools.

In this study, a hypothesis is made that integration of a particular learning management system with massive open online courses on digital e-learning platform offers great benefits to teaching and learning in Zimbabwean institutions of higher learning.

Thus, the study aims to address the design problem of integrating learning management systems and massive open online courses on Enhanced Communication Networks' digital e-learning platform and establish the implications of the design model for policy and practice in Zimbabwean Universities.

The researcher proposed to design and recommend a hybrid technology model to serve as a tool in university policy making. Logical designs of the software design model are proposed. The quality of the design model is evaluated by software engineering experts through a combined task-technology fit model and technology acceptance model. The task-technology fit model and technology acceptance model are adopted and used together with the design science research framework. The relevance cycle of the design science research, being the first cycle, stipulates requirements for the study and defines evaluation methods of the software model. Goodhue and Thomson (1995) present an argument that; besides technology being accepted freely, it must be suitable for its intended users and match their activities to show its efficiency. Task-technology fit was adopted in this study, since it is a model which articulates why a set of technology is used for a particular task. If the task characteristics and technology characteristics are aligned, then the technology is used better.

The researcher believes that the key to successful usage of learning management systems is eliciting requirements from software experts, lecturers and students. The focus of the study is on requirements specification for automating communication between learning management systems and massive open online courses on a selected common digital platform.

1.2 Motivation

Lecturers go through a difficult process of choosing relevant learning content for deployment into learning management systems (Limongelli, Sciarrone & Temperini 2015). They spend time creating the content, and retrieving content from databases and online repositories (Bhalalusesa et al., 2013). However, success in this regard is subjective and dependent on the lecturer's competency.

Considering the challenges that lecturers go through in order to upload relevant and useful content on learning management systems, this study sought to integrate learning management systems and massive open online courses to provide better access to learning materials. Automated content selection allows for better learning experiences (Seale, 2014). Similarly, a learning management system integrated with other platforms is envisioned to be engaging and to have a much better chance of being utilized. It would likely allow students to access up-to-date relevant learning content (Soga, Nakahara, Kawana, Fuse & Nakamura, 2015; Mustea, Naaji & Herman, 2014).

The researcher was also inspired by the ever-increasing amount of digital learning tools available, which necessitate learning management systems' integration with many other platforms (Brown, Dehoney & Millichap, 2015). Modern learning management systems focus on rich learning materials that can be used and made available for other purposes. These learning materials often originate from the lecturers' manual effort. Therefore, the availability of an automated process of identifying quality content from various massive open online course sources could ease the lecturers' burden and provide additional material to support students' learning (Kalou, Koutsomitropoulos, Solomou & Botsios, 2015).

The motivation for integrating learning platforms is further increased by the presence of Web 3.0 tools which allow information retrieval and cloud services that can be used to automate the process of lecturers' uploading of content (Alexander, 2014). The proposed design model also considers emerging innovations such as mobile learning (Oliveira, Behnagh, Mohsinah, Burgess & Guo, 2019); scalability initiatives (Niederhauser, et al., 2018), and massive open online courses initiatives (Ossiannilsson, Altinay & Altinay, 2016). The implications of these designs to education contribute greatly to the benefits of integrating learning management systems and other systems, considering that innovative use of technology plays an important role in teaching and learning (Johnson, Adams , Estrada & Freeman, 2015).

The greater demand for an exciting learning experience for students, justifies the need for more innovative ideas on how the process of accessing up-to-date relevant learning material can be automated. Thus, universities that would implement the proposed design model, derived from implications of the proposed designs, would provide a conducive learning environment. Lecturers will be supported in their responsibility to upload material for many courses, particularly with the heavy workload policies adopted in Zimbabwe universities because of staff shortages. The design model seeks to aid lecturers' and students' adoption of automated learning tools. That way, the responsibility or authority traditionally vested in lecturers, of uploading learning material would shift to the automated systems. The study understands that, while the proposed design may not answer the very general learning management systems – massive open online courses integration problem, it will likely inspire dialogue and further research aimed at providing generic design views for proposed integrated platforms.

1.3 Research Objectives

The study particularly focuses on achieving the following four objectives:

- To conduct a requirements elicitation and specification exercise towards the design of a software model for integrating a particular learning management system and massive open online courses on the EcoNet e-learning platform.
- To propose logical designs of the proposed software design model.
- To carry out technology acceptance evaluation of the proposed software design model.
- To tailor design and recommend a hybrid technology adoption model to serve as a tool in university policy making relevant to teaching and learning.

1.4 Research Questions

The particular questions guiding the study are as follows:

- What are the functional requirements of a software model with which to integrate a particular learning management systems and massive open online courses on the EcoNet e-learning platform?
- What are the component units and design levels of the logical designs of the proposed software model?
- To what extent are the proposed model designs accepted by practitioners in the software engineering circles, and by stakeholders in universities in Zimbabwe?
- To what extent is the proposed integrated software design model compliant with known technology adoption models for potential implementation and installation in universities in Zimbabwe?

1.5 Envisioned contributions

Literature reveals that embracing massive open online courses' introduction in teaching and learning (Libing, 2014; Escher, Noukakis & Aebischer, 2014) and supporting automation of content update (Contractor, et al., 2015), are some of the positive implications of the present study's proposed work to teaching and learning, and education at large (Wong, Tee & Lim, 2015). However, common design challenges such as content sequencing (Katuk, Zakaria, Wahab, & Ghazali, 2017) as well as learning content retrieval from knowledge repositories (Marciniak, 2014) are associated with learning platforms. This study draws attention to the problems of content uploading and sequencing faced by lecturers. Lecturers expend time creating content. In some cases, they fail to upload material for all their courses. The present study seeks to make a contribution, from a learning content's point of view. Precisely, our proposed model puts learning management systems, massive open online courses and a digital learning platform under one design. That on its own, is likely to improve the teaching and learning process, and classroom management principles. The improvement is likely to be in the way teaching and learning is administered and the way lecturers prepare their content. Instead of lecturers issuing handouts to students, the proposed system will assume the responsibility of automating information retrieval from massive open online courses. Besides changing classroom management principles, it would also change lesson preparation strategies and the way students interact with content. Such a model would likely foster automated content selection and uploading, free from administrators and editing teachers' interventions.

The envisaged facility to run the integrated application on lightweight devices will purport the "anywhere and anytime access" (McKay, 2015) features, which would reap positive outcomes towards deep learning and enhanced teaching and learning.

From an e-learning point of view, the study contributes to the working of e-learning management systems through the automation of content upload to learning management systems. It is an additional aspect to Web 3.0 technologies. The contribution extends to learning platforms such as modular object-oriented dynamic learning environment and massive open online courses which will be enhanced and upgraded. Furthermore, the proposed design model suggests presentation of learning material in a specific order (Pursel, et al., 2016) and content sequencing without lecturers' or course administrators' direct intervention. This is a creative and novel offering in learning management systems.

From a computer science point of view, the study contributes to software engineering principles. Methodologically, the study employs design science research by integrating it with software engineering methods to address challenges in teaching and learning. Design science research is a concept in research where designs are embraced as a science (Vaishnavi & Kuechler, 2015). In this study, a software artifact is designed, hence the use of design science research as a theoretical framework. The research pyramid (Jonker & Pennink, 2010) is used to guide the methodology adopted.

Though the work is looking at designs of the integrated model, it also serves as an audit of what institutions use and where institutions are with regards to the use of e-learning platforms. More so, creation of localized massive open online courses from global massive open online courses simplifies access to massive open online courses via a digital e-learning platform. These implications of designs to policy and practice may be relevant to policymakers in Zimbabwe universities in as far as instituting policies on the use of learning management systems. In addition, the proposed model supports activities that encourage effective teaching and learning, at the same time embracing use of information and communication technologies on lightweight devices (Barry, Murphy, & Drew, 2015). Importantly, technological advances lessen the timeframe and increase the evidence base for policy decisions (Höchtl, Parycek, & Schöllhammer, 2016).

1.6 Location of the Study

Although a bigger chunk of the study emphasizes the technical design of a software model, the implications of a successful software model to teaching and learning, is of paramount interest to both the researcher, lecturers and students in higher institutions in Zimbabwe. Requirements in the form of functionality of the proposed design model, will be sought mainly from potential users (lecturers and students) as well as software engineering experts in Zimbabwe universities. The population of participants to this study is practitioners (lecturers teaching the discipline of software engineering in sixteen universities around Zimbabwe) and other potential users (lecturers and students).

Given the relatively small number of universities in the country, no sampling was considered (on the selection of software engineering lecturers only) and all universities were considered participants in the study. One attribute considered in selecting practitioner participants was the practitioners' specialization (bachelor's degree majors to include Computer Science and or information systems with a strong bias towards systems analysis and design, software methodologies, and or software engineering). The software engineering experts used in this study were fifteen.

The population of potential users of e-learning platforms was drawn from two clusters that comprise lecturers and undergraduate students. Since the entire number of students and lecturers was known, probability sampling was appropriate. Cluster sampling was then applied. This is followed by simple random sampling within each group, since participants' views towards e-learning platforms were expected to be uniformly distributed within the group. This was done to raise a sample size of 200 participants. The sample size was large enough for normally distributed variable and the findings were likely typical of those that would obtain in similar cases.

1.7 Limitations

A possible limitation to this study was the fact that evaluations were done on one learning management system. Since numerous learning management systems exist, working with every learning management system was not feasible; therefore, the results may not be generalized to other platforms yet. The present study was considered as investigative, seeking to inspire dialogue and further research aimed at providing generic models for the proposed integrated platforms.

1.8 Overview of the Thesis

Chapter 1 was the introductory chapter of the study. It outlined the structure of the thesis as depicted in Figure 1-2. Precisely, the chapter presented the statement of the problem, and the objectives and research questions that guided the study. It presented the motivation and envisioned contributions of the thesis. More so, the chapter highlighted the location of the study, as well as the possible limitations to the study.

Related work is reviewed in Chapter 2. The chapter reviews work on the values of learning management systems and the benefit of massive open online courses in teaching and learning. Literature on learning management systems is more focused on views related to the first objective of the study. The chapter further explores literature on the integration of learning management systems, massive open online courses, and other learning platforms. Gaps in previous studies are established and the current research efforts to fill in such gaps are acknowledged as an initiative aimed at adding value to the body of knowledge.

Chapter 3 describes how the desired requirements elicitation was conducted, the analyses made to achieve the structured functional requirements required for designing the proposed model. The chapter provides data flow diagrams at different levels as component units of the proposed model, thereby expressing the high-level requirements of the proposed model.

Chapter 4 provides detailed logical designs of the model. The logical designs are created based on the requirements specifications obtained from the elicitation process completed in Chapter 3. These logical designs are expressed as data flow and entity relationship diagrams.

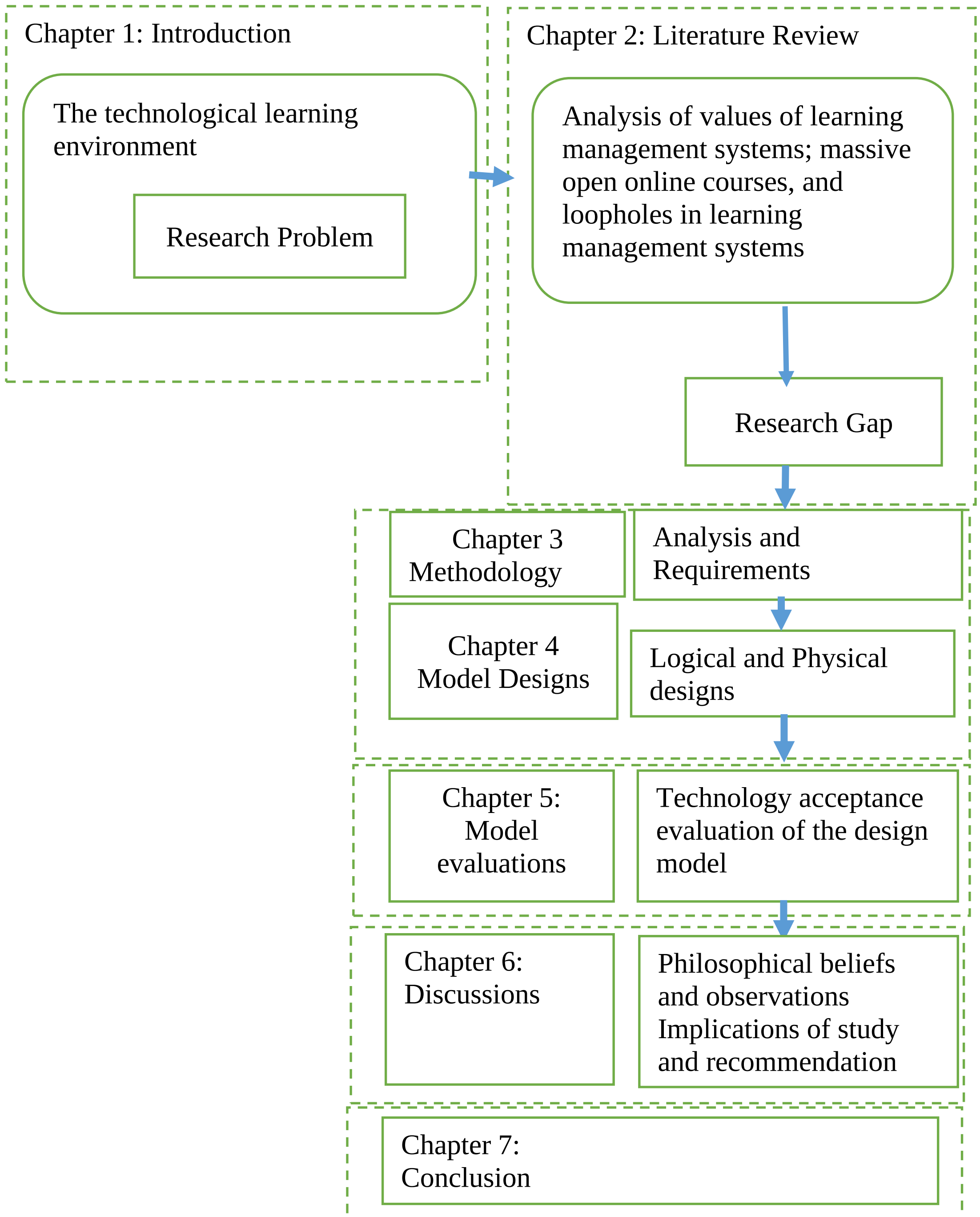

Figure 1-2 Research Outline

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Chapter 5 describes the evaluation processes considered in this work. It describes the technology acceptance model and task technology fit model used as strategies for evaluating the proposed model and certifying the designs according to the functional requirements set. Chapter 6 presents the study's philosophical beliefs and observations. It provides the implications of the study and recommendations to university management.

The concluding chapter, chapter 7 summarizes the problem set to be solved, and describes what was achieved. The chapter revisits the contributions of the work and suggests prospects for future work.

1.8.1 Other Key Terms of the Thesis

In this study, the following terms are used based on the definitions given below:

- Web 3.0: The beginning of semantic web, where computers will produce information rather than people (Hendler, 2009).
- Partial Least Squares-Path Modeling: An approach used to analyze relationships between multiple data tables (Henseler, Ringle, & Sinkovics, 2009) .
- Inner model: A model for connecting abstract variables according to a network of linear relationships.
- Outer model: A model which relates each block of manifest variables to its corresponding latent variable.
- plspm (): A function that estimates a path model using partial least squares techniques.
- Traitor variables: A traitor variable is an indicator that loads higher with other constructs than the one it is intended to measure.
- Path coefficients: Represent effects of latent variables on target variables (Ozkan & Kanat, 2011).

1.9 Conclusion of the Chapter

This chapter provided some background to the study and introduced the statement of the problem, the questions, and the aim of the study. Most important is the repeated reference to the desire to integrate learning management systems and massive open online courses on a digital learning platform. It also indicated interest towards requirements elicitation for a design model and the implications of the same design model to education and training. The following research questions, which guide the study were presented: (a) What are the requirements specifications for a software model with which to integrate a particular learning management systems and massive open online courses on the EcoNet e-learning platform? (b) What are the logical designs for the proposed software design model? (c) To what extent is the proposed design model accepted by practitioners in the software engineering circles and stakeholders around universities in Zimbabwe? (d) To what extent is the software design model compliant with known technology adoption models for potential installation in universities around Zimbabwe?

The chapter presented an explicit motivation for this study, emphasizing three factors. Topping the list was the hope to save lecturers' valuable time of choosing relevant learning content for deployment into learning management systems and eliminate subjective in the administration of courses. The hope to automate content selection towards better learning experiences, quality education, and increased engagement are also pinpointed as a motivation for undertaking this work.

Beside stating the objectives and research questions of the study, the chapter also shared the envisioned contributions of the work, emphasizing three. First, contributions emanate from an administrative point of view, where teaching and learning process and classroom management principles are integrated, thereby changing the way teaching and learning is administered. Another contribution ensues from a technical angle, where automation of processes such as content selection and content sequencing stand out. These are creative interventions in learning management systems. Lastly, the study envisions extending design science research views by integrating it with software engineering methods to address challenges in teaching and learning. The location of the study and envisioned limitations are also elucidated in this chapter. The next chapter reviews relevant literature related to the phenomenon under study.

Chapter 2

Related Work

Introduction

The problem of trying to integrate learning management systems with other learning platforms and enabling technologies, is not a new phenomenon. Studies related to design models have been done (Andronico, Carbonaro, Colazzo, Molinari, Ronchetti, & Trifonova, 2004); Koscianski & Zanotto, 2014). Technically, a design model is the implementation of a functional information system (UHCL, 2017) comprising design subsystems, collaborations, and relationships between them. A model is defined as a microcosm of a real object which can be used in calculations (Osterwalder, 2004). A design model of educational multimedia software by multidisciplinary teams from software engineering and education is presented (Koscianski & Zanotto, 2014). In this study, the researcher brings into play two known disciplines; software engineering and education. Therefore, the study contributes to the field of computer science education. In the same vein, a model was designed based on educational technologies for open learning environments (Holotescu, 2015). The model presented integrated existing learning environments with open technologies and practices. Aserey & Alshawi (2013) introduced a conceptual model that integrates several learning management systems to fulfill educational requirements.

Technological advances continue to provide more ways of interaction whilst at the same time offering potential opportunities for teaching and learning. The present learning environment needs continued innovations which in turn result in obtaining the desired learning goals. Quite sadly, opportunities related to integration of learning platforms in Zimbabwean universities are not fully exploited. Thus, designing relevant learning management systems is critical. This leads to the need for developing innovations in the use of learning platforms, to facilitate the sharing of relevant information among students.

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In this section of the study, several key themes are presented and studied. The relations between the themes are established. The researcher highlights possible shortcomings or opportunities for learning management systems, massive open online courses, and digital learning platforms.

2.1 Overview of the Chapter

Three important areas of digital learning platforms have received attention; learning management systems, massive open online courses and learning management systems on mobile learning platforms. Learning management systems concept has been approached from two perspectives; high adoption rates and student perceptions. The most important developments in terms of massive open online courses have been to spruce up the open distance learning education. Learning management systems on mobile platforms have also been an important area of study in this field.

In this chapter, the researcher examines the future trends of learning platforms, also referred to as next generation digital platforms (Brown et al., 2015). The researcher also considers real problems of the current learning management systems. Even though the platforms have been used for a long time, they seem to have integration facilities not fully exploited. Another problem encountered with learning platforms is the intervention of tutors in uploading learning material. This results in some courses being left without content, and in information overload. The chapter also models the integration requirements for learning platforms. As a researcher, there is need to understand the requirements from stakeholders, to achieve automation of the data sharing processes among students. However, it is seen from the past studies that the development of learning platforms, particularly massive open online courses, has been done in developed countries. This establishes the need to enhance the infrastructure of digital technologies in universities in developing countries. Therefore, in this study, the researcher combines the advantages of learning management systems, massive open online courses, and mobile platforms to design an integrated learning platform.

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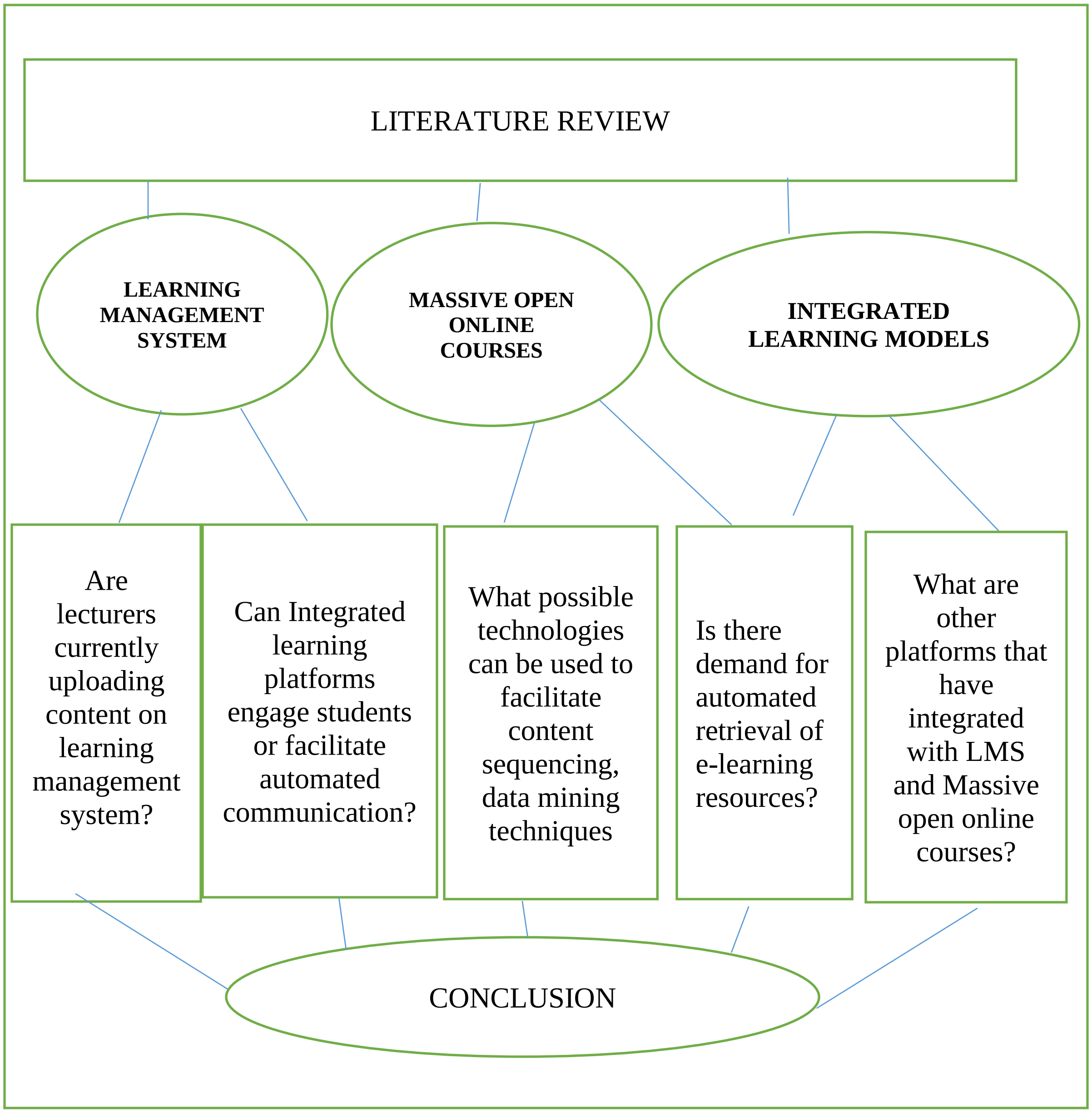

Figure 2-1 Overview of Chapter 2

The remainder of this chapter is organized as follows; in section 2.2, the current trends of learning management systems in higher education is considered. In section 2.3, the massive open online course concept is explained. The researcher presents an overview of already researched limitations of massive open online courses, accompanied by new findings from an analysis of massive open online courses.

Several interesting novel approaches, in integration with other learning platforms, are discussed. Detected shortcomings are used as a basis for the new design model, focusing on data mining of massive open online courses for learning content. This is done for integration of massive open online courses with other platforms. In section 2.4, the digital learning platforms are discussed considering the various possibilities of interaction between massive open online courses and learning management systems. In section 2.5, the implications of integrated learning models are discussed. Section 2.6 provides insights into the design science research methodology. The conclusion of the chapter is drawn in section 2.7.

2.2 Learning Management Systems in Higher Education

As described in Chapter 1 Section 1.1, learning management systems support educational activities encouraging presentation of data for managing the learning process (Szabo & Flesher, 2002). Learning management systems are institution-wide, web-based systems with interoperability capabilities and a variety of pedagogical, andragogical, heutagogical and administration tools (Williams et al., 2016). Key reasons why institutions often consider the installation of these e-learning tools include; efficient content delivery (Moses, Ali, & Krauss, 2014; Mihci & Donmez, 2017), effective communication between lecturer and students or peer to peer interaction (Betul & Dawn, 2014; Dobre, 2015), learning material distribution (Liu & Geertshuis, 2016), knowledge portal (Ilyas, Kadir, & Adnan, 2017), and better coordinated assessment (AAMC, 2008). In addition, they provide accountability and transparency to teaching and learning (Cavus & Alhih, 2014), as well as prospects for educational innovations (De Smet, Valcke, Schellens, De Wever, & Vanderlinde, 2016). Furthermore, learning management systems support content in numerous formats, e.g. multimedia, video, and text, anytime access to learning content and updated course material (Sharma & Vatta, 2013) .

Another point to consider is that, making courses accessible is desirable because the learning is not limited to time and place; giving students more options and opportunities. Creating learning environments that give students varied learning experiences is a good idea in education (Meier, 2016). Exciting learning experiences are derived when students interact with content, and the interaction results in intended learning outcomes and completing studies (Zimmerman, 2012). Another study by Zimmerman (2012) confirms the claim that widening the range of content-based e-learning options engenders more satisfying learning experiences (Rodriguez & Armellini, 2013). In addition, through content reuse, time is saved as well as the cost of changing learning content is lowered (Gurunath & Kumar, 2015).

The vital but least exploited feature is the integration facility between learning management systems and other application systems (Gautam, 2010). Even past research (Payette, Blanchi, Lagoze, & Overly, 1999) has emphasized the importance of integrating learning management systems. They argue that integration deploys diverse technologies to diverse students, who are enabled to access the same type of information.

When it comes to improving communication or interaction, Liu and Geertshuis (2016) observe that learning management systems are not being fully exploited. In fact, users of learning management systems often use a few of myriad functionalities, ignoring vital important sub-systems such as online assessments, students grading (Mtebe, 2015), discussion forums (Sclater, 2008), and catering for individual student needs (Imran, Belghis-Zadeh, Chang, & Graf, 2016). In the Zimbabwean context, these shortcomings are particularly apparent in institutions where off-the shelf learning management applications, such as modular object-oriented dynamic learning environment, are used. These trends probably emanate from improper training of users, genuine unawareness of the functionalities offered (Wilcox, Thall, & Griffin, 2017), or most worryingly, unavailability of resources to fully exploit the facilities offered.

Although Sailer, Kiefer, & Raubal (2015) focused on relevance and problems of location-based learning, they brought out integration of Geography Information Systems with learning management systems without depending on a particular subject. However, the work lacked the content aspect. In this study, the researcher integrates learning management system with massive open online courses on a digital learning platform already designed for students.

Learning management systems were also integrated with an online tutor system (Duong, 2014). The emphasis was on the technical side, how to reduce effort in designing integration code. Despite reports that integrating learning management systems with other systems pose some challenges (Jellad & Khemaja, 2014), it is possible for learning management systems to interact with external application such as semantic web servers. Attempts to automate the functions of learning management systems were done through the work of Fardinpour, Pedram, and Burkle (2014). However, their work does not cover content access issues which is the focus of this study.

To add to that, learning management systems can integrate with cloud computing services (Gutiérrez-Carreón, Daradoumis, & Jorba, 2015). Although the integration was evaluated through pedagogical techniques, the work does not show the benefits of the integration efforts compared with other systems. Nevertheless, cloud computing is a trending Internet technology requisite for the provision of more data sources.

Furthermore, learning management systems in virtual campuses were integrated using a software architecture based on combining multi-tier patterns (Navarro, Cigarrán, Huertas, Rodríguez-Artacho, & Cogolludo, 2014). The product was a complete connection of the external applications with virtual campuses. However, the work lacked pedagogical approaches and stakeholder involvement. Web 3.0 tools have also been integrated in traditional learning environments (Conde et al. , 2014). The authors revealed an opportunity for integration and aimed to propose other interoperability scenarios that facilitate gathering information automatically from the Personal Learning Environments to the learning management system.

Whilst researchers point to integration works in their study (Skouradaki, Kalogiannakis, & Plexousakis, 2016), they revealed a weakness of learning management systems as lack of adaptability to student’s choices. Their work extended the modular object-oriented dynamic learning environment functionality of tagging resources. Since this study is based on the modular object-oriented dynamic learning environment learning management system, the enabling technology of adaptive learning aspects are covered. There is need to study the emerging trends of learning management systems in higher education (Dobre, 2015).

In as much as learning management systems have benefits, there is a lack of stakeholder input in the design processes. The researcher elicits requirements from software engineering experts to obtain relevant input for the integrated designs (Jordan & Duckett, 2018).

Another drawback of learning management system is that of minimum interaction among students due to the design of the systems. To get around the challenge, the researcher takes advantage of the integration capability of learning management systems to offer designs which allow content to be presented in a manner that students interact more with content (Jordan & Duckett, 2018).

Issues surrounding use of standards (Anistyasari, Sarno, & Rochmawati, 2018) have led some learning management systems to work in a closed environment since they are unable to communicate with other learning management systems. Adopting common frameworks for learning content is an enabling factor to achieve interoperability. In light of that, the researcher aligns the integrated design model with the current learning content framework.

Learning management systems are also known to give students a narrow minded view of learning resources (Arora, 2018) such that they would not consider other learning material outside their learning system; thus, limiting potential access to external learning content repositories.

Challenges such as information overload have been noted where learning management systems have been integrated with social networks (Ternauciuc, 2014). To minimize challenges of distraction and abandonment of learning activities, web resources were integrated with web-based learning management systems (Krieger, 2015). However, social networks have been integrated with massive open online courses to get enhanced information about user interaction with contents (Cruz-Benito, Borrás-Gené, García-Peñalvo, Blanco & Therón, 2015).

Other known challenges of integrating learning management systems are availability, reliability and scalability, particularly when sharing learning resources between cloud platforms and other networks. Jayasena and Song's (2017) contribution was a framework for a virtual private network integration with cloud environment to enhance resource sharing in universities. The fact that most e-learning content is distributed based on location makes it a challenge to put together the learning resources. Service oriented architecture has been implemented in order to address challenges of this nature (Palanivel & Kuppuswami, 2014). In this study, I explore the use of micro services architecture (Namiot & Sneps-Sneppe, 2014) in integration works. Micro services architecture is an approach used to develop software where components are broken and are independent from each other (Dragoni, Giallorenzo, Lafuente, Mazzara, Montesi, Mustafin, & Safina, 2017). They achieve the same but better results and probably deal with Service oriented architecture limitations. This study considers scalability issues in the event that the learning content increase in size in terms of maintenance. Trends in technology point to use of microservices (Dragoni et al., 2017) capable of storing large amounts of data as well as enhance the low of data in integrated systems.

The default design of integrating learning management systems may not readily allow integration with current cloud systems as pinpointed by (Jerković, Vranešić, & Radan, 2017). That adds up to the challenges to consider when designing our integrated model.

I have confidence in pursuing the integration idea, borrowing approaches from the studies where learning management systems have been integrated with Facebook before (Razali, Shahbodin, Ahmad, & Mohd, 2017; Kalelioglu, 2017; Avila, Hembra, Mueco, & Zamora, 2015; Jones, & Bogle, 2017).

In describing challenges of integrating learning management systems, Greenberg (2017) indicates that higher education institutions suffer lack of data sharing, system compatibility, consistent and comparable platforms. Some challenges addressed in literature are using and integrating cloud computing and Web 3.0 tools to attain intended learning outcomes (AlCattan, 2014).

The aforementioned challenges are manifest in other disciplines besides education; hence, the possibility to adopt the remedies to address the challenges in our designs. Whilst researchers have implemented cloud computing to address challenges in the learning management systems domain, there remain pertinent issues in cloud adoption. The work of Jeffery et al., 2015; Masud, 2016; Boja, Pocatilu and Toma (2013) pinpoints issues surrounding cloud computing. Knowledge of cloud computing assists in software model designs so all trendy technologies may be considered. Figure 2-2 depicts weaknesses and threats of cloud computing in educational systems (Boja et al., 2013). The design model should also inform universities on how to integrate cloud computing successfully.

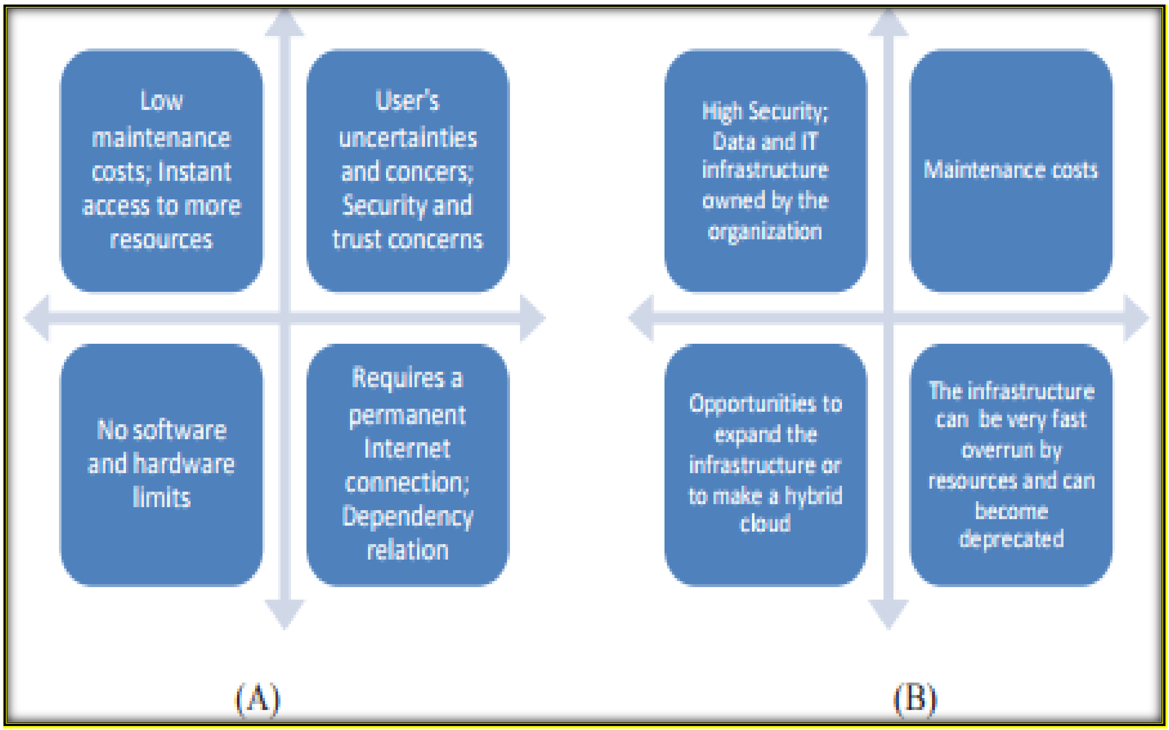

Figure 2-2 SWOT matrix for cloud systems Boja et al (2013)

2.2.1 The need for mobile learning management systems

The concept of sharing learning content among learning platforms is not new (Tian, 2017; Alanazi, Abbod, & Ullah, 2014). Together with improved bandwidth obtained from the use of wireless technologies (Stone & Zheng, 2014), mobile learning management systems avail the tooling that allows lecturers and students to access content (Asiimwe, Grönlund, & Hatakka, 2017). However, most learning management systems are not mobile ready; hence, the need to make them mobile ready. The future designs are supposed to be lightweight and interoperable (Casany et al., 2014).

In the previous section, benefits of learning management systems were outlined. Next, it is important to emphasize that alongside the popularity of learning management systems, mobile learning management systems are also a theme emerging in research studies (Han & Shin, 2016)**.** In addition, it is clear that educators are taking advantage of mobile devices, creating opportunities for students to interact with learning content. Further to that, inherent benefits of mobile devices (Hori et al., 2015) such as reduced electricity problems and various portions of communication would benefit ultimate users of the integrated design model.

Some evidence (Adams et al., 2017) shows that 51.3% of web browsing worldwide took place via mobiles and tablets, exceeding desktop browsing. The report predicts a continued 36% annual increase in the global market for mobile learning, which shows that there is a significant increase in the number of students using mobile devices for learning (Delcker, Honal, & Ifenthaler, 2018). Zimbabwe is not left out in the race, with 81% of the students in Universities owning mobile devices like laptops, smartphones and tablets (Chimhenga, 2017), as access to mobile devices keeps on rising in developing countries.

To harness the existence of mobile devices in learning, learning management systems are considered a base where expansions can be made to meet teaching and learning needs.In this study, the functionality of learning management systems is extended to mobile technologies to allow students to interact with content using mobile phones, tablets and laptops. The ultimate objective is to integrate learning technologies within the learning environment (Kalz, Bayyurt, & Specht, 2014). However, students experience challenges ranging from technical to social (Glahn, 2016; Demir & Akpinar, 2018), such as: problems with availability of websites and learning material; lack of use of mobile devices in teaching and learning (Dahlstrom et al., 2014); students' use of mobile devices for many other activities neglecting access to electronic learning resources (Joo, Kim, & Kim, 2016).

Moreover, Zimbabwean universities are also facing several challenges in implementing mobile learning, including the cost of the mobile devices, cost of data bundles, resistance to change, lecturers' negative attitudes towards use of learning management systems, lack of knowledge on how to use digital learning platforms, and slow internet speed, among others (Mupfiga, Mupfiga, & Zhou, 2017). Thus, to encourage continued use of the mobile devices for improved teaching and learning, there is need for newer models.

The researcher suggests automation of content uploading, used together with mobile platform frequently used by students to access learning material, to enhances student-content interaction. The future of learning management systems is described as open, flexible and supportive of mobile computing (Stone & Zheng, 2014). Thus, learning management systems' openness also means their integration with existing systems such as massive open online courses.

This integration gives opportunities for automation of content retrieval tasks since the mobile devices constitute the basis of the present study's designs incorporating light weight mobile devices. Massive open online courses interaction with mobile devices assist in the provision of updated content. However, Zhuo and Jiang (2014) suggested that there should be mobile architecture for massive open online courses platforms. That is the gap the study seeks to cover. The next section brings out the other side of learning management systems seemingly encountered by lecturers.

2.2.2 Lecturer pressures on content uploading

The researcher concurs with Swart (2016) that not all academics dump learning content on learning management systems. In fact, for the content which is just left on the site, efforts are put to find means for searching and filtering through it to retrieve relevant content (Ilukwe & Biletsky, 2014). There is therefore, need for learning content to be accessed in real-time (Merriman, Coppeto, Santanach, Shaw, & Díaz, 2016).

Among other limitations, it appears that lecturers lack time to update learning content from different learning management systems (Favario, Meo, & Masala, 2015). In addition to that, the use of large learning content repositories in an effective manner is another challenge. These limitations offer opportunities to expand and enhance learning management systems.

To solve the problems, different architectures have been designed. For example, Brusilovsky et al. (2014) designed an architecture that facilitates the integration of smart learning content in computer courses. Also, efforts have been made to address the issue of uploading content on modular object-oriented dynamic learning environment servers from external sources. While suggestions have been made that lecturers need tools to support content creation, this study aims to produce designs that enable lecturers to share the content they already have, with students on a digital platform.

Indeed, lecturers carry the responsibility of creating, retrieving, sequencing and updating learning content (Bhalalusesa et al., 2013) to avail content to students. Since lecturers have now been exposed to various learning management systems still, they are not keen to use learning management systems because of time management issues vis a vis workload. This study comes through to provide automation of the uploading task, thereby supporting lecturers who go through a difficult process of choosing relevant learning content in learning management systems, and creating the content retrieved from databases and online repositories (Limongelli, Sciarrone, & Temperini 2015).

With regards to content uploading, several researchers have looked at the subject from different perspectives (Bhalalusesa, Lukwaro, & Clemence, 2013; Alanazi, Abbod, & Ullah, 2014) . Some work has been done that allows lecturers to share learning content under limited bandwidth environment (Kautsar, Kubota, Musashi, & Sugitani, 2016). The efforts are made to address the problem that lecturers face of up-loading learning content which requires enormous effort and wastes time, particularly in sequencing learning materials. However, depending on the set-up of the learning management systems, there are various options available for lecturers to perform the task.

Early work by Limongelli, Lombardi, Marani, Sciarrone, and Temperini (2016) intended to reduce workload from lecturers working with traditional learning management systems. In addition, a single research also looked at the process of general searching of learning content from a file server repository (Kiryakova, 2014) to assist lecturers to design learning content and organize the sequencing. The results showed that lecturers still had to upload content own their own; instead of teachers creating their own content. Thus, the proposed design model aims to automate the process of adopting learning content from massive open online courses. There is a vast amount of learning materials in massive open online courses, which requires data mining techniques for analyzing the learning content to facilitate the work of selection of relevant learning content.

The study takes advantage of access to existing open massive open online courses' data. Security is an issue to be considered when matters regarding learning content sharing are considered (Al-Roshdi & Al-Khanjari, 2015).

2.2.3 New Generation Learning Management Systems

This study particularly seeks to bridge the gap between technology advancement and learning content in the learning environment. Designs in this study, seek to meet the needs of the educational environment and avoid such dangers as the underutilization of technology in education (García-Peñalvo et al., 2015).

While learning management systems yield benefits, they are known to lack flexibility, choice and personalization (Thorleif, 2016), and are characterized by control of the content requirements.

Considering current trends of learning management systems, a fusion of designs of learning management systems and cloud computing offered by Radwan, Senousy and Alaa El Din (2014), show important how learning management systems have improved as shown in Figure 2-3.

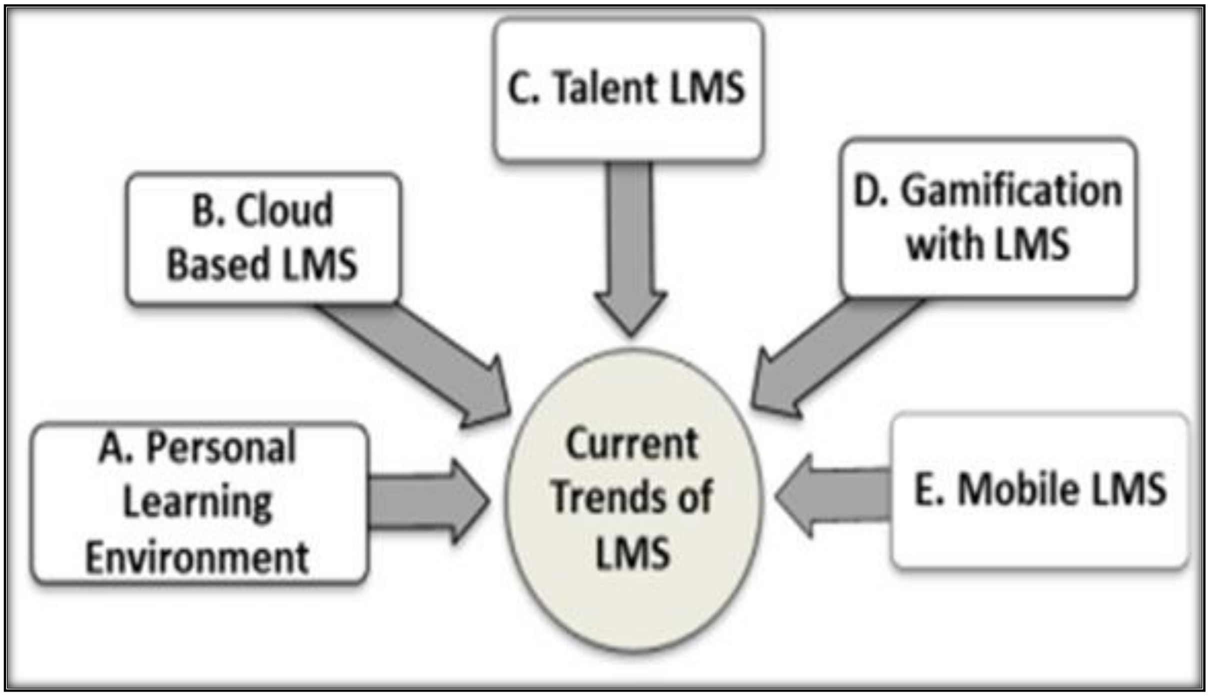

Figure 2-3 Current trends of learning management systems Radwan et al (2014)

Cloud computing, implemented as software in Figure 2-4 has been integrated in the design of learning management systems too. Modular object-oriented dynamic learning environment, known as the most popular learning management systems, has been integrated with cloud computing platform (He, Qiu, & Zhai, 2015). This study supports the efforts already made in the provisions of Learning Resource as a Service reflected in Figure 2-4. The automated designs are relevant in that regard. Nonetheless, Kaewkiriya and Utakrit (2012) acknowledge the challenges that exist when obtaining learning content that is distributed on the internet. To address the problem, they designed a model, integrating cloud computing, web services, and learning management systems.

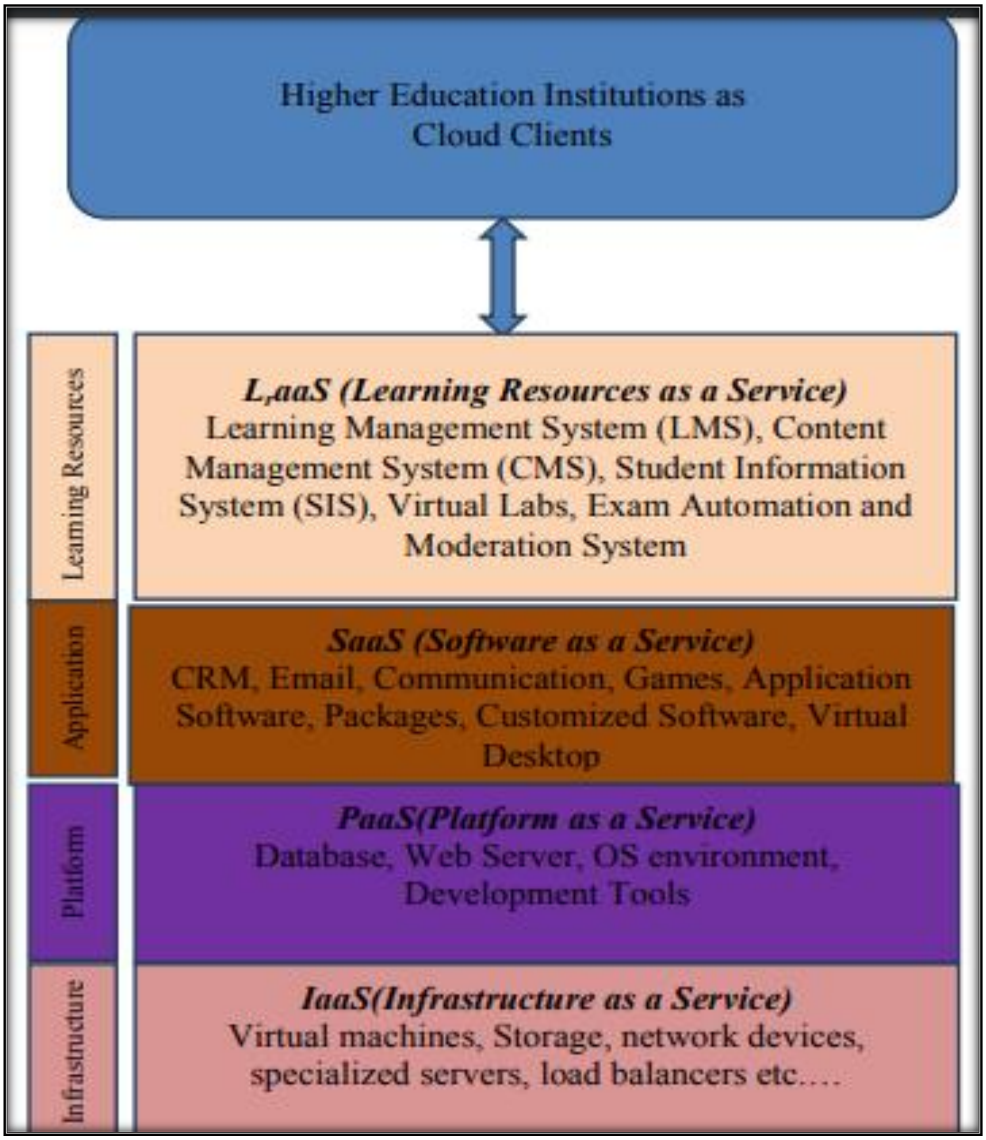

Figure 2-4 Cloud architecture for higher education institutions Bhat, Singh, & Singh (2017)

In this study, the focus was on integrating learning management systems with Massive open online courses to enhance learning content distribution whilst, taking into account the limitations modelled by cloud computing.

Future generation learning management systems (Figure 2-5) should also include ability for users to collaboratively manage digital content. The authors suggest that the content could take various formats (Vogten & Koper, 2014).

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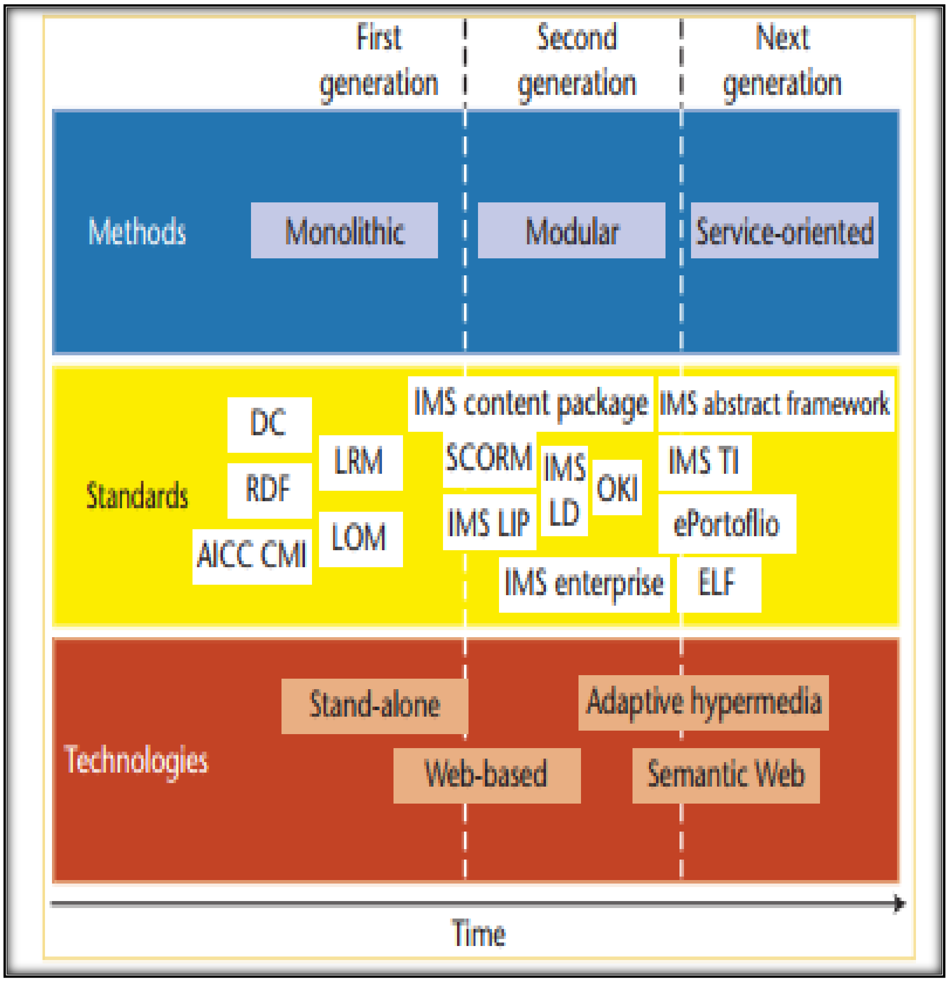

Figure 2-5 Generation of Learning management systems Dagger et al. (2007)

The generations move from monolithic to modular, through service-oriented, and then possibly move to microservices in the next generation. The researcher shares the same sentiments as Long and Mott (2017) who envisioned the next generation of learning management systems adopting integration capabilities which incorporate both the networked learning model of the learning management system; and the adaptive, personalized learning model. The envisaged model comprises software architecture and learning components as depicted in Figure 2-6.

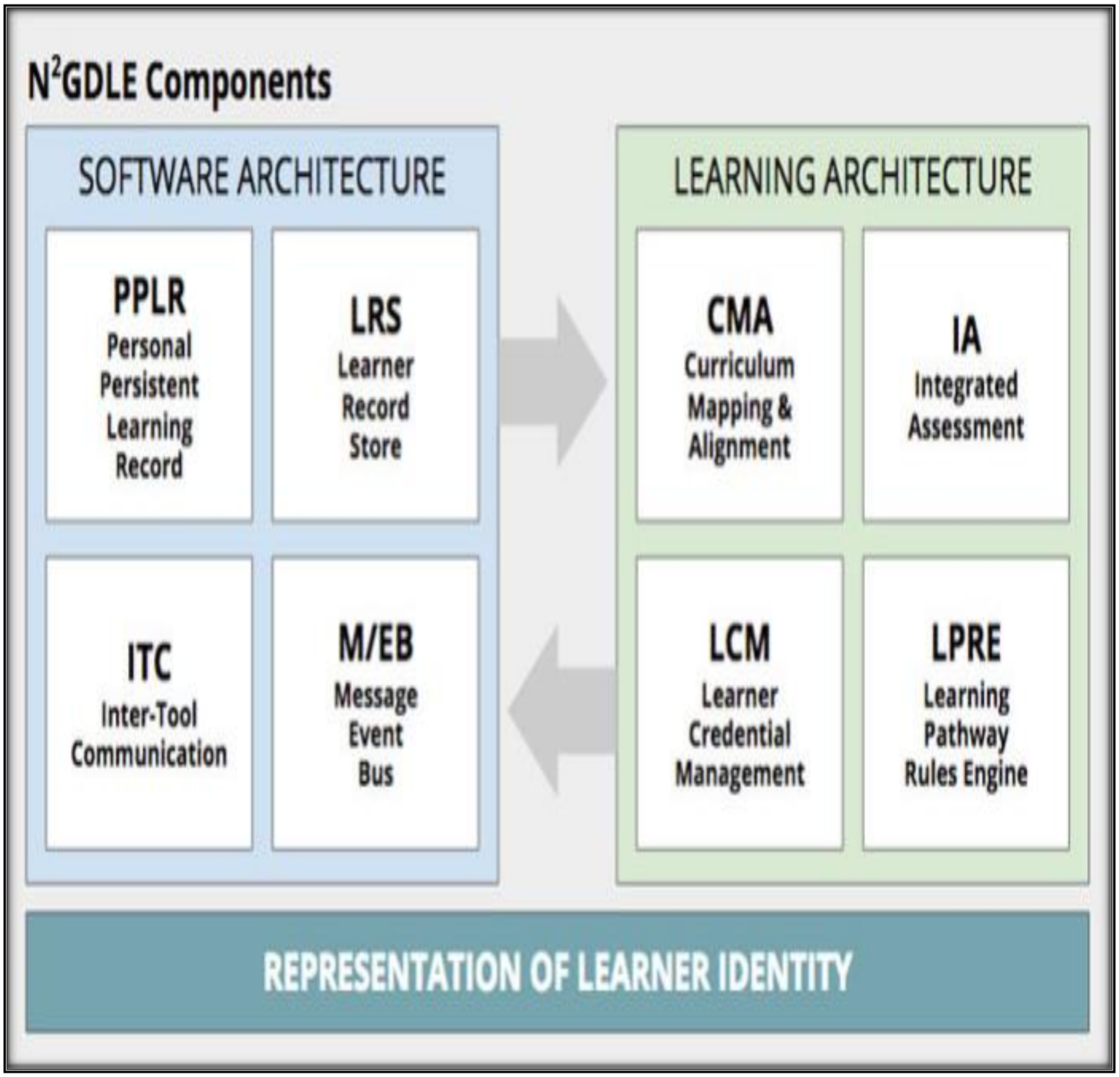

Figure 2-6 Next Generation Components of Digital Learning environments Long & Mott (2017)

Of interest from the next generation components of digital learning environments, is Learning Pathway Rules Engine (LPRE). An LPRE facilitates the creation of learning sequences in the future learning management systems. The rules engine establishes rules and logic that automatically updates content. The design model for this study incorporates the content sequencing aspects of the learning system environment.

When designing learning environments for the future generations, student and learning content interaction is one principle to be considered. As the researcher designs a model to integrate learning management systems, it is imperative to look into newer and trendy technologies as they are applied to Massive open online courses and learning management systems (Anshari, Alas, Yunus, Sabtu, & Hamid, 2015). In the same vein, a prediction is made (Galanis, Mayol, Casany, & Alier, 2017) that technological advances in the domain of learning management systems would emanate from the use of existing platforms like massive open online courses.

Technological advances align with the integration of massive open online courses with digital learning platforms as presented in this study. The technological advances promote availability of content to what lecturers usually add to the learning management repository. The learning space should be open, based on learning management systems standards for networking, and the software should be sharable. Compatibility with mobile devices is also key as we move into the future of education technology (Wiley & Mott, 2013).

2.3 Massive Open Online Courses

While the weaknesses of learning management systems can be addressed through internal staff development programmes and awareness campaigns, the integration challenge requires creative interventions. Presently, as creative interventions are sought, the concept of massive open online courses emerges. The massive open online courses are often presented as global online courses, without formal admission requirements, and can accommodate an unrestricted number of students. Massive open online courses form globally–networked learning environments, characterized by openness, (Castaño & Cabero, 2013) massification and massive and interactive participation. The structure of massive open online courses platform is depicted in Figure 2-7.

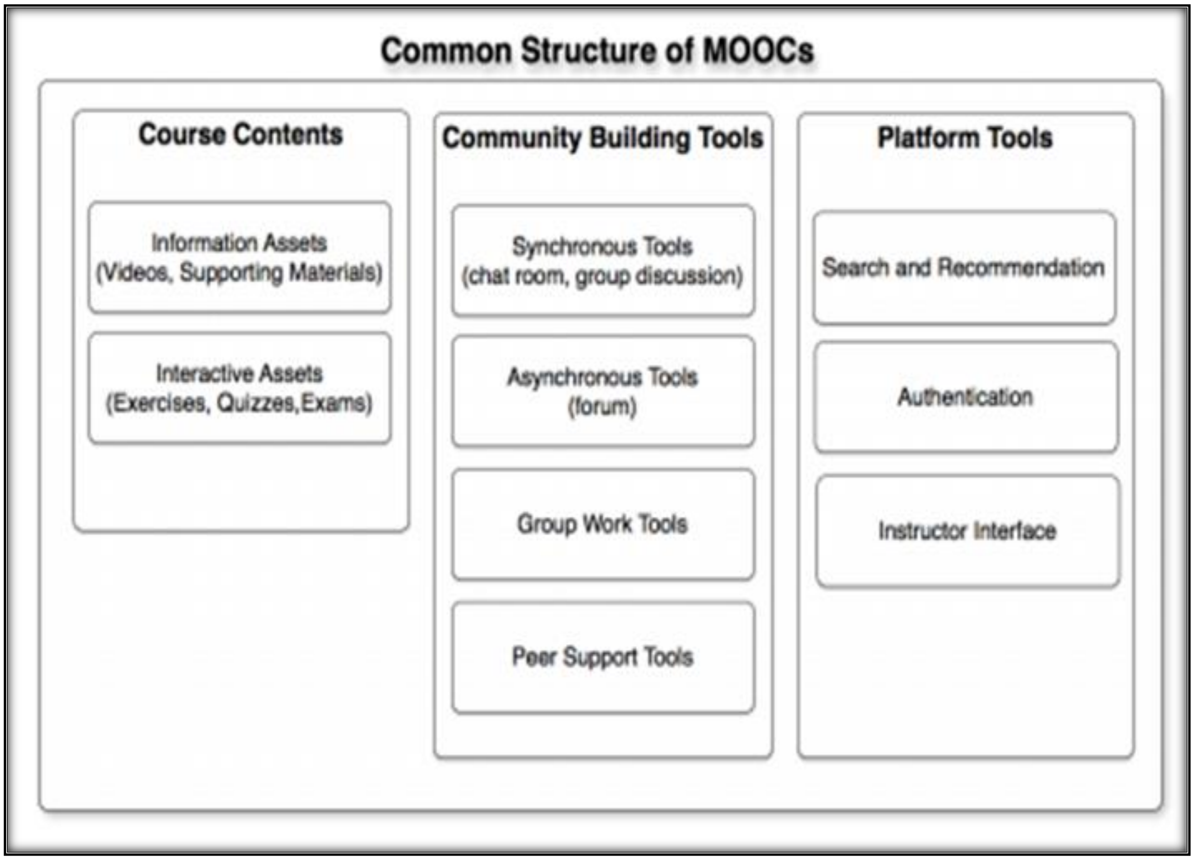

Figure 2-7 Structure of massive open online courses platforms Sun (2018)

It is also important to highlight that globally, 58 million students enrolled in massive open online courses, suggesting their popularity. Similarly, more than 25 million people (Dennis, 2017) enrolled in massive open online courses between 2012 and 2015, including 39% from developing countries (Kizilcec, Saltarelli, Reich, & Cohen, 2017). All these statistics suggest massive open online courses' presence in teaching and learning.

Milheim (2013) in (López & Hernández, 2017) shows other principal features of massive open online courses, including limited interaction between students during the courses, and low cost for students and universities. However, Dos Santos, Punie and Castaño-Muñoz (2016) pointed that massive open online courses face passive resistance by academics, have need for training staff on open education, and require technical integration in some cases (Aleven, Baker, Blomberg, Andres, Sewall, Wang, & Popescu, 2017).

Advantages of massive open online courses are that they provide a collective engagement. Universities are engaging in massive open online courses and making them part of their curriculum. In relation to content, massive open online courses include improving access to quality resources, cost reduction for content development, and general improvement in variety, quality of learning material in teaching and learning. More benefits could be derived from combining massive open online course features with components from other learning management systems. Opportunities to bring together students to collaborate with each other on multiple projects at a goal are brought out through massive open online courses integration with other learning management systems (Hernández, Morales, & Guetl, 2016).

As discussed earlier, massive open online courses' features (accessible anywhere and anytime) attractively counter oblivious excuses by lecturers and students for limited uses of e-learning tools, excuses related to limited energy supplies and poor access to electronic services. As a case study and proof of concept, the study's focus is on integrating modular object-oriented dynamic learning environment (the most used learning management system in Zimbabwe) with a few massive open online courses on the EcoNet e-learning platform.

The courses expand students' opportunities for lifelong learning, even in countries with a poor infrastructure. (Boga & McGreal, 2014), are often used in economically developed countries (Hyman, 2012; Liyanagunawardena, Adams, & Williams, 2013) though their characteristics suit economically challenged countries best. Moreover, at present, research around the massive open online courses has been done mostly in the developed countries and little has been done on the use of massive open online courses in developing countries (Hyman, 2012; Liyanagunawardena et al., 2013; AMDI, 2014). Massive open online courses have been studied over the years, but not in the Zimbabwe context, as shown by the scarce literature. In order to establish massive open online courses participation in developing countries, there may be a need to look into massive open online courses from the developing countries' perspective, since the environment may be different from developed countries (Castillo et al., 2015). African governments need to meet requirements to make massive open online courses a channel for accessing higher education in Africa (Oyo & Kalema, 2014).

Similarly, to offer massive open online courses most effectively, it is important to establish what Zimbabwe institutions require to participate in a massive open online courses' initiative, in light of what technologies they already have, the general awareness amongst stakeholders, as well as their perceptions of massive open online courses. The findings may help to ascertain how massive open online courses can facilitate relationships among institutions and how they can collaborate and produce massive open online courses for some common courses to cut on costs of massive open online courses production (Hollands & Tirthali, 2014).

Again, massive open online courses have been implemented in the context of limited resources in the African context. This is the case with this study save for the fact that there is lack of learning management systems integration which would increase the benefits, since institutions of higher education in Zimbabwe already have the infrastructure in place (Chimhenga, 2017).

Although the use of massive open online courses is expanding, several challenges are presented with it. Massive open online courses may not be as open as is suggested in their name when it comes to copyright issues (Cheverie, 2013). Existing massive open online course providers claim ownership of course content and do not allow the sharing or remixing of material. Therefore, not all massive open online courses should be assumed open. However, massive open online courses resource issues (Bollweg, Kurzke, Shahriar, & Weber, 2018) include overload that emanates from the uploading of coursework by students. Such challenges could spill over to learning resources too. There is need to consider scalability issues in relation to massive open online courses content repositories.

Higher education institutions are known for sharing knowledge. However, when dealing with massive open online courses, there are certain restrictions that exist which violate the traditional culture in Universities, such as licensing and copyright issues on learning materials. User authentication as well as digital rights management are some of the challenges (Jakimoski, 2016). In education, managing intellectual property is of great importance for content authors to share their content in open systems. The purpose of the design in this study, is to make content readily available based on an integrated approach.

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More challenges are put forward by Hori et al. (2015), who argue that traditional learning management systems do not integrate well with massive open online courses, and what is required is a flexible approach in which massive open online courses can operate together with traditional learning management systems, since institutions would have already invested in those systems. Nevertheless, our study embraces existing integration standards so that learning management systems and massive open online courses can be accessed in a flexible way.

Whilst challenges may prevail, massive open online courses facilitate ways to look at content issues from different perspectives. To add to that, massive open online courses provide opportunities for creating technology (Bassi, Daradoumis, Xhafa, Caballé, & Sula, 2014) .

There is need for researchers to consider integration of massive open online courses with learning management systems since it boosts the operations of the providers and reduces duplication of information (Mustapha, Muhammad, & Salahudeen, 2016). The inclusion of massive open online courses in our designs brings value addition in that more open resources are availed to support the learning environment. The support is enhanced by the automation of our design model regarding retrieval of content from massive open online courses (Spector, 2014).

This study presents an opportunity to create designs that cater for the challenges mentioned above, such as intellectual property clearance. The continuous integration of learning management systems and massive open online courses in a cloud computing context would in turn provide content to the Big data technologies by improving the size of data sets for analytics Figure 2-8.

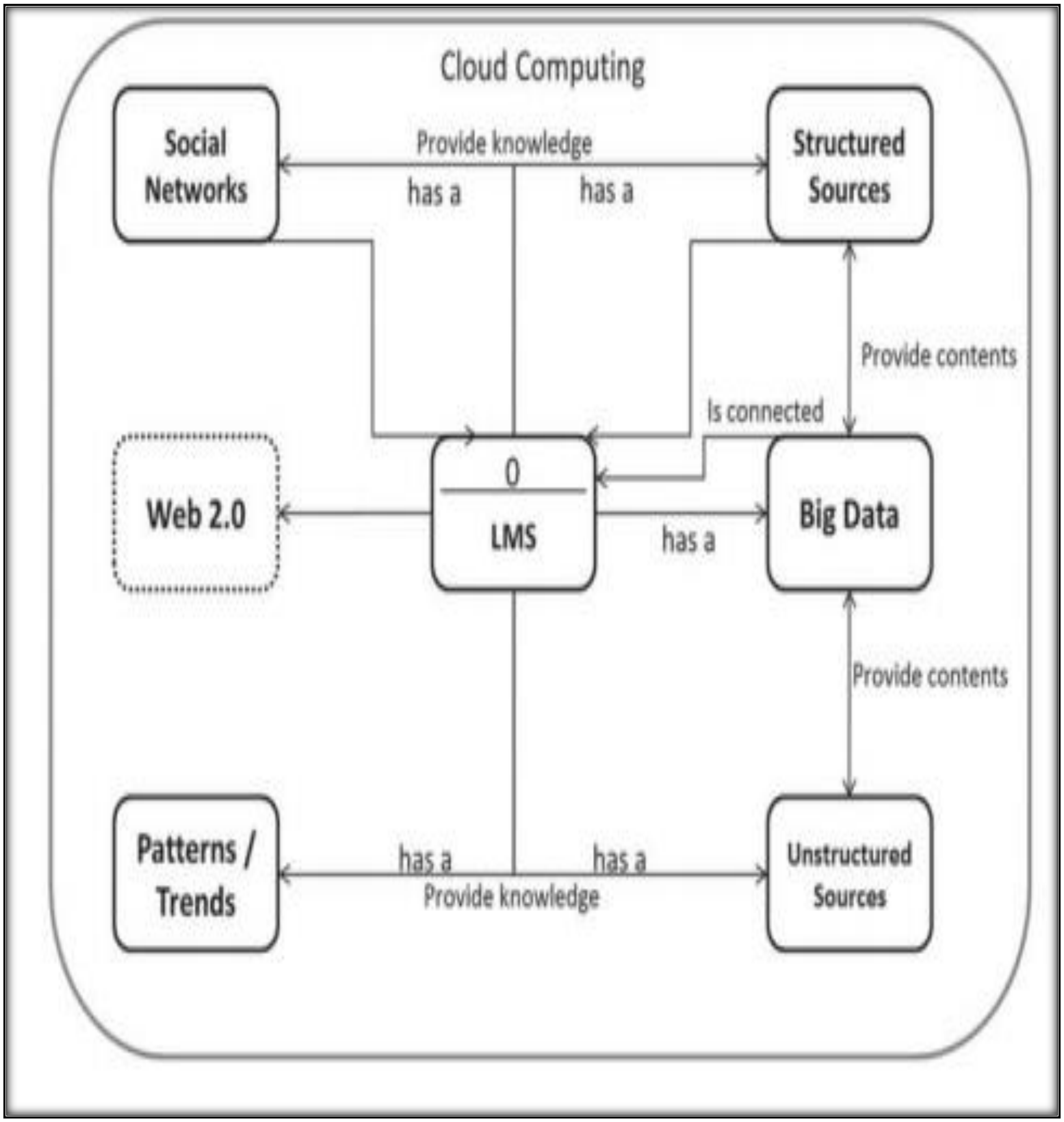

Figure 2-8 Learning management systems, Web 2.0 and Big data Anshari et al. (2015)

2.3.1 Current integration efforts between learning management systems and Massive open online courses

Massive open online courses include features designed to integrate with other systems (Collazos, González, & García, 2014).Massive open online courses are already being used with other trending technologies to include data analytics for student data, as well as adaptive systems (Haggard, 2013).

Linking external platforms with massive open online courses is a necessity since it adds value to the existing student environment (Meinel, Totschnig, & Willems, 2013). Learning platforms provide benefits when used on their own; hence, integrating the tools is likely to enhance the teaching and learning environment. Thoughts around the design of integrated platforms earlier on included; integrating learning management systems with the cloud (Gutiérrez-Carreón et al., 2015), integrating learning management systems with digital assignments repositories (Díaz, Schiavoni, Osorio, Amadeo, & Charnelli, 2015), or integrating the same with virtual worlds (Morgado et al., 2016). However, cloud services repositories are insecure (Oyeleye, Fagbola, & Daramola, 2014) while virtual worlds are still being explored (Kotsilieris & Dimopoulou, 2014).

In the integrated platform the present study proposes, I exploit the benefits of massive open online courses related to anytime, anyplace, by-anyone delivery and access to content. Gros and García-Peñalvo (2016) argue that learning management systems have lost their demand as a research area. However, the integrated platform can be a very important unit for integration with other tools that may be useful for educational purposes.

Massive open online courses have been integrated with Open Educational Resources for e-learning content provisions (Chunwijitra, Junlouchai, Laokok, Tummarattananont, Krairaksa, & Wutiwiwatchai, 2016; Miller & Jay, 2015). The present study aims to address issues where academics do not use learning management systems (such as modular object-oriented dynamic learning environment) because of lack of effective learning materials (Bhalalusesa et al., 2013). We propose integration of learning management systems with massive open online courses on a digital learning platform.

To improve students' concentration on studying, a modular object-oriented dynamic learning environment plug-in which integrates the platform with e-books and a content sharing system was developed (Soga, Nakahara, Kawana, Fuse, & Nakamura, 2015).

In spite of the successful integration, Stantchev, Colomo-Palacios, Soto-Acosta and Misra (2014) avoided use of learning management systems through integration of cloud file hosting, citing that learning management systems may include features that differentiate learning management system tools from cloud services.

Massive open online courses were integrated with learning management systems to meet students' learning requirements (Mustea, Naaji, & Herman, 2014). In the same line, a digital learning platform for students using social networks was developed (Hori et al., 2015). These efforts show the potential that massive open online courses have when it comes to integration with other learning management systems. To add to that, Thirouard et al., 2015; Del Blanco, Serrano, Martinez, Fernandez-Manjon and Stanescu (2013) integrated massive open online courses, learning management systems, and a game using Learning Tools Interoperability (LTI) standard and HTML5, which operates on standard mobile devices without compatibility challenges. Their work contributed to innovation that is required in education. Massive open online courses' integration with adaptive systems shows opportunities of artificial intelligence applied in education (Aleven et al., 2017). A closer look at the above-mentioned studies, showed lack of students' views on the integration approach. Our work engages students during requirements elicitation.

Some integration efforts have been done on cloud computing architecture. These included integration of data systems in a learning system, specifically modular object-oriented dynamic learning environment and other proprietary toolkits (Despotović-Zrakić, Simic, Labus, Milic, & Jovanic, 2013). In this study, we adopt integration approaches that have been used (Chunwijitra et al., 2016), to facilitate the integration of Massive open online courses and open educational resources (OER), as well as with library systems, and specifically, modular object-oriented dynamic learning environment (Kampa, 2017).

2.4 Digital Learning Platforms

In the educational technology domain, a digital learning platform can be described as a system that facilitates learning resource sharing in the context of higher education (Matsunaga, 2018). In this study, we integrate digital learning platforms for the purpose of automating the process of retrieving learning content.

Digital learning environments serve the purpose of supporting teaching and learning (Dron, 2018), whilst platforms are foundational technologies on which other systems are constructed. Platforms are supposed to work together with other software applications. A learning platform is a combination of internet-based services that offer teachers and students learning material to support teaching and learning. They provide a learning experience by putting together technology and learning material. Since they have been in existence for some time, the future provides opportunities for advancement of learning management systems.

A digital learning platform can be described as a flexible open center, which allows for personalized learning, and around which all learning radiates. The flexibility is made possible by plugins and data flows to support learning activities (Thorleif, 2016). Digital learning platforms offers flexibility and personalization through use of standards like Learning Tools Interoperability. The learning platform should be an integral part of the digital learning environment, together with a changing landscape of third-party applications, that you plug in and out.

The platform approach is essential since it provides opportunity for efficiencies and system scalability. Institutions of higher learning face challenges, due to massification, spanning from infrastructure to security issues (Battle, 2018).The digital learning platform provides media that encompasses learning content in the form of audio, video, text, web resources and events generated by students interacting with content (Dede & Richards, 2012; Goodyear & Retalis, 2010). Digital learning platform gives students control over time, place and device they choose to access learning material. The platform enables students to access course content. Mobile digital learning platforms facilitate student engagement as they interact with content on the platform. Opportunity to provide for diverse learning styles is catered for in mobile learning platforms. (Cochrane, 2013; Stoerger, 2013) in (Ally & Prieto-Blázquez, 2014). Earlier work (Ford & Botha, 2007) supports learning from mobile devices as a possibility for Africa.

Zimbabwe has not been left out in that race. EcoNet introduced an integrated set of interactive online services that provide students with information, to enhance education delivery and management. Econet has a digital education platform that provides scholars and educators with on-the-go affordable and reliable access to world class educational content. Econet has a strategy to help educators and students gain access to learning content from across the globe (Econet, 2016). Econet zero rated websites include some massive open online courses. Whilst digital learning platforms are advantageous to learning, there are limitations of working with the platforms as different students may have different levels of familiarity with using mobile technology.

2.5 Implications of integrated models

Integration of learning management systems and other platforms allows learning technologies to be gradually introduced and allowing reduction of manual tasks, thereby increasing automation of processes that were previously done manually (Hojaji, 2012). In addition, they create newer learning management systems or improve the existing ones in line with education principles. The focus of this study is not on innovative technologies alone. Without educational principles, the challenges faced by students and lecturers may persist. In order to address these challenges, it is important to know user characteristics along with technical aspects as well. In this study, information regarding users' views is collected, as well as requirements about the systems. The users in our project are university students, lecturers and administrators. Once the requirements are gathered, the next phase is to transform the requirements to technical terms and to model the 'design model' based on the collected information.

Whilst making these design considerations, it is worth to note that integration challenges not only exist in the teaching and learning environment (Jakimoski, 2016). Common challenges which do not necessarily pertain to teaching and learning alone are technical policy issues like user authentication (Asiimwe & Hatakka, 2017). Safeguarding intellectual property for content creation also poses an issue in integration of education technology systems. Standardization has helped address such pertinent issues. It is important to note that Sharable Content Reference Model (SCORM) based systems provide a sequencing structure for learning material (Saarela, 2018). This study seeks to embrace standards that are used for developing learning tools particularly those to do with integration.

Integrating learning platforms has policy implications that cannot be ignored (Queirós, Leal, & Paiva, 2016). After doing some study on adaptive systems (Oxman, Wong, & Innovations, 2014), integrating any systems into learning management system can succeed without hassles. Thereafter, students and staff require training and there is need for additional staff for support as well. the present study's design model sits on a platform that is already used by students for other communication activities; hence, minimal training may be essential.

Moreover, it is important to identify stakeholders who provide access to learning platforms to facilitate the creation of automated ways of accessing learning content from various repositories. The need to understand the views of educators cannot be ignored (Seale, 2014). They are the key stakeholders in learning material creation and the administrators who maintain the platforms. Our study considers how best repositories can be supported by information retrieval models.

Earlier work by Sidiropoulos and Bousiou Makridou (2005) exposed navigation challenges that students experience when they access learning material via web links. Students end up selecting links that are not relevant to their subject area. In this study, the content creators do not use web links. Though massive open online courses can be integrated with several platforms, Aleven et al. (2015) highlight a key challenge in integrating intelligent tutors in learning management systems. A problem attributed to the complexities surrounding scaling out web-based learning management systems.

Arpaci, Kilicer and Bardakci (2015) reveal that security and privacy are vital variables to be considered for potential learning management systems to use cloud services scaling learning applications. For better access to a plethora of content, there is need to consider the cloud option. Siemens (2013) concurs to privacy and data ownership being central to enabling technologies associated with learning management systems.

In another study, Brown, Williams and Pelosi (2018) provide technologies used in the construction of learning content from various repositories. They highlight the significance of the use of creative commons for accessing open access material. In integrating massive open online courses with learning management systems, I consider the use open licensed content.

2.5.1 Design Integration requirements

Using standards improves the performance of integrated systems (Abdullah, & Ali, 2016). There are benefits that flow from using standards (Martin, Polly, Jokiaho, & May, 2017). Standards address integration challenges that may arise while making different applications and services work together, helping systems become efficient and easier to maintain (Del Blanco et al., 2013). Most commonly used standards are learning tools interoperability, content object repository, and resolution architecture (Ochoa & Ternier, 2017).

It has been noted (Bashir, Abd Latiff, Ahmed, Yousif, & Eltayeeb, 2013) that the content-based information retrieval systems require large computing power and resources. Additionally, the widespread use of massive open online courses has necessitated a highly scalable environment (Dragoni et al., 2017). Whilst integration of learning management systems is a noble innovation, issues of concern such as scalability (Barbosa, Barbosa, & Rabello, 2016) need not be ignored during the design stages of the technologies.

The design model in this study would include strategies and technologies for scalable learning management systems. Since the study comprised the use of light-weight mobile devices as a technical requirement, authentication protocol (Muyinda, Mayende, & Kizito, 2015) should be considered to facilitate standard communication practices among devices.

2.6 Conceptual Framework of the study

Designing software models require an understanding of the design principles and processes. This study is mainly guided by design science research as the grounding theoretical framework (Simon, 1996). This involves emphasizing gradually developing component units of the desired software design model, assessing each component unit separately, and iteratively adding completed component units until the main software design model is produced. The aim of the study was to design a software model bringing together the disciplines of education, computer science and information systems.

2.6.1 The Design Science Research

Design science research is a method of creating novel technologies that provide solutions to real challenges in the world (Vaishnavi & Kuechler, 2015). Besides solving problems, design science research contributes to theory in the field which it is applied (Hevner, March, Park, & Ram, 2004), in the present study's case, the discipline of computer science education. The two activities involved include creation of knowledge and evaluation of the artifact's use, based on stakeholder requirements (Vaishnavi, Kuechler, & Petter, 2017). One important characteristic of design science research is the evaluation phase of the process (see Figure 2-9 below for related illustration).

Improvement of existing technologies often leads to change in environments. Design science research promotes development of new artefacts which include software design models. Thus, integrating learning management systems and massive open online courses may lead to changes in the learning environment. These learning environments are complex when we consider other factors such as technologies used, human complexity, and economic dynamics. As a research paradigm, design science research is open to paths that lead to effective designs (Hevner et al., 2004).

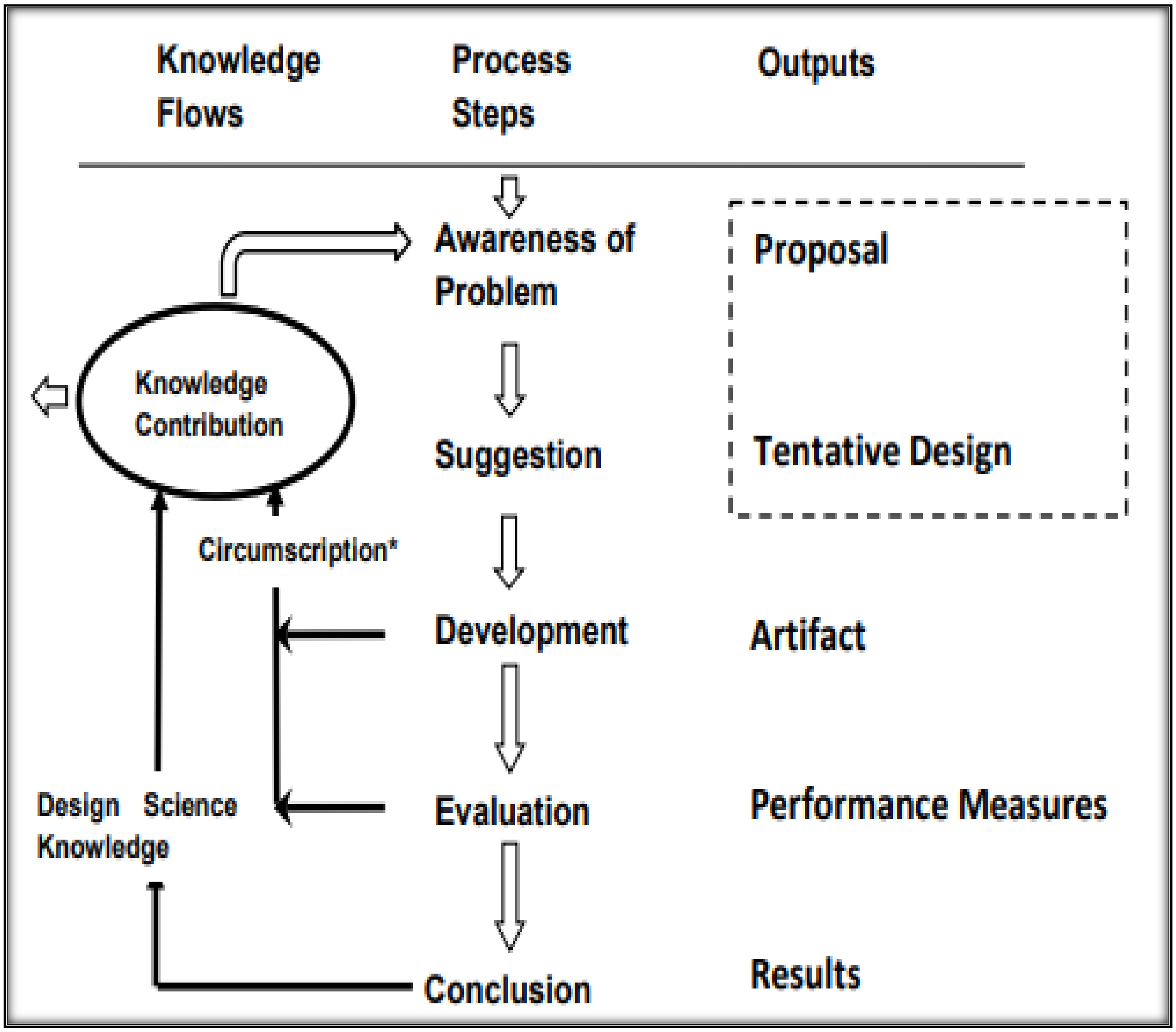

Figure 2-9 Design Science Research Process Uysal (2016)

Design science research produces innovative artifacts, and these usually rely on existing theories and techniques that have been tried and tested (Vaishnavi et al., 2017). In this study, software engineering methods are employed in the design science research approach as well as technology acceptance model and task-technology fit. Considering the objectives of this research, design science research would be useful to lecturers and other practitioners, students and related communities, software developers, and university management at large. Design science research's problem phase informs awareness Figure 2-10, while its iterative process strengthens the same methods used during development and evaluation of the artefact.

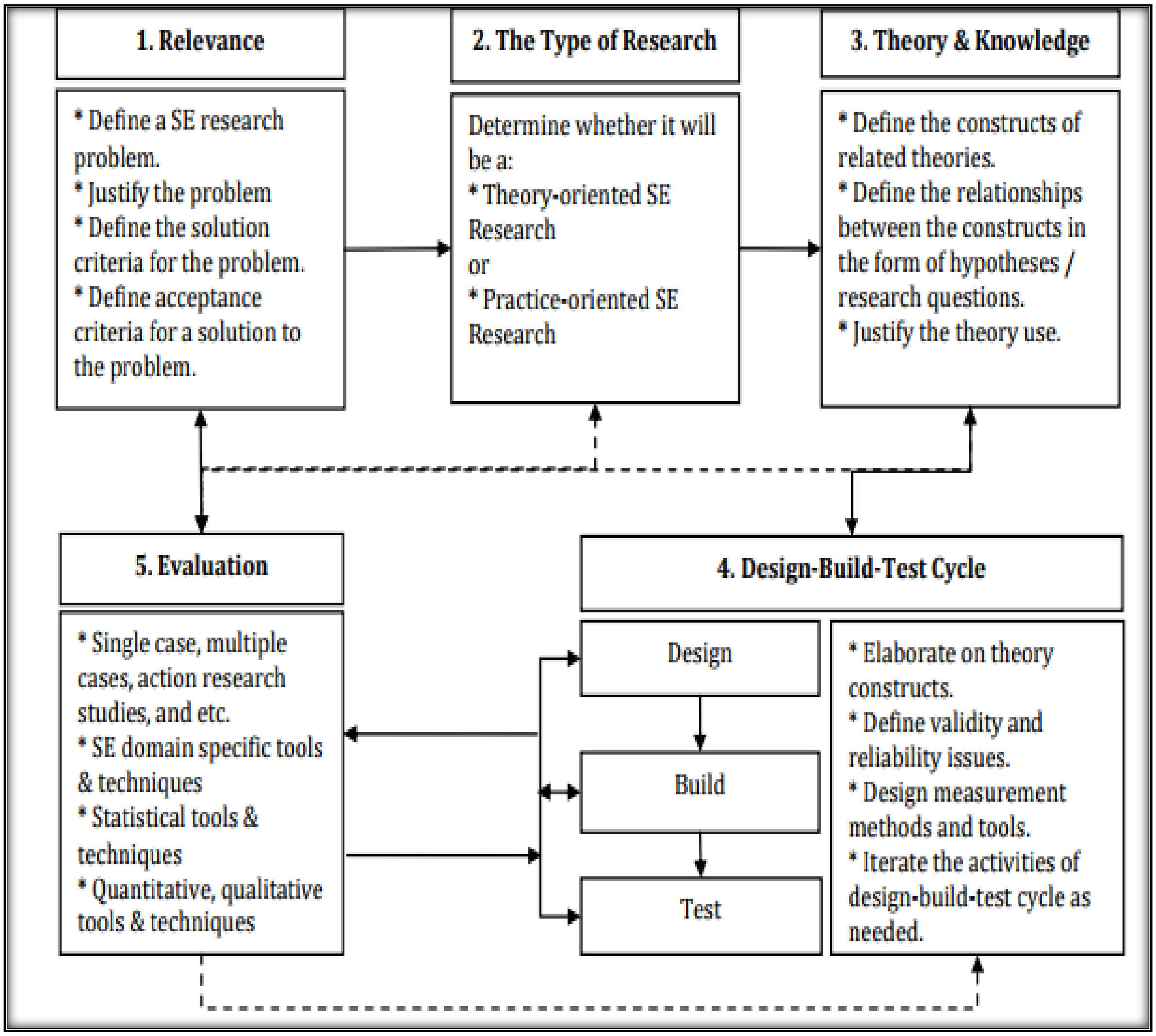

Figure 2-10 Extending Design Science Research (Uysal,2016)

The study focuses on the development of logical designs of the proposed software design model and assesses their acceptance, both at unit and integrated or functional levels. In each case, as purported in design science methodology, component units are developed with the intention of improving the functional angle of the software design model.

Therefore, both quantitative and qualitative views arise through spiral interactions (set goals, risk analysis, unit development, assessment, evaluation) with participants; connoting action research principles as well. The researcher used an extended version of the technology acceptance model to study the acceptance of the design model.

2.6.2 Technology Acceptance Model

Technology acceptance model is an information systems theory that illustrates how users are caused to accept and apply a certain technology (Fathema, Shannon, & Ross, 2015). It shows that when users are presented with a novel technology, they are encountered with factors which influence their decision on how and when to use the technology (Radif, Fan, & McLaughlin, 2016). Technology acceptance model, which is an adaptation of Theory of Reasonable Action, is specifically tailored for modeling users' acceptance of information systems or technologies. A study by Fathema, Shannon and Ross (2015) reveals that technology acceptance model is the most influential, commonly employed, and highly predictive model of information technology adoption.

This study takes advantage of the fact that use of technology adoption model is valuable as it has been applied in education research (Fathema, et al., 2015). Technology adoption model has been used widely. It has been used as a theory to identify the intention of individuals to use technology (Ariffin, Heng, Yaakop, Mokhtar, & Mahadi, 2017). Technology acceptance model's theoretical soundness and simplicity (Sánchez-Prieto, Olmos-Migueláñez, & García-Peñalvo, 2016) are what make it a reliable source for acceptance of innovation. Considering its advantages, I employ technology acceptance model in this study.

Applying technology adoption model in this study, university management, as a stakeholder, may explore barriers to accepting the proposed software design model as well as predict acceptance levels. Technology acceptance model has been used before in support of e-learning use and acceptance (Abdullah & Ward, 2016), mobile technologies acceptance (Park & Kim, 2014), and social media and massive open online courses (Zheng, Li, & Zheng, 2017). Though technology acceptance model is widely used, the model has some known weaknesses. It has been reported that technology acceptance model does not include specific task aspects (Chang, Lee, & Ji, 2016). Other studies show that technology acceptance model lacks relevance with regards to the information technology domain (Swart, Bere, & Mafunda, 2017). It is; thus, worthwhile for this work to look at one other theory that focuses on task aspects, particularly, task-technology fit.

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2.6.3 Task Technology Fit

Task-technology fit in this study is defined as the measure at which a system ties with interests, fits with tasks, and meets with needs (Lu & Yang, 2014). Task-technology fit has been defined as a measure to which a system helps users in doing a task (D'Ambra, Wilson, & Akter, 2013). It also appears to Lu and Yang (2014) as a degree to which a technology is appropriate in helping in the completion of tasks. Task-technology Fit emphasizes individual impact which refers to improved efficiency, effectiveness, and or higher quality (Goodhue et al.,1995). The same author assumed that the good fit between task and technology is to increase the likelihood of utilization and to increase the performance impact since the technology meets the task needs and wants of users more closely. As shown in **Error! Reference source not found.**, this model is suitable for investigating the actual usage of the technology, especially testing of new technology to get feedback.

The task-technology fit is good for measuring the technology applications, for example commercial software. The technology acceptance model theory describes how users come to accept and use technology (Radif, Fan, & McLaughlin, 2016). Technology acceptance model is designed to ascertain usage prediction (Wu & Chen, 2017). The concept of acceptance which flows from stimulus through response, shows how an artifact's features and capabilities influence end-users' motivation to use the application, and finally how the actual system is used (Davis, Bagozzi, & Warshaw, 1989) (see Figure 2-11 below for illustration).

Task-technology fit is the extent to which a technology supports users to accomplish tasks (Goodhue & Thompson, 1995). More specifically, it displays the ability of Information Technology to support a task. Task-technology fit explores the relationship between individual tasks and technology fit profiles it by measuring user performance and technology utilization. Task-Technology Fit has been on individuals to assess and explain information systems success and impact on individual performance (Goodhue & Thompson, 1995).

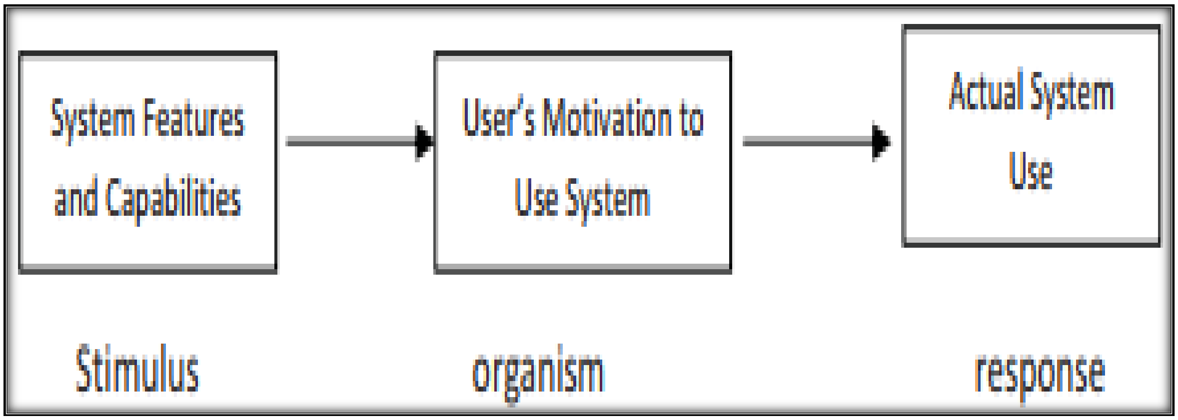

Figure 2-11 Conceptual model for technology acceptance Davis(1985)

2.6.4 Integrated Technology Acceptance Model and Task-technology fit

In this study, I add the task-technology fit model to the technology acceptance model to evaluate the impact of the design model to policy-making in universities in Zimbabwe. Task-technology fit extends technology acceptance model by considering how the task affects us, as in how well the new technology fits the requirements of a given task. The researcher further used a model which is a hybrid of technology acceptance model and task-technology fit to provide a clearer understanding of massive open online courses (Wu & Chen, 2017). The task-technology fit model compensates for the limitations of the technology acceptance model.

Technology acceptance model aims to recognize how beliefs and attitudes influence the behavior of users' use of technology. Task-technology fit extends technology acceptance model in Figure 2.12 by considering how a task will affect the use of information systems technology. Therefore, the use of an integrated model of technology acceptance model and task-technology fit will provide a model that is more powerful than the model using technology acceptance model or task-technology fit on its own.

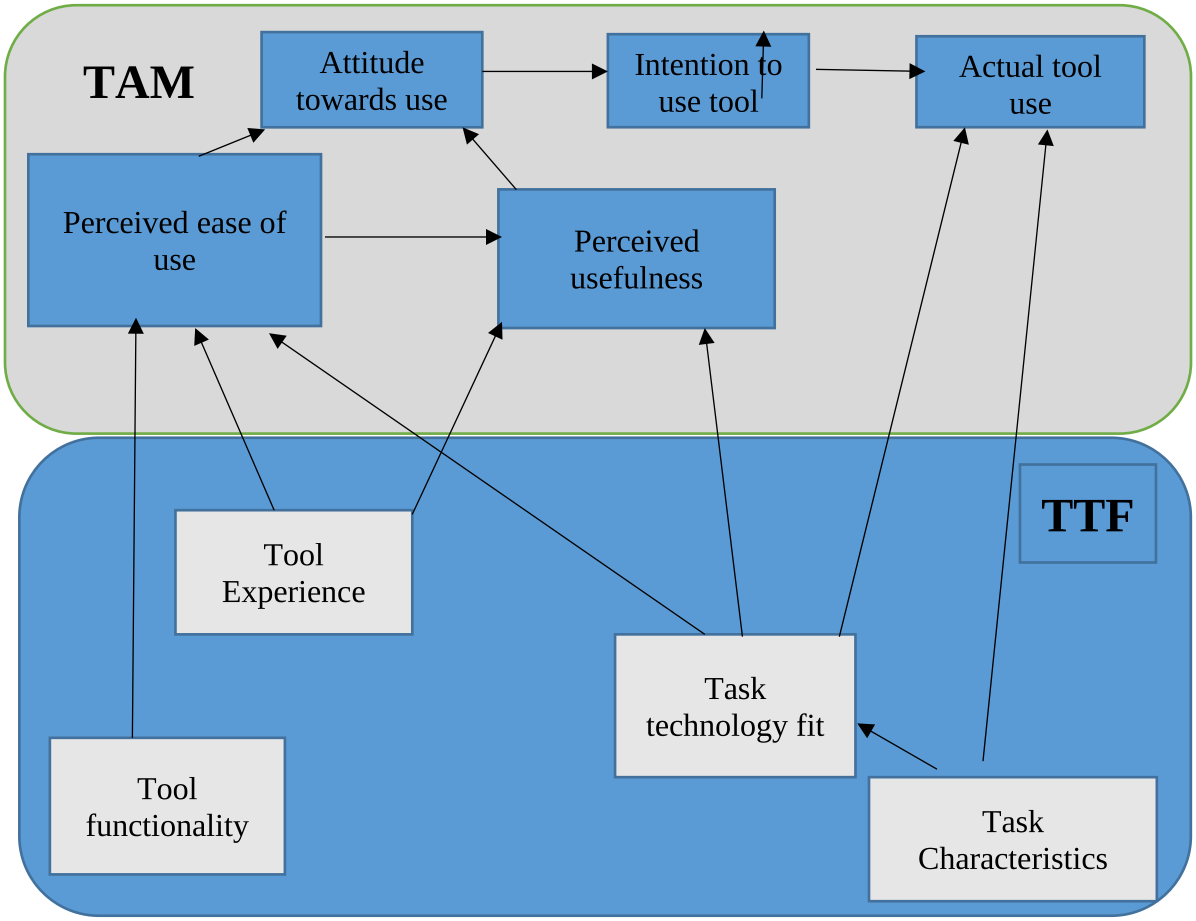

Figure 2-12 Technology Acceptance Model and Task-Technology Fit Recker (2008)

2.7 Conclusion of the Chapter

In this study, the researcher explores the integration of learning management systems and massive open online courses on a digital learning platform. This integration, to the best of my knowledge, has not been closely explored. I particularly focus on improving on learning management system's weakness of lack of personalization, lack of automated processes, and subjective dependency on human interaction during provision of study resources to students. Similar interventions have been proposed in the literature. For example, Hernandez, Lamb, Paepcke, & Ullman, 2015; Khribi, Jemni and Nasraoui (2012) created an automated system to provide learning materials to students from massive open online courses content. However, these differ from the proposed model in that there are no learning management systems aspects in the automation. The works of Hijazi & Itmazi, 2013; Klašnja-Milićević, Vesin, Ivanović, Budimac and Jain (2017) solved the information overload problem from digital libraries by recommending learning content per student's knowledge requirements. In this study, I aim at automating the process of content filtering and sequencing from global massive open online courses without any additional effort from lecturers or course editing teachers. This is a gap in the body of knowledge worth exploring.

While existing literature on integration of learning platforms emphasizes the need for blending learning management systems with enabling technologies, the focus has been mostly on internet technologies. Content aspects are largely ignored. Even in research that considered integrating learning technologies, there is a huge gap between teaching and learning and administration of uploading content on learning management systems, further motivating the undertaking of this research. Further research is needed to investigate how newer systems can implement and integrate features of learning management systems and those of massive open online courses, as well as how learning environments can be changed by these new system (Stone & Zheng, 2014).

Furthermore, our work is different from most similar research presented in the literature, in that it integrates massive open online courses and a learning management system on a locally supported EcoNet platform. That alone enhances accessibility, availability, affordability, and compatibility with the cellular technology around Zimbabwe. To the best of my knowledge, this is the first time a software model design is proposed where a learning management system, particularly modular object-oriented dynamic learning environment, is integrated with specific massive open online courses on the EcoNet e-learning platform for enhanced teaching and learning in the Zimbabwean context. Chapter 3 elaborates the research methodology that was followed.

Chapter 3

Research Methodology

In this chapter, the research methodology followed is presented. The strategy followed in presenting the process of designing an integrated software design model is mapped out. I indicated in chapter 2 section 2.7.1, that this study is mainly guided by design science research as the theoretical framework (Simon, 1996). This includes all the argumentation and reasoning presented, emphasis on gradually developing component units of the desired software design model, assessment of each component unit separately, and iterative addition of completed component units until the main software design model is produced.

The focus of this study was the development of logical designs of the proposed software design model and assessing their acceptance, both at unit and integrated or functional levels. In each case, as purported in design science methodology, component units are developed with the intention of improving the functional angle of the proposed software design model. Once the model was completed, the researcher used the technology acceptance model and task technology fit model to evaluate the impact thereof, to policy-making in universities around Zimbabwe.

In order to structure the presentation of this study's methodology in a logical order, section 3.1 first introduces the research pyramid adopted for the software design model. Section 3.2 presents how the design science research paradigm fits into this thesis. The design science research, a problem-solving approach with the aim of creating innovative solutions, stems from sciences and engineering. After that, section 3.3 describes the research methodology. Thereafter, section 3.4 explains research methods. Section 3.5 presents research techniques. Finally, section 3.6 concludes the chapter offering a general picture of the selected methodology.

3.1 Research Pyramid

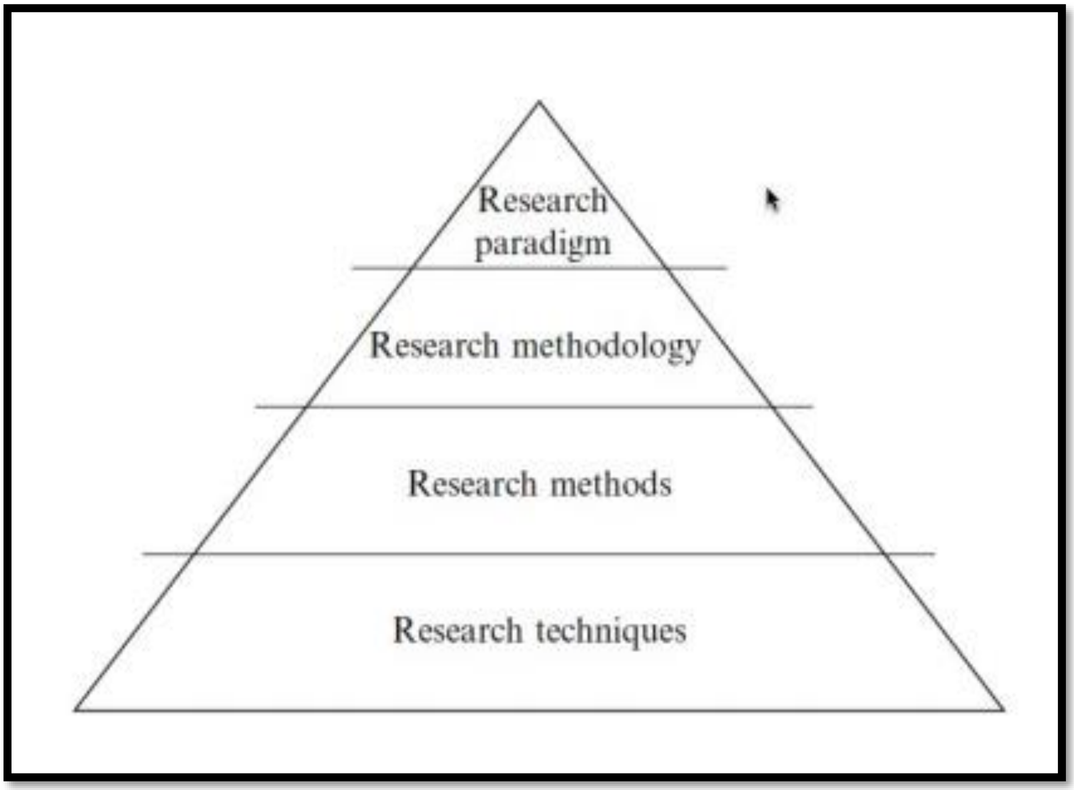

Figure 3-1 Research Pyramid (Jonker & Pennink, 2010)

To outline a research methodology, the research pyramid (Jonker & Pennink, 2010) is used as a guiding tool (see Figure 3-1 for a detailed illustration of the research pyramid).

In the context of this study, the main function of the pyramid is to assist with knowledge on how to structure the research methods. Loebbert (2011) ; Gao (2015) argue that it's often a difficult process to determine actions that provide the specific steps to be followed to obtain requirements specifications for the proposed software model.

The research pyramid comprises four levels, techniques, methods, methodology and paradigm, as depicted in Figure 3-1. The pyramid levels show how requirements are linked together with logical designs of the integrated software design model (Gulliksen, 2012). To move from the top of the pyramid through the bottom, requires making choices (Combrinck, 2014) about the techniques to use from requirements elicitation up to the compliance tests of the model using technology acceptance models. Below are the detailed reviews of how each level fits into this research from top-down the research pyramid.

3.2 Research paradigm

The paradigm level expresses the basic approach on how we view reality (Tomlin & Borgetto, 2011). The paradigm sets out views about how the problem of content uploading could be understood and considered. It combines research questions (Aken, 2004), outlines the methods such as joint application development sessions, and the ultimate artefacts, designs of the integrated software design model. The paradigm used in this study is design science research. Design science research was reviewed in section 2.7.1, as a research approach that is used in information technology and other areas, where the development of an artefact is similar to the development of a theory or methodology (Carstensen & Bernhard, 2016).

It is beneficial to combine design science research model with software engineering. The combination addresses some of the issues in software engineering research domain (Uysal, 2016). This thesis aims at creating a software design model, which solves the problem of content uploading and content sequencing on learning management systems. There could be some research methods that help to attain that. Nevertheless, design science methodology demonstrates potential to be helpful in research that requires problem solving through construction of artifacts such as software design models. The iterative approach implemented in design science methodology supports perfection and improvement of the model. For the development of the software design model for integrating learning management systems, massive open online courses on a digital learning platform, the design science research methodology is applied as presented by (Peffers, Tuunanen, Gengler, Rossi, & Bragge, 2006). The seven guidelines for design science research are aligned to the study as proposed by Hevner et al. (2004).

Although design activities occur in areas such as engineering and humanities, the design science approach is mainly a problem-solving paradigm (Hevner et al., 2004) looking for the creation of advanced artifacts; through analysis, design, and implementation processes. Design science research has been used in building a framework of a learning environment (Doyle, Sammon, & Neville, 2016), and an adaptive learning decision support system (Piramuthu & Shaw, 2009), with success. It is; thus, my premise that, based on the successes reported in the past, the paradigm would work for the context of this thesis as well.

The mix of science and art provided by design science research enables it to be used in the creation of game based applications (Cheong, Cheong, & Filippou , 2013 ; El-Masri , Tarhini, Hassouna, & Elyas, 2015), as well as for new innovations in business practices business value and impact (Meyer, Helfert, Donnellan, & Kenneally, 2012). Because design science research is trusted as a rigorous research paradigm (Venable, 2011), I anticipated successful yield of desired results and findings from using this paradigm.

Design science research ensures consistency in its processes; from problem definition through evaluation (Abraham, Aier, & Winter, 2014). However, design science research has weaknesses that have been pointed out, which this study has to guard against. Key weaknesses include rapid technological advances which could overtake design results (Peffers et al., 2018). Some remedies suggested include, adaptation of requirements engineering in the problem identification phase to cement design stages, and to keep the process more transparent (Braun, Benedict, Wendler, & Esswein, 2015). Slow uptake of design science research amongst South African computing scholars was also noted as a challenge (Naidoo, Gerber, & van der Merwe, 2012). The authors claimed design science research was a paradigm that addressed the role of Information Technology artifacts in information systems research and lacked practical relevance of information systems research. In this work, I aim to address the design problem of integration, and hope that the outcome will contribute to the knowledgebase of design process knowledge (Iivari, 2007).

The four cycles (Figure 3-2) of the design science research, namely; the change and impact, the relevance, the design, and the rigor (Drechsler & Hevner, 2016), as well as the seven guidelines for using the design science research paradigm, namely; design as an artifact, problem relevance, design evaluation, research contribution, research rigor, design as a search process, and communication of research (Hevner et al., 2004) help to understand and evaluate the quality (effectiveness) of the design science research.

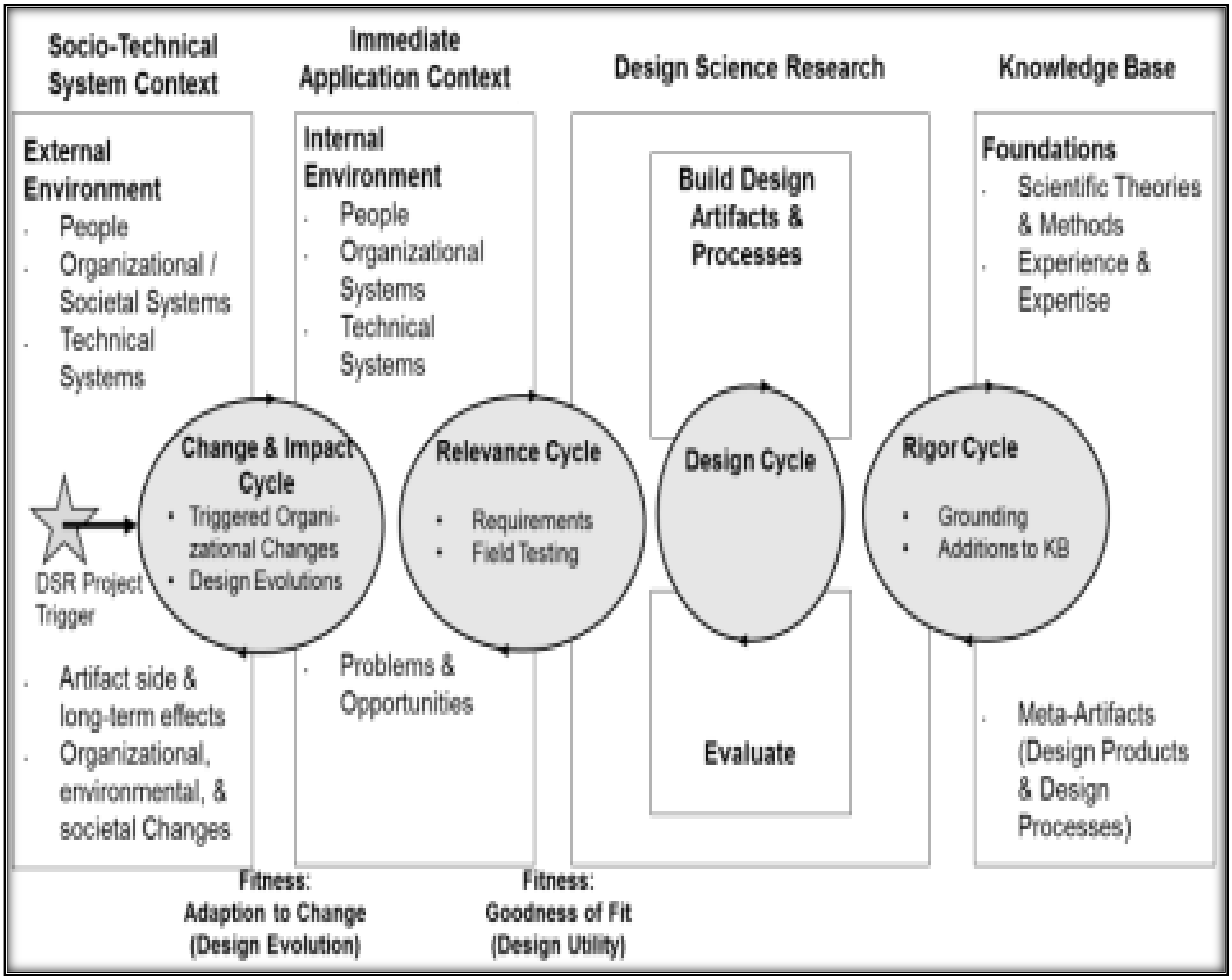

Figure 3-2 Information Systems research framework Drechsler & Hevner (2016)

Precisely, these assist in bringing together software engineering concepts that would ultimately guide into development of software design model.

A graphic representation, as given by Drechsler and Hevner (2016) comprise three cycles: the rigor cycle, the relevance cycle, and, in between, the design cycle. Figure 3-2 depicts an extension to the three cycles. An additional cycle, that is, change and impact is placed in the greater design science research context. The cyclical nature of design science research is beneficial to this study as it shows how the activities are related.

Figure 3-3 shows the application of the research framework in the context of this study. The relevance cycle is depicted by arrows (a), (b) and (c). Design cycle is shown by arrows (f) and (g). Rigor cycle is shown by arrows (d) and (e). The variables for each cycle are described in the following sections.

3.2.1 Relevance Cycle

Relevance stages a crucial role in design science research. The design science principle advocates tangible needs of stakeholders of a particular technology (Gregor & Hevner, 2013). The proposed integrated software design model could address the automated content uploading and content sequencing in higher education. The surveys in this thesis address the relevance cycle, through a close relationship with the people, organizations and technology that are involved in the use and development of the proposed software design models for learning management systems' integration with massive open online courses. Requirements elicitation from software engineering experts and lecturers are applied in creating the software design model artefact in the design cycle. A feedback loop is added from the design cycle where the designs are fed back to the university stakeholders for use and manipulation. Since the logical designs are not always perfect, the process iterates twice in this study. The overall goal is to design a software model that could be applied by universities (lecturers and management) to facilitate creation of an integrated systems facilitating content uploading and sequencing.

3.2.2 Design Cycle

The design cycle is about creating, assessing and refining the core artefacts. The design model artefact is developed iteratively based on requirements from software engineering experts, lecturers and students, and best practice technological designs. Within each design cycle, an assessment using expert feedback initiates a refinement of the design model. The cycle continues till the artifact is ready for implementation.

3.2.3 Rigor Cycle

The rigor cycle entails the use of applicable foundations and methodologies from the design science research knowledge repository. In this study, based on the design science research,

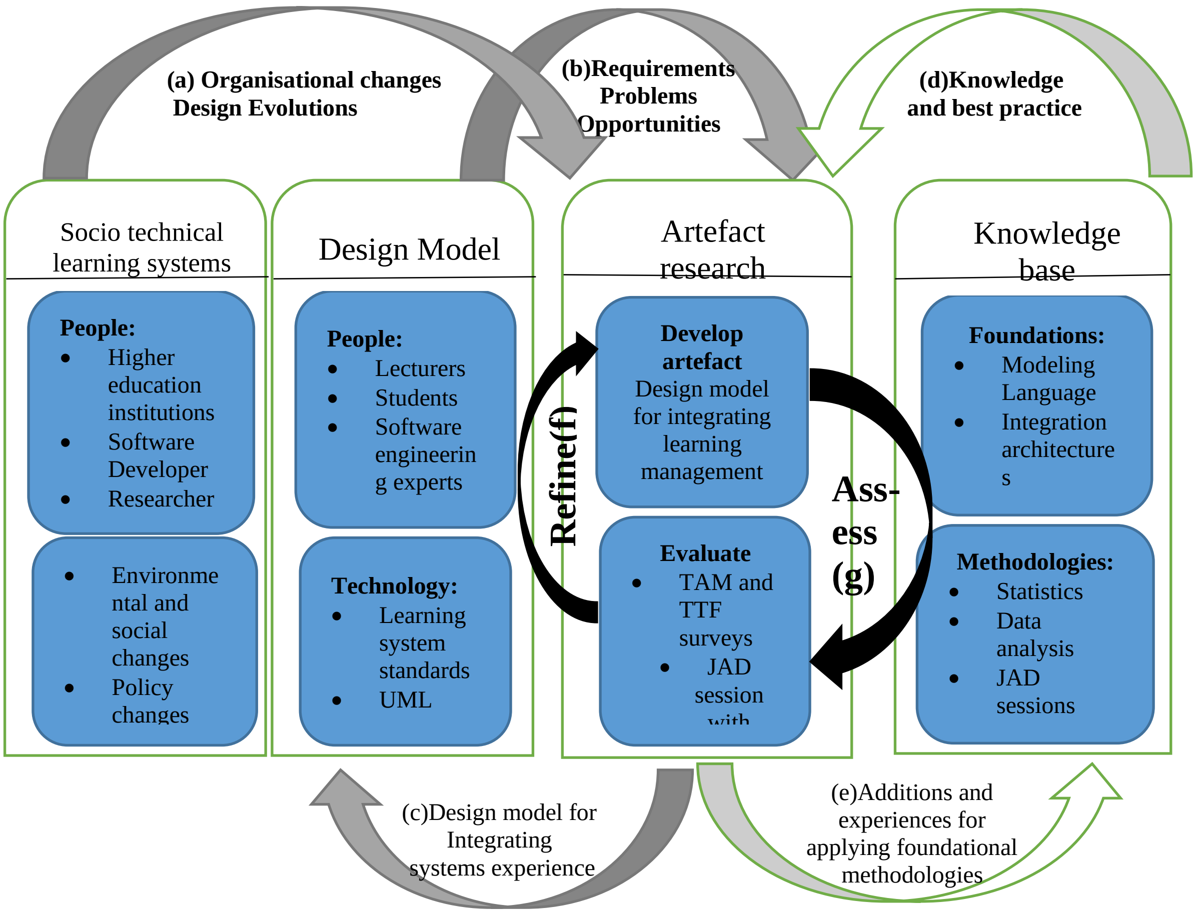

Figure 3-3 Information Systems research framework (Drechsler & Hevner, 2016)

the knowledge source comprises expertise from software engineering practitioners. Existing knowledge about the design models for learning management systems, relevant standards for integration, micro services and domain best practices, are important input to the design of the software design model for integrated learning management systems and massive open online courses on a digital learning platform.

The rigor depends on the suitable selection of what goes into knowledge generation. In this study, the likely contributions to existing knowledge could be feedback from and experience for software engineering experts. The evaluation of the design model based on the technology acceptance model and task technology fit rigorously contribute to the knowledge base. The evaluation findings could extend existing theories and experiences.

3.2.4 Change and Impact cycle

The newly introduced cycle (Drechsler & Hevner, 2016), which is known as the change and impact cycle, covers the design artifacts' second-order impacts to their wider organizational and societal contexts. The change and impact cycle are there to cope with the ever-changing application areas. In this study, the software design model, the mobile devices, and the stakeholders that use the model, are the immediate application context; while the more encompassing education technologies (even at a larger scale), and the corresponding Zimbabwean society in need of education, would costitute the wider context.

3.3 Research methodology

Following the research pyramid, level two is the research methodology. This provides the way to do the research that is custom-made to the design science research paradigm. The methodology for the study is developed based on Hevner et al. (2004). Design science research guidelines incorporate (Peffers et al., 2006) the design science research process. Design science research guidelines and design science research process describe the steps from the beginning to the end. The beginning is the problem definition and the end is the ultimate artifact. In this study, I fulfill some identified guidelines characterizing design science research; like that it must produce a practical artifact, which would be in the form of a software design model (Vaishnavi & Kuechler, 2008).

3.3.1 Research process

Figure 3-1 depicts methodology on the second level of the pyramid. The methodology for this study is within the context of design science research paradigm. A process model (Peffers et al., 2018) presents design science research process and is evaluated against design science research guidelines presented later in this chapter.

3.3.2 The research entry point

The design science research process model contains six activities that cover the research sequential steps. Depending on the research study, the research entry point differs. The four

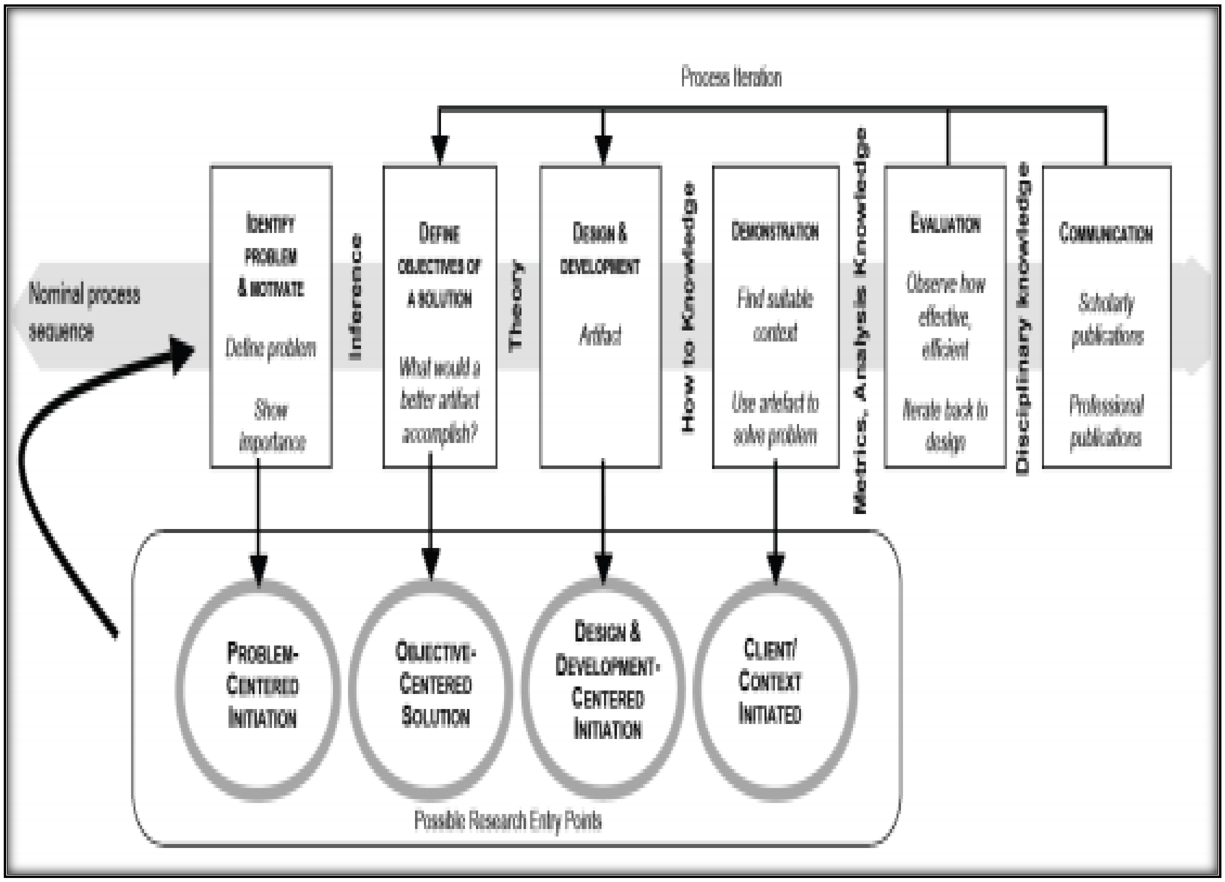

Figure 3-4 Design Science Research Methodology Process Model Peffers et al (2006)

research entry points well-defined are; problem centered, objective centered, design and development centered, and client or context centered. In this study, the entry point is the problem centered initiation. The study is centered around a problem which was identified in existing literature. Based on Figure 3-4, this entry point implies that the research process will be followed in sequential order, starting with the first activity, “identify problem and motivate”.

3.3.3 Identify Problem and Motivate

This stage of the design science research methodology comprises description of the problem and validation of the anticipated solution (Gregor & Hevner, 2013). When lecturers are faced with challenges that affect teaching and learning, there is need to respond by putting measures. The time that lecturers take without uploading content on learning management systems impact the learning process. Students need to constantly interact with content to achieve the intended learning outcomes. Earlier in this study, I explained the content uploading challenges, to justify the development of a design a solution that automates content uploading and content sequencing. Without such an intervention, students would interact with irrelevant learning content.

3.3.4 Define Objectives of a Solution

In general, the objectives of an artefact can be defined in two ways; quantitative or qualitative (Peffers et al., 2006). In this study, the quantitative and qualitative views arise through spiral interactions (set goals, risk analysis, unit development, assessment, evaluation) with participants. However, the overall objective of the study is to design an integrated model of integrating learning management systems and massive open online courses on a digital learning platform. In order to achieve this, the designs are based on the problem of learning content uploading and sequencing. The nature of the study is evaluative as the study measures the extent of the acceptance of the design model as well as the model compliance within institutions of higher learning in Zimbabwe.

3.3.5 Design and Development

Based on the objectives identified, the artifact was designed. In this study, the artifact designed is the integrated software design model which is designed based on the requirements specifications. During this design process, the objectives of the proposed solution were translated into actual features and functionalities; that is, logical designs. The designs are created using iterations adding to the functionality of the overall design model. To accomplish this, the spiral model is incorporated in the process as explained in section 3.4.

Logical designs serve as a construction against which requirements are plotted. They provide a mechanism for mapping relationships and possible interactions between components. Logical designs act as a concept layer between the design factors and the specific solutions, products and technologies. Furthermore, they allow the creation of a framework of the design without getting hung up in solution-specific or product specific details.

3.3.6 Demonstration

Activity 4 in design science research process model requires demonstration of the proposed artifact. To do so, a prototype may be implemented based on the integration concept. The purpose of the prototype is to show feasibility of the design model. The design model is presented to software engineering experts from the higher education sector. To present the model, the demonstration includes the steps of model development; that is construction of the model and drawing implications of the model to university management. In the demonstration phase, feedback on the major features of the model is provided. A survey is done with lecturers to determine the usefulness of the model in the learning environment. The feedback is added to the design model.

3.3.7 Evaluation

The design model is evaluated based on the criteria explained in the research proposal. The criteria are the output of the awareness of problem phase. Any deviations from the requirements elicited are explained. Section 2.6.2 describes technology acceptance model and task-technology fit models as evaluation methods for the software design model. The evaluation of the proposed design artifact is a crucial part of a design science research process (Hevner et al., 2004).

Technology acceptance model is described as an analytical framework (Losova, 2014). This concurs with design science research evaluation methods (Hevner et al., 2004). In this study, evaluation of design model is described in Chapter 5.

3.3.8 Communication of Research

Communication of design science research is very important. This thesis acts as a communication tool when written as per design science research guidelines (Gregor & Hevner, 2013). The study also makes a case for its knowledge contribution since the aim is to make an improvement on teaching and learning (developing new knowledge/solutions for known problems) (Gregor & Hevner, 2013).

3.3.9 Research Methodology Validation

The research methodology developed in this chapter is summarized and evaluated against the seven DSR guidelines suggested by Hevner et al. (2004). These guidelines are elaborated on in the following subsections.

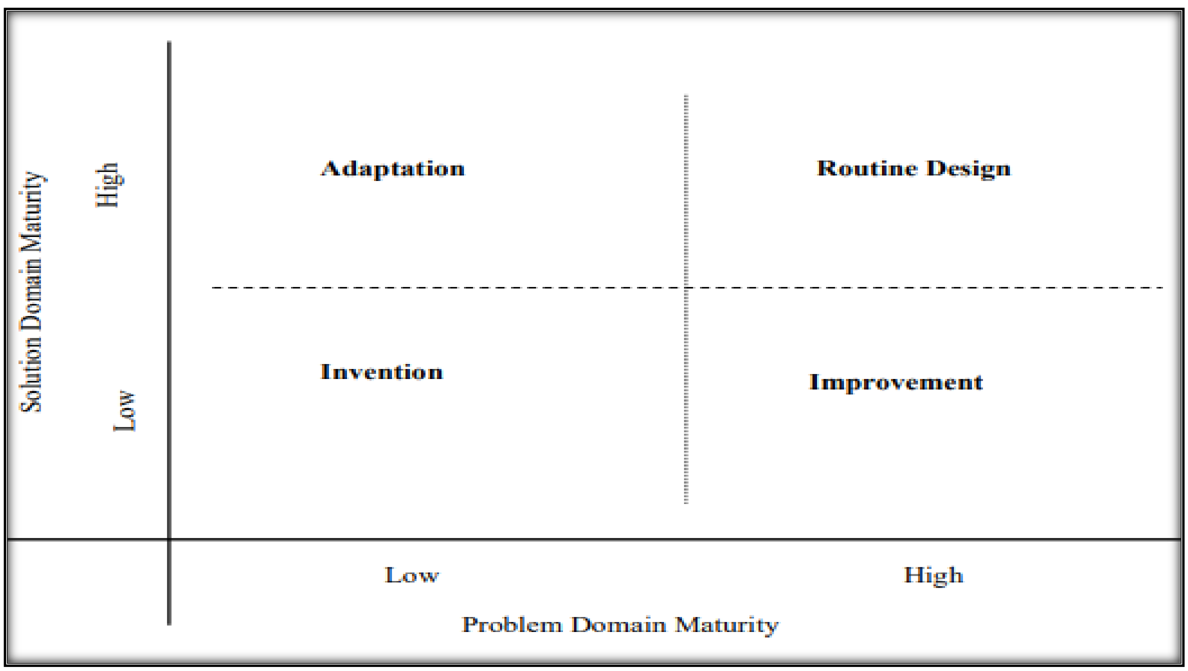

Figure 3-5 Design Science Research Knowledge Contribution Framework

Gregor & Hevner (2013)

Guideline 1–Design as an Artifact

Under this guideline, the output of a design science research project should be some form of artifact in the form of a construct, a model, a method, or an instantiation (Kotzé, van der Merwe & Gerber, 2015). The resulting artefact in this study is an integrated design model. Artifacts constructed in design science research are rarely complete information systems that are used in practice (Prat, Comyn-Wattiau, & Akoka, 2014). Instead, artifacts are innovations that define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, and use of information systems can be effectively and efficiently accomplished (Hevner et al., 2004). The aim of this research was to automate the process of uploading learning content.

Guideline 2–Problem Relevance

The objective of design science research is to develop technology-based solutions even to education environments. The objectives addressed the main research question which identifies the designs for integrating learning management systems in Zimbabwe. Steps were taken to achieve the objectives, including developing requirements specifications. To determine the requirement specifications, I solicited advice from fifteen software engineering experts (see Chapter 1 section 1.6).

Guideline 3–Design Evaluation

The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods. Rigorous evaluation of an artefact (Hevner et al., 2004) is of importance. The authors further suggest five evaluation methods that can be applied in Information Systems design science research. The context of the evaluation is given by the environment which the artifact operates in, and the proposed artifact should integrate into the environment. Of the suggested evaluation methods, technology acceptance model and task-technology fit were chosen as analytical evaluation frameworks.

Guideline 4–Research Contributions

Effective design science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/ or design methodologies. Three contributions that can come out of a design science research project are the design artefact itself, addition(s) to the foundations of design science research or methodologies (Hevner et al., 2004). Based on the reviewed literature in learning management systems and massive open online courses, opportunities were identified to improve and advance the concept of digital content by combining the two technologies. The contribution of this research is an artefact that provides automated means to access learning content. The contribution is discussed in more detail in Chapter 1 section 1.5.

Guideline 5 Research Rigor

Design science research relies upon the application of rigorous methods in both construction and evaluation. In summary, using the research pyramid as guideline to establish a research methodology, in combination with design science research guidelines and process model, presents a complete research methodology to address the research question. Design and construction of the artefact, the design model, is described in Chapter 4. The design model is based on relevant literature in the fields of educational technology and digital learning platforms. Evaluation by technology acceptance model and task-technology fit model are accepted methods in the respective reference disciplines (design science research and Information Systems disciplines). The spiral model used as a technique in this study also presents one cycle view of the problem solving process. The deternimation of objectives, alternatives and constraints on the spiral model helps in the understanding of solution alternatives which improves design science research.

Guideline 6-Design as a Search Process

Design science research is an iterative process to find an effective solution to a problem. This involves the use of knowledge base in the respective reference disciplines. Chapter 2 presented a selection of literature that was reviewed for this research, and the contribution of this research. Chapter 4 continues the search process by deriving design objectives from literature. These objectives are transformed into logical design components. In chapter 5, the design model is evaluated.

Guideline 7-Communication of Research

The results of design science research projects are interesting and relevant for both university management and software developers. However, those audiences have different perspectives and information requirements. As this research is a PhD project, this thesis is the main piece of communication and are targeted towards an academic audience.

3.4 Research methods

A research methodology is an overall framework which must be completed with concrete methods that define how a study is conducted. The choice of methods develops from the selections made on levels above, according to the pyramid. There are several research methods applicable to design science research in Information Systems (Hevner et al., 2018). The method of particular interest here are both quantitative and qualitative views, arising through spiral interactions (set goals, risk analysis, unit development, assessment, evaluation) with participants, connoting action research principles as well. In this work, spiral interactions follow the Boehm spiral model setup which emphasizes risk management (Boehm, 1998). Each cycle of the spiral Figure 3-6 is characterized by objectives of the artefact, alternative solutions and constraints executed on the application of the alternatives. Another step that follows, is the evaluation of the alternatives in relation to the stated objectives and constraints. The whole process helps to identify potential sources of risk. Should there exist any possibilities of risk, this may involve administering user questionnaire.

3.5 Research techniques

The fourth level of research pyramid contains information on tools used with research methods described in section 3.4. In this study, I used experimental design which is consistent with design science research (Hevner et al., 2004).

Chapter 4 describes experimental design in detail. In this study context, techniques refer to practical tools for generating, collecting and analyzing data.

3.5.1 Data collection

In design science research, which may also be referred to as a problem-solving strategy, the first activity is to establish clear goals of the artefact features being looked for. The purpose for data collection in this study was gathering requirements from potential users. These requirements were functional, technical, operational, social and economic.

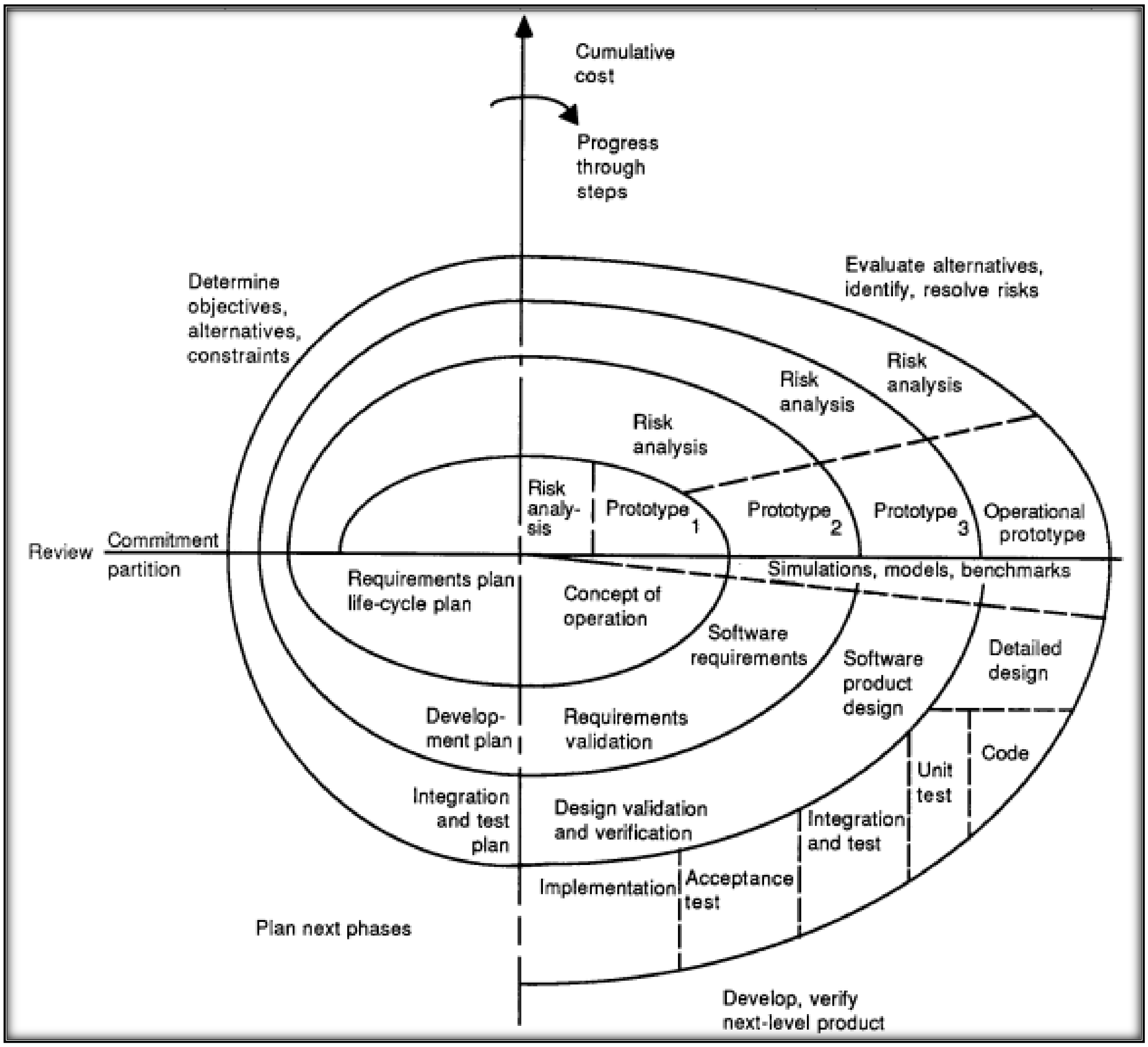

Figure 3-6 Spiral Model (Alshamrani & Bahattab ,2015)

The study, being survey-based research, lends itself to quantitative data collection and statistical analysis. However, it is possible in design science research to exploit both quantitative and qualitative data, depending on the goal and purpose of the research. The focus of the quantitative component of this study, was to report on technological requirements related to learning content, that lecturers and students desired to have.

3.5.2 Participants selection

The research was conducted in two main phases. In the first phase, the quantitative data was collected via an online questionnaire from 15 software engineering experts (see Chapter 1 section 1.6). Data was also collected from 28 lecturers and 15 students from non-computer related disciplines. The goal of this phase was to gather requirements which would be considered during the design of logical designs. Experts were requested to complete questionnaires. The designs were shown, partially for the first iteration. Software engineering experts were given an opportunity to express their views on the completeness of the first set of designs. Questions asked pertained to matching the rules of completeness against the provided diagrams. These data flow diagrams could be understood by the software engineering experts since they interact with such in their domain. Besides, questions asked, based on the logical designs, were around identifying missing elements or components from the diagram. In the second phase, quantitative data was collected using a questionnaire, from a sample of 117 participants, including those who participated in the first phase of the study. The goal of this phase was to evaluate the proposed design model.

3.5.3 Questionnaire

Data in this study mainly emanated from questionnaires distributed to practitioners, other lecturers and students. The first questionnaire (see Appendix A) was administered with software engineering experts to solicit achievable goals and objectives of the model, as well as risks and challenges. The second questionnaire (see Appendix B) was conducted with lecturers, soliciting known issues in the use of learning management systems and massive open online courses, including operational requirements, functional requirements, potential risks and challenges. The third questionnaire (see Appendix C) was administered with potential beneficiaries, that is students, to find social implication and any other user needs. The fourth questionnaire (see Appendix D) was administered to software engineering experts, lecturers and students for evaluation of functional component units. The questionnaire was chosen because of its practicality – it is the fastest instrument given time constraints, and is also cheaper to administer (Gupta & Taya, 2012).

The questionnaires consisted of sections where respondents identified levels of different variables using Likert scale. In the questionnaire, the researcher predominantly used an ordinal 5-point scale for all questions relating to respondent perception, attitude or belief. An ordinal scale made it simpler to convert responses into a percentage response rate. It is also best when researching a variable that includes preference and opinions such as in attitude scales. The questionnaire used such options as strongly agree, agree disagree, strongly disagree, among other five-point opinion preferences. Nominal questions were used to collect demographic details of participants. The survey research design was preferred since most recent and relevant data could be collected much quicker using this method.

3.5.4 Data Analysis

Respondents' data from questionnaire was analyzed. The main objective was to get statistical inference that would be used for model validation and hypothesis testing. Statistical analysis using Partial Least Squares – Path Modeling for validating the proposed software model was applied for model validation. From the partial least squares – path modeling analysis, the hypotheses that stated relationships between variables in the proposed acceptance model were tested. The steps involved in data analysis are described intensively in Chapter 5.

Statistical Package for Social Scientists (SPSS) software was used to analyze the quantitative data. For likert-scale statements, the means (in some cases) were calculated. Due to the small sample size, Mann-Whitney U test and Kruskall-Wallis test was applied to the quantitative data. Chi-squares test of association was used to investigate any association between two different sets of observations or variables. Analysis of data from experiments was mainly descriptive. Qualitative data obtained from the open questions was analyzed for themes that emerged, which were coded. Thematic analysis was used to analyze each response from the requirements elicitation phase. In analyzing open-ended questions, the researcher first read through all the responses per given question and identified themes, then assigned codes to these, before finally tabulating the codes, just like for the responses in closed-ended responses.

The results from the data analysis and evaluation were repeated from a broader perspective and used to explain the outcomes of the research; related to the literature review, the proposed framework and the research model. The results were also used to test the hypothesis and validate the models. In chapter 7, some conclusions are drawn from the present study in addition to answering the research questions as presented in Chapter 1 section 1.4.

3.5.5 Validity, Reliability and Rigor

Technological improvements to teaching and learning respond to fast changing Information and Communications Technology facilities nowadays (Johnson & Christensen, 2008). Action research on e-learning solutions to teaching and learning challenges in Zimbabwean institutions is thus; indispensable (Derntl & Motschnig-Pitrik, 2004). The study ensured reliability and validity of the proposed designs through iteratively repeating evaluations and assessment by practitioners (connoting technical action research) (Wieringa & Morali, 2012). Opinions from experts in software engineering regarding potential design models to follow, system requirements and specifications, as well as probable component units and sub-systems to consider in the proposed design model, all added rigor.

Validity is ensured when the final product undergoes technology acceptance and adoption evaluations. Validity is also broadened when we spirally review the objectives of the model and manage potential risks now and again. Reliability is realized when the proposed model is evaluated under conditions of practice by experts and practitioners in the field. In my view, such expert intuition (Hillston, 2003), where software engineering practitioners repeatedly reviewed the proposed model designs, made suggestions, and provided feedback for improvements (Denzin & Lincoln, 2005), strengthened the validity, reliability, rigor, and consistency of the findings, and consequently of the model designs. Additional reliability was found in using previously established methods and processes for assessing acceptance and adoption (Hevner et al., 2004).

3.6 Conclusion of the Chapter

The focus of this chapter was on the research design and research methodology used in this thesis. The research pyramid was used as a high-level framework. Design science research was the paradigm chosen for this research, and was in accordance with the reviewed literature (e.g. similar to works presented in (Hevner et al., 2004). This was a suitable approach to investigate problems in the domains of Information Technology and Information Systems. The methodology was particularly suitable for resolving the integration of a learning management systems and massive open online courses on a digital learning platform.

The paradigm, in combination with design science research process model, outlines the individual research activities and ensures a rigorous research process. The title of the thesis identifies as focus area, design of an artefact and implications on institutional operation, precisely university policy. Therefore, design science research in Information Systems was selected. The first research question pointed to a design science research cycle. The research steps described were problem identification, objectives definition, design and development, and evaluation. Outcomes of the development in one sub-cycle initiates new awareness and the start of a following sub-cycle. A detailed description of the design research activities follows in Chapter four.

Chapter 4

Design model

The problem of designing a software model for integrating learning management systems with massive open online courses for automated content uploading and sequencing is an issue that needs careful attention. In order to address this integration problem, a conceptual data flow approach was employed. A conceptual data flow approach basically shows the relationships that exist among elements in a particular system (Hoffer, 2012). In this study's context, the conceptual data flow approach describes the different entities and content repositories of the proposed integrated system, and how the content is handled among learning management systems and massive open online courses content repositories.

In designing the software model, the researcher elicited requirements which became the building blocks of the integrated software design model. In that regard, the researcher established the completeness of the software design model by testing all designs, based on four metrics, namely; completeness, scalability, consistency and complexity. In this context, completeness refers to the degree to which functions employed through the designs cover specific stakeholder objectives, and is measured by missing requirements if any, as well as inconsistences with the modeling techniques used. Scalability refers to the ability of the integrated design model, when implemented, to sustain workload, and is measured by amount of content collected when designs are implemented. Contrary, consistency talks of no contradictions (Mohagheghi & Dehlen, 2009) in the software design model, and is measured by a description of the characteristics of the software model components. Complexity accounts for the degree of connectivity between entities in a software design model. We measure complexity by a total analysis of the component designs. The software designs are tested in iterations since it is important to make sure the necessary requirements are obtained early enough in the process' initial stages.

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This chapter starts by presenting the explicit statement of the problem which is drawn from the main statement of the problem of the study (see Chapter 1 section 1.1). Particularly, preliminary designs are produced from analyzing the learning content related activities among lecturers and students. The researcher further elicits more requirements through experimental design in order to validate the proposal designs collected from software engineering experts. The procedure for validating those preliminary designs is outlined in this chapter. Software engineering experts are engaged to review the finalized and jointly developed designs to ensure that all the requirements are met. The descriptions provideD of these designs are in line with Institute of Electrical and Electronics Engineers' (IEEE) definition of software design reviews (Laplante, 2017). It is stated that the reviews comprise a formal forum at which an artifact's preliminary designs are presented to the users, customers, or other concerned parties for comment or approval.

The purpose of the proposed preliminary designs is to ensure that the requirements elicited are shown and represented in the model, as well as to evaluate the value. Furthermore, preliminary designs give an overall bigger picture, which are the ultimate complete designs. The same software designs yielded, require validation and analysis upon which conclusions are drawn.

4.1 Statement of the problem

The statement of the problem introduced in chapter one emphasized resolving the design problem to integrate learning management systems and massive open online courses on a selected digital platform. This chapter focuses on a sub-problem to the main problem; the problem of coming up with the proposed logical designs of the proposed software model. The statement of the problem further identifies the major components of the proposed software model. Sub-systems and the component units of the integrated learning management systems and massive open online courses on a digital learning platform are identified, designed, and integrated towards establishing the implications of the software model to policy and practice in Zimbabwean universities. This, in turn, would facilitate relevant content access by both the lecturers and students anywhere and at any time.

The problem of providing designs for a software model stems from an understanding that learning environments require adequate feeder systems for relevant content. This feature can, possibly be brought about by integrating different learning management systems and other platforms. Stakeholders from universities (including lecturers and students) would then effectively interact with relevant content, automatically uploaded and logically sequenced, for deep engagement and retrieval. The expectation is that the proposed designs will bring simplicity to implementation challenges, and user friendliness of the technologies thereof, and accommodate acceptable requirements from stakeholders.

4.2 Preliminary designs

This section presents the preliminary designs of the proposed software model. In this study's context, preliminary designs are data flow diagrams and entity relationship diagrams. The same are referred to as designs. To begin the design process, preliminary designs are created with the objective of obtaining detailed reviews of the design concept expressed as data flow diagrams and entity relationship model. These reviews are sought from software engineering experts.

The first stage in producing the preliminary designs is usually referred to as conceptual design. These are high-level designs (Jackson, 2015). During the preparation stage of these preliminary designs, the high-level designs are created, including context diagrams. Preliminary designs progress by breaking components of the context diagram into sub-systems and focusing on the sub-parts that make up the integrated system.

After breaking down the context diagrams into lower level sub-systems, the researcher puts together rules and integration approaches that assist in providing the solution to the stated integration problem. In software engineering terms, the preliminary design requirements are used to check if the requirements have been fulfilled against the designs. Requirements elicitation is carried out regarding lecturers' and students' needs. Since the designs involve a software model, attention is given on the overall performance of the resultant designs. Designing this model is an iterative process as shown in Figure 4-1, where I thoroughly

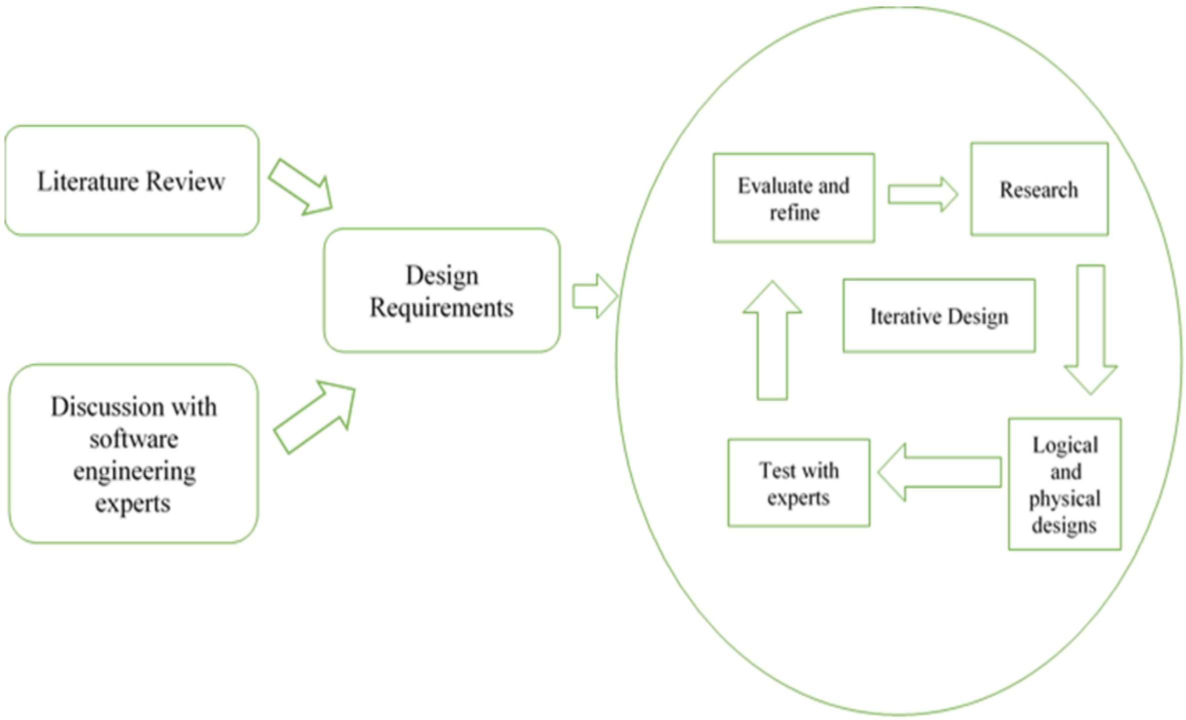


Figure 4-1 Research process

observed possible solutions and discarded unfit solutions or ideas from software engineering experts or engaged stakeholders.

The preliminary designs outline the design model components and their interfaces. They should be able to trace between requirements and designs. The designs are reviewed by software engineering experts for completeness. The reviews from software engineering experts warrant progression from the preliminary designs to detailed designs that meet the specified requirements. This phase of the study defined the design constraints and the ultimate design model.

A preliminary survey was carried out to evaluate the designs based on the information given by the stakeholders who would benefit from the proposed deliverable. The designs were reflective of the requirements gathered from stakeholders which were collected during the proposal phase of this study. The purpose of the survey was to obtain feedback regarding the completeness of the designs' requirements for the proposed model; providing a basis for developing the guidelines for the model development.

The survey elucidated the requirements used to modify the mind maps towards obtaining an overview of the revised design model as shown in Figure 4-1. The survey made available, data which responded to the first research question presented in Chapter 1 section 1.4. Ultimately, the design model aimed to support lecturers with the capacity to automate content uploading, sequencing and updating of existing repositories.

4.2.1 Research process Flow chart

The design process is divided into three phases; elicitation of requirements, development of logical designs, evaluation with software engineering experts.

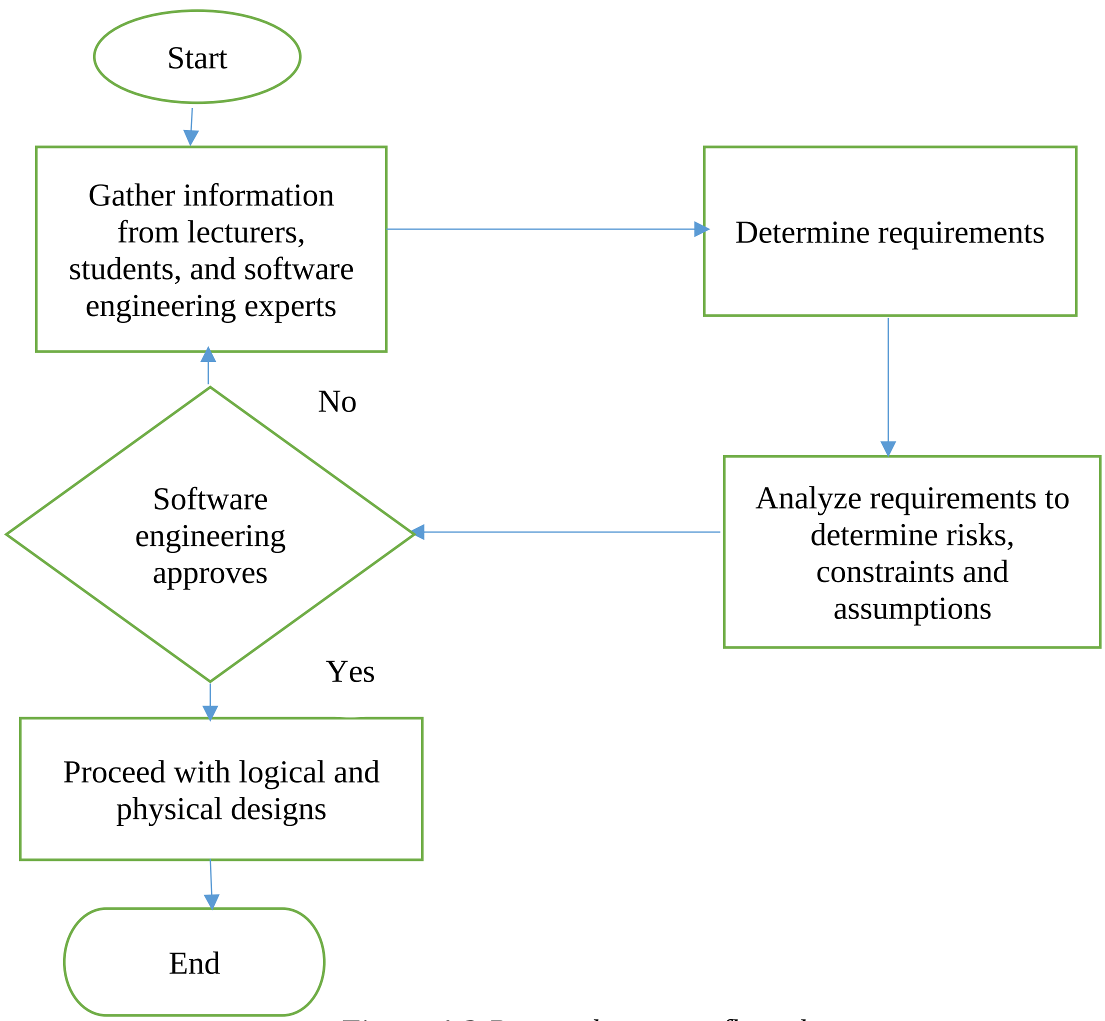


Figure 4-2:Research process flow chart

The design attributes were obtained first, after gathering information from potential users such as lecturers, students, university management, and software engineering experts as depicted in Figure 4.2. When software engineering experts agreed to the requirements, the process continued. Based on the results of the data collection phase, the study provided an analysis of the situation and described the potential needs of lecturers and students from the results of this exercise. These needs were recorded in a requirements specification document. These were the same requirements that were used later when the design model was implemented.

Based on the analyses of the feedback from the second and third phases, the requirements could be improved and modified based on the recommendations from software engineering experts. At this point, the recommendations were of great importance. Software engineering experts are experienced in determining whether requirements are valid or not.

4.3 Requirements elicitation

In this study, surveys accompanied with experiments were used to grow the understanding of stakeholders, their content related activities, and their learning environment. The survey also provided the requirements to obtain an overview of the design model from which Figure 4-3 emanated.

A questionnaire (see appendix A) was administered with software engineering experts to solicit achievable goals and objectives of the best design model (querying Joint Application Development and Boehm Spiral Model), technical requirements, units and subsystems, risks and challenges. The survey informed the initial understanding of some of the concerns and issues related to learning management systems and massive open online courses content repositories. The process of creating the software design model continued with a preliminary survey conducted with software engineering experts to elicit familiarity with the existing processes of learning management systems and massive open online courses designs, as well as current trends. The preliminary study formed the basis of the designs, with the overall aim being that of eliciting the requirements in terms of the need for the technologies that could improve the process of content uploading to learning management systems. Figure 4-2 depicts the overall approach the researcher took to address the design problem. The survey also provided a wider context in which to view integration of learning management systems.

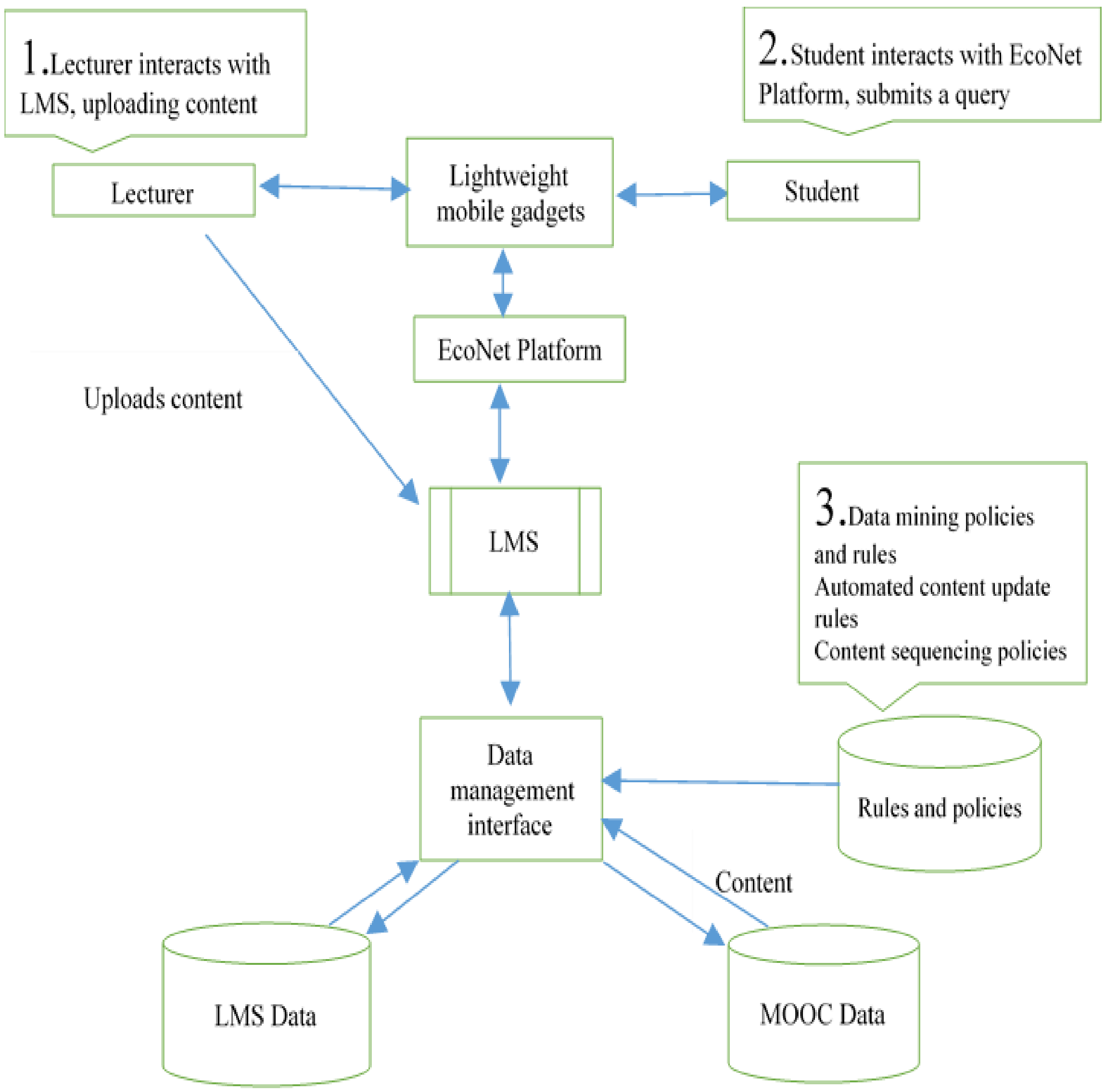


Figure 4-3 Preliminary design

4.3.1 Questionnaire with software engineering experts

A survey was conducted to establish the requirements from stakeholders. The major goal was to have an appreciation of their access to available resources, particularly the learning content, and possibly how they would want to benefit from the integration of learning management systems with massive open online courses. A questionnaire (see Appendix A) was used, which had structured questions in four sections: a) section one dealt with achievable goals and objectives of the proposed model, b) section two dealt with design process for the proposed software model, c) section three dealt with units and subsystems of the proposed model, and d) section four dealt with risks and challenges of system integration.

Section one asked questions about what thoughts experts had of the suggested objectives such as to facilitate the automation of content selection, uploading, updating and removing. Besides the objectives, experts were asked about what possible information extraction techniques existed for content filtering and sequencing. The researcher also sought for techniques used to retrieve information from content repositories. Subsection two of the questionnaire A focused on the software engineering methods that could be adopted for designing the integrated model. Since the attention of this chapter was on designing a software model, sub units of the software model were investigated. The component units and sub-systems were designed as integration plans were considered. The unit designs were presented to software engineering experts for throwing-away, modification or adoption. The outcome of this cycle were revised component units, answering the third research question which evaluated the extent to which the proposed model designs were accepted by practitioners in the software engineering circles and stakeholders around universities in Zimbabwe.

4.3.2 Software engineering experts' summary of responses

The questionnaire was designed with the participation of software engineering experts selected from State Universities.

Google forms were distributed via institutional emails (see Appendix A). The requirements were gathered so the needs were considered in design model development. All software engineering experts gave responses to the same questions, so they could provide varied responses as per their expertise. The results showed how much software engineering experts understood the design problem, particularly in the context of uploading content to learning management system and related technologies.

Software engineering experts were presented with objectives of the proposed software model (see Appendix A). The objectives spelt out what a design was meant to achieve. They described functional and non-functional qualities of a design model, guiding the design process. The software engineering experts commented that the proposed design model would widen the spectrum of shared knowledge, and that a wide range of courses and massive open online courses could be taken by many students simultaneously, and increase response time.

The experts indicated desire for a fault tolerant system, which is a cloud-based resource. Referring to Figure 4-3, experts highlighted that the presentation did not show the point that content producers would be many lecturers from different institutions. One expert said they thought the diagram should show that there were many e-learning databases that the mobile gadgets could query results from. The suggestions put forward were considered during data flow diagram creation. The data mining techniques software engineering experts spoke of were a description lightly used in this study to refer to automation tasks. Clustering techniques were an example given by expert as a preferred technique considered for software model.

The next question was about best approaches of integrating learning management systems and massive open online courses. According to their answers, experts mentioned that there was no need to keep massive open online courses on a separate database since it required queries to get the right data within the shortest possible time. To add to that, one response proposed choosing a multimedia format that could be managed on a large scale making a special mention of Hadoop ecosystem. Moreover, it was said data integration could cause system performance issues. Another suggestion was given of getting access to massive open online courses databases on run time, then integrate with learning management data.

To answer the question about which standards were needed for integration, standards link learning management systems with other learning systems were stated. This elucidated the impression of interoperability compliant which is a global technical standard for integrating learning applications. Generally, the ideal was, integration must be seamless, reliable, efficient and user friendly.

In response to the question what impact the standards have on the design process and the proposed model, one expert answered that knowledge of standards allowed different learning system components to work together. In their view, standards generate scope of design process, and when adhered to, they led to successful designs. Standards enable compatibility, allow repeatability, and create ease of maintenance and support. However, risks and challenges were noted and the potential of the integration process to fail owing to the problems inherent in integration. One expert also mentioned that the proposed design model risked poor content selection and presentation. Again, wrong expectations could emanate from the user's side. Further, there was also a risk of complete failure of the whole system. Another view was to consider human factors as well, i.e. the integrated system must be user friendly. Data synchronization and network failure were cited as potential challenges. Besides, when necessary or vital elements of the system are left out, that can lead to additional costs required to revise the design late in the development cycle.

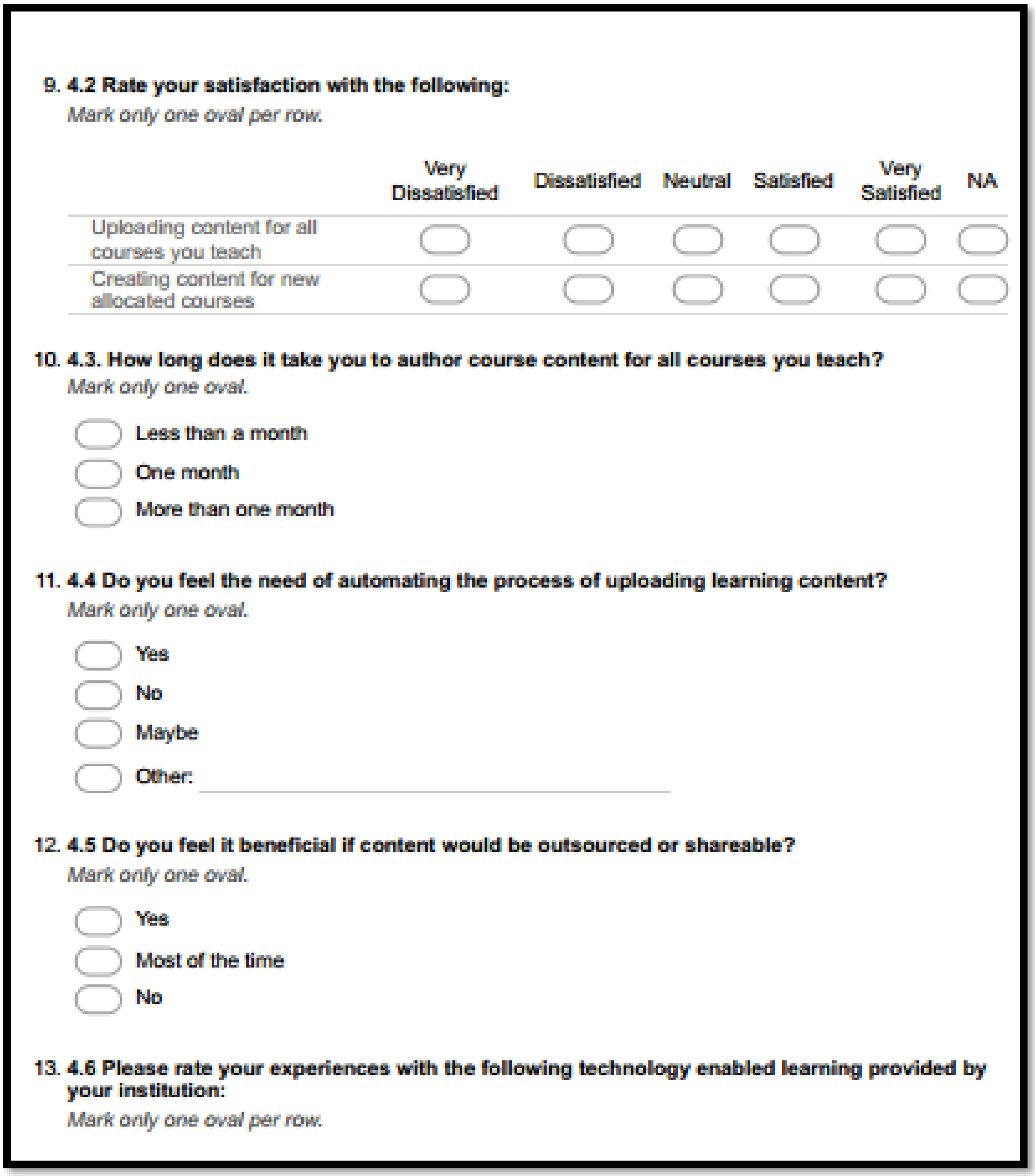
Among the methods suggested, included Joint application development, spiral model and agile principles. The last two sections (see Appendix A) were on units and subsystems of the proposed model, and risks and challenges of system integration. The questions posed required known or best approaches to integrate learning management systems with attention paid to subsystems of the integrated model. To achieve improved sharing of content and other learning resources, there was need to have information on standards applied to systems used in teaching and learning. Lastly, there was a question on risks and challenges of integrating learning management systems with massive open online courses. The software engineering experts gave their views on the issue.

The sentiments of software engineering experts on the first section of achievable objectives, was that the objective was good. A question was raised on whether it was still necessary to facilitate automation of content uploading, yet one service provider had that facility in the backend of their system. One participant agreed with others that automation saved time compared to traditional manual methods for as long as selection rules matched users' needs. The next section adds to requirements from lecturers' perspective.

4.3.2 Requirements from Lecturers

Requirements were elicited from lectures and students (see chapter 1 section 1.6) since they both interacted with content. Questions were asked in a survey questionnaire generated for lecturers. Participation was requested through email. The question had sections which included learning environment, teaching, learning, and technology use. As a way of obtaining qualitative data, each section consisted of questions in different formats, including a flair of open-ended questions to allow participants to freely express themselves. All questions were compulsory. Closed questions were provided to create some quantitative data. Lecturers and students were asked different questions since they had different roles in the learning management systems processes.

Submissions were anonymous, since email addresses were not collected. A sample google form from the questionnaire used for lecturers is shown in Figure 4-4. Further to that, a chi-squares test (see Chapter 3 section 3.5.4) was conducted to test if there was a relationship between lecturers' need for automation and their discipline. The null hypothesis for this test was that the need for automation and lecturer discipline was independent. The alternative hypothesis was that the need for automation and lecturer discipline are not independent.



9. **4.2 Rate your satisfaction with the following:**
Mark only one oval per row.

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	NA
Uploading content for all courses you teach	◯	◯	◯	◯	◯	◯
Creating content for new allocated courses	◯	◯	◯	◯	◯	◯

10. **4.3. How long does it take you to author course content for all courses you teach?**
Mark only one oval.

- ◯ Less than a month
- ◯ One month
- ◯ More than one month

11. **4.4 Do you feel the need of automating the process of uploading learning content?**
Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ Maybe
- ◯ Other: ____________________

12. **4.5 Do you feel it beneficial if content would be outsourced or shareable?**
Mark only one oval.

- ◯ Yes
- ◯ Most of the time
- ◯ No

13. **4.6 Please rate your experiences with the following technology enabled learning provided by your institution:**
Mark only one oval per row.

Figure 4-4 Google Form Lecturer

The results on Table 4-1 revealed that the p-value[1] was 0.858. Since the p-value of 0.05 (95% confidence) for degrees of freedom equal to 6 and our chi-squares statistic value 2.593, is lower than 5.99, we do not have sufficient evidence to reject our null hypothesis stated above.

[1] p-value is a probability distribution which gives the probability of all possible outcomes if the null hypothesis is true. In this case we take the standard accepted level of significance to be 0.05.

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So, we retain the alternative hypothesis which says, the need for automation and lecturer discipline are not independent. Hence, we conclude that, there is a relationship between the need for automation and lecturer discipline. Lecturers who are more technical are seemingly more interested in automation than their counterparts in arts and social sciences.

Table 4-1 Automation need

Automation need * Discipline Crosstabulation

Count

		Discipline				Total
		Humanities	Creative Art and Design	Business	Engineering and sciences	
Automation need	yes	4	1	5	14	24
	no	0	0	0	2	2
	maybe	0	0	0	2	2
Total		4	1	5	18	28

Chi-Squares Tests

	Value	Degrees of freedom	p-value
Pearson Chi-Squares	2.593 a	6	.858
N of Valid Cases	28		

4.3.3 Requirements from Students

Students were asked about tools they wish their instructors would use in the learning environment. An example is depicted in Table 4-3. Students who owned android smartphones wished their instructors used e-books more, so they could engage with learning content. The applications based on integrated model designs should run on lightweight devices hence device use, and ownership were to be ascertained from students. Table 4-4 shows that a third of the participant did not use tablets for their studies; and Table 4-5 illustrate great usage, just above 50%, of smartphones by students for almost all of their courses.

Table 4-2 Community service E-books and Smartphone

E-books * Smartphone Crosstabulation

		Smartphone			Total
		Android phone	Windows Phone	Other	
	Don't know	2	0	0	2
Ebooks	4	0	1	0	1
	more	4	0	2	6
Total		6	1	2	9

Table 4-3 Device use and ownership -Tablet

Students who owned and used a Tablet

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not use	4	33.3	80.0	80.0
	Used for about half courses	1	8.3	20.0	100.0
	Total	5	41.7	100.0	
Missing	System	7	58.3		
Total		12	100.0		

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Table 4-4 Device use and ownership - Smartphone

Used smartphone

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Did not use	1	8.3	10.0	10.0
	Used for at least one course	3	25.0	30.0	40.0
	Used for all	6	50.0	60.0	100.0
	Total	10	83.3	100.0	
Missing	System	2	16.7		
Total		12	100.0		

Table 4-5 Web based content

Web based content

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't know	1	8.3	11.1	11.1
	less	1	8.3	11.1	22.2
	2	1	8.3	11.1	33.3
	3	1	8.3	11.1	44.4
	4	2	16.7	22.2	66.7
	more	3	25.0	33.3	100.0
	Total	9	75.0	100.0	
Missing	System	3	25.0		
Total		12	100.0		

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Table 4-6 Access Content

Accessing content

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	service not offered or not functional	3	25.0	27.3	27.3
	Fair	1	8.3	9.1	36.4
	Good	6	50.0	54.5	90.9
	Excellent	1	8.3	9.1	100.0
	Total	11	91.7	100.0	
Missing	System	1	8.3		
Total		12	100.0		

Table 4-7 Smart phone and Content access

Smartphone * Accessing Content Crosstabulation

		Accessing Content				Total
		Service not offered or not functional	fair	Good	Excellent	
Smartphone	Android phone	2	0	6	1	9
	Other	1	1	0	0	2
Total		3	1	6	1	11

Chi-Squares Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Squares	6.519[a]	3	.089
N of Valid Cases	11		

Learners do have a technology experience in their University experience. For learning to effectively take place, the ideal scenario is to have students and lecturers use the same resources. Students were asked the resources they wished lecturers would use. The results as illustrated in Table 4-6 pointed to open source content such as Khan Academy, as resources that students wished their lecturers used more.

Table 4-7 shows students who were satisfied with the institution's learning management system and owned smartphones. The chi-squares value of 6.519 shows there is a significant relationship between device ownership and use of e-learning platform.

The final question asked about other requirements. Students were to give other requirements in relation to accessing content on the existing e-learning platforms. Most participants did not give responses to this question. This could be due to the subject matter being a bit technical for non-technical students. However, among the comments received, one student highlighted the need for the e-learning system to be integrated with the student information system. Another comment was that the student felt the need for the system to be improved so that lecturers could be able to post information on time.

4.4 Requirements specification

An informal initial definition of users' needs was gathered through survey questionnaire with software engineering experts' lecturers and students. These requirements form the basis for the logical designs. The data obtained from the questionnaires was organized into groupings. The purpose of the procedure was to infer the groupings into functional and non-functional requirements. The results formed the basis of qualitative input used by the researcher in designing the integrated design model. The structure entails mapping user requirements and the integrated design features.

1. Purpose

Institutions of higher learning, such as universities, have an option of implementing content repository-based technologies to facilitate teaching and learning. The integrated design model provides a case for learning systems to be used together to ultimately enable learners to engage more with relevant content. The queries that students make provide a basis for creating another content repository to benefit more learners.

2. Intended audience

From the data collected, the researcher noted that issues of content uploading are of concern to lecturers and students. The integrated designs, when implemented, would possibly improve the teaching and learning experience of the same.

3. Description

The integrated design model is an arrangement of learning content resources grouped together. The content resources are linked together as they are able to communicate with one another. Methods and processes of how automation takes place are offered in the design model. The design approach used in this study helps the researcher to focus on the elements of integration.

4. Design model view

Since Universities are meant to change to the innovative demands of education (Cycholl, 2015), the design model is used as fundamental to other process stages in implementing the data flow diagrams. Generally, the stakeholders were of the opinion that the model is scalable, possibly cloud based, with fault tolerance. The specific detail of the model encompasses two interface elements; one for query processing, the other on the repository communications end. The architecture of the design model is derived from data flow diagrams and the relationship among them.

5. Software design model functions

Students should access content from a learning management system. The content would be gathered from different massive open online courses. Learning content based on the user query should be delivered, and the content forms a new creation of a massive open online courses repository based on user requested information. The use of lightweight devices to access content enables learners to access content anytime, anyplace, in the right formats.

6. Operating environment

The design model should allow for scalability considering massification in institutions of higher learning. Access to content should increase, be flexible, and help more learners. Educational technologies are dynamic; the model should be integrable, allowing for additional features.

7. User environment

Users of the implemented designs comprise of software developers and university stakeholders. The users should have some familiarity with e-learning systems, and knowledge of the policies. Users need to be knowledgeable about the query-based search and content uploading.

8. Design/implementation constraints

At this point, in this study, the main challenge was to get the stakeholders to understand the application of designs in the education realm. The participants wanted to implement the designs on more fault tolerant, cloud-based platforms. Choosing a multimedia format that can be managed on a large scale.

9. Assumptions and dependencies

The design model improves the teaching and learning experience.

10. External Interface Requirements

The model is dependent on technology. Issues concerning learning content standards as well as learning management systems are examined.

11. User interfaces

The user interfaces are divided into two, query management and repository. Users should be able to access content from their devices without having some software installed on their devices.

Query management interface

This is described as a user interface with capabilities to forward queries to repositories upon successful location of a repository. The developers can provide a usable template for query management.

Repository interface

The designs should present automated retrieval of content within the confines of the submitted user query. There is need to constantly monitor technologies.

12. Communication protocols and interfaces

Since there is interaction among learning management systems and massive open online courses repositories, there are cross repository links which are created to achieve automation of the content uploading process. With the possibility of scalability, the communication protocols and interfaces for content that is relayed over the internet could be based on Kafka for example, which delivers a shared mechanism between content repositories and content users. Other protocols that could be considered are SWORD (Simple Web-service Offering Repository Deposit) which allow content to be transferred between different locations.

13. Integrated design model features

Content Location

The designs should feature identification and selection of the massive open online courses with open access massive open online courses.

Content Delivery feature

The model should facilitate the sharing and extraction of learning content. There is need to facilitate the processes so queries can get the right data within the shortest possible time.

14. Automation of content uploading

"The system can be improved if information is posted on time (students)" (P4)

To improve on query turnaround time, the empty MOOC repository could be one where resources are not stored per se but rather referenced from other sources reducing the response time. As the number of content repositories increase, users can access the resources without facing network challenges.

15. Integrating with sub-systems

To provide learning content together with other data required by students, integration can be extended to other University systems. Results from the elicitation process show that participants would appreciate it if learning management systems and massive open online courses were integrated with existing university information systems.

16. Other Nonfunctional Requirements

The software model should assure a more engaging learning process through an enhanced content access process.

17. Standards

There is need to consider learning system standards that pertain to learning content access. Standards could give the scope of the design process, and when adhered to, they are often central to successful designs. The integrated design model should be based on standards which enable compatibility and create ease of maintenance and support.

4.4.1 Section summary

Data analysis for the preliminary survey reveals that the major stakeholders in university require an improvement in the learning content access. In most courses, learners may not obtain relevant learning content timeously. Therefore, the automation on the side of the lecturer would facilitate the provision of the needs of the stakeholders.

Most of the lecturers wish for a learning management system, preferably one that runs on light weight devices, which improves learner engagement as they interact with relevant content anytime and at anyplace.

4.5 Designing the model

A model is described as a concept of implementing a functional information system as referred to in chapter 2 section 2.1. Two iterations were done to create the design model. While the study began with abstract designs of the model, it transformed to consider the expectations of other users as well.

The designs generally reflect a group effort to designing an integrated learning system. The group of software engineering experts as well as university stakeholders could possibly be users of the system once the model is implemented. The designs were inclined to the responses submitted by survey participants. A brief explanation of the iterations is provided hereafter.

First iteration represents a conceptual design which was evaluated by software engineering experts. This was followed by logical designs evaluated by the same. The final design model was evaluated by all stakeholders in universities.

4.5.1 Logical designs -First Iteration

Logical design is a structural design of the model that gives as much detail as possible without confining the design to a technology or environment. The details of the techniques used to satisfy the requirements are spelt out at this stage. In this study, the logical designs are diagrams that show the relationship between model entities.

4.5.2. Data Flow Diagrams

To carry out a breakdown of the broad functions as highlighted in the problem statement, structured analysis was employed. This was a method used to represent the functions in a visual way. At this stage, a breakdown of functions is obtained. Each module for the integrated design is analyzed and further broken down into further detailed functions.

Designing the integrated design begins with the abstract idea of the design model. Varied designs are introduced in stages. To enable the researcher to do the design process, data flow diagramming is employed, which follows seemingly modest rules, for example, the rules system for content sequencing or content retrieval.

Data flow diagram is a technique that shows the flow of content within a learning environment particularly content repository. Data flow diagram has been constructed to represent an abstract view of the design model by presenting its processes, the entities it communicates with, and the data it stores. The squares box is used to represent external entities which are the learning repositories of the design model. The circle represents the design model process. The arrows show the flow of data from the entities to the central process. The output from this process is stored in the data store, represented by two parallel lines.

4.5.2.1 Level 0 diagram

Level 0 diagram shows the relationship that exists between the integrated design model and external entities, such as content repositories that relate directly with the design model. The level 0 diagram always has the main system at the center (Wiegers, 2014). In Figure 4-5, the entities of the model are shown. For example, the arrow pointing towards the process at the center represents requests made to the integrated learning systems.

4.5.3 Description of Entities

In level 0 data flow diagram, the student inputs a query and the system gives relevant, updated content as per student's request. Information is sought based on query passed through the query management interface. The query management interface is the main display where the lightweight devices begin accessing the system.

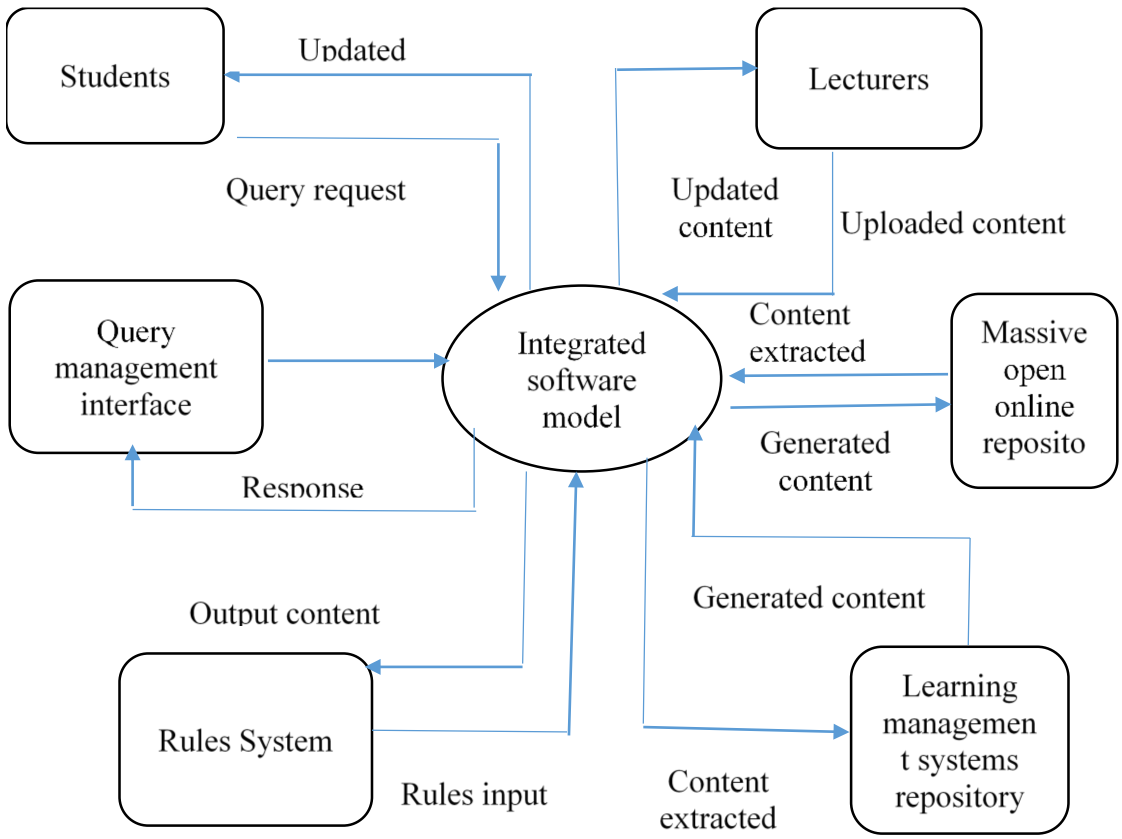

Figure 4-5 Level 0 DFD Diagram version

4.5.3.1 Student

Student entity defines all students who interact with content. The student submits a hybrid query request; that is, information they require from the repositories together with course information from their profile. The output from the model is then updated with new learning resources.

4.5.3.2 Lecturer

Lecturer entity defines content authors who upload content on the learning management systems platform. The aim is to automate content uploading, which complements lecturer generated content. Lecturers in turn, benefit from the updated content which includes access to content from the “empty massive open online course”.

4.5.3.3 Query management interface

The query management interface is a tool for performing, that enables students to express their queries, and the results are published through the interface via lightweight devices. As users search for learning material through the query management interface, results are obtained through massive open online courses connected to the learning management system repository.

The query management interface automatically transforms the query into the required format, and forward it to the repository interfaces. When the other processes of content identification and extraction are completed, then the content is downloaded from the repository.

4.5.3.4 Rules system

The rules are input into the model to manipulate learning content in a useful way. Most important, we focus on sequencing rules which regulate the ordering of content.

4.5.3.5 Learning content resources

The entity defines learning management system repository, open massive open online courses and a hybrid repository or empty massive open online course. The empty massive open online course is then produced from the queries made by students. Content is also extracted from learning management systems and open massive open online courses.

4.5.4 Decomposition of the sub-processes

The diagrams below show the various decomposition levels of the processes in the data flow diagram of the proposed integrated design model. In Level 1 of the data flow diagram, Figure 4-6, further explains how the automation process is given. As students and lecturers input query for content retrieval, the content extraction process takes place, which assists in retrieval of content from massive open online course repositories.

4.5.4.1 Level 2 Data flow diagram

In level-2 data flow diagram, the sub processes used in data extraction are described. The initial query submitted is analyzed in order to help to identify the topic or subject.

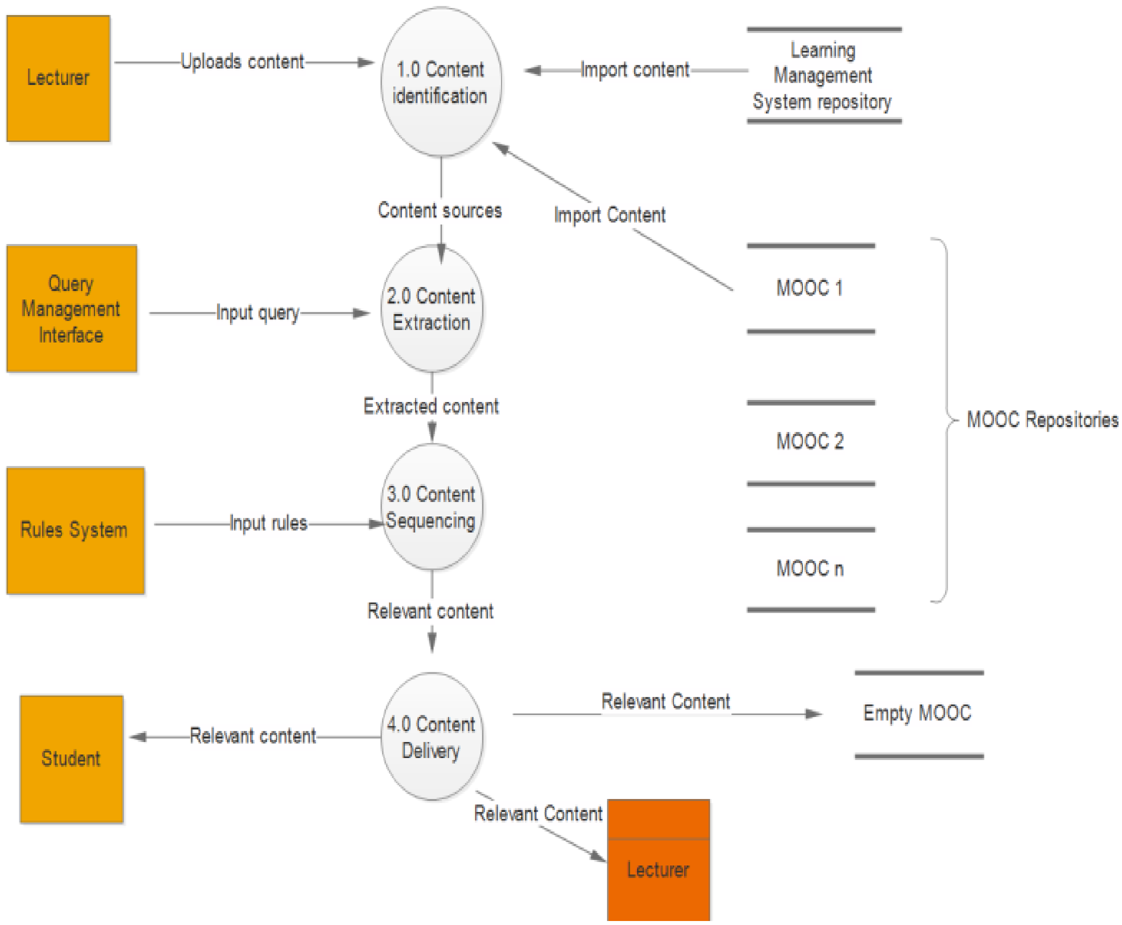

Figure 4-6 Level 1 Diagram

4.5.4.2 Content Identification

Figure 4-7 provides details about the identification and selection of the massive open online courses with open licenses that are available. The process can be automated.

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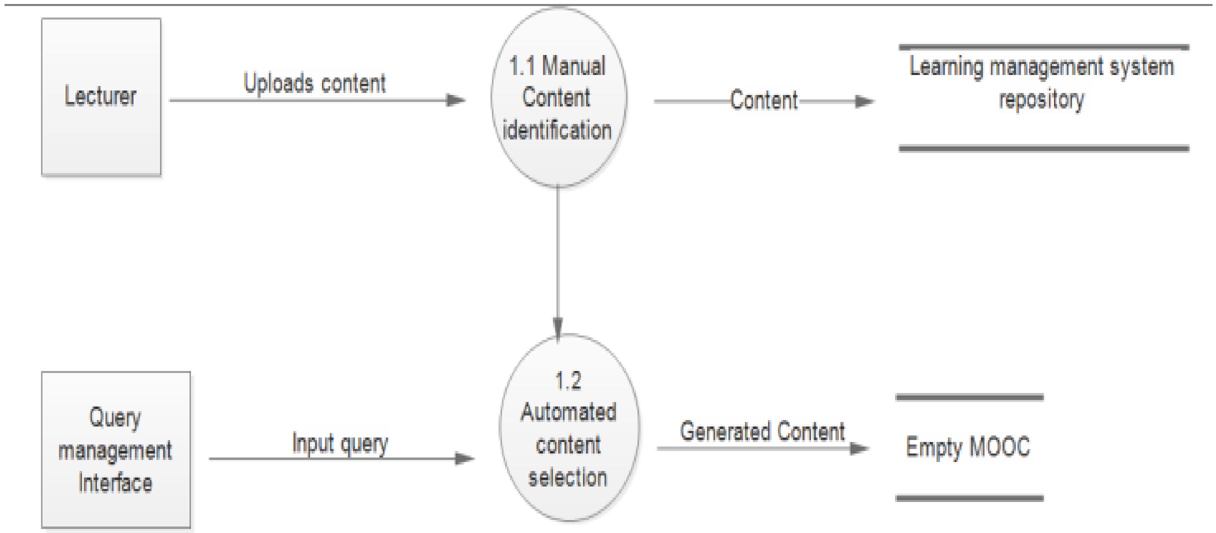

Figure 4-7 Content identification process

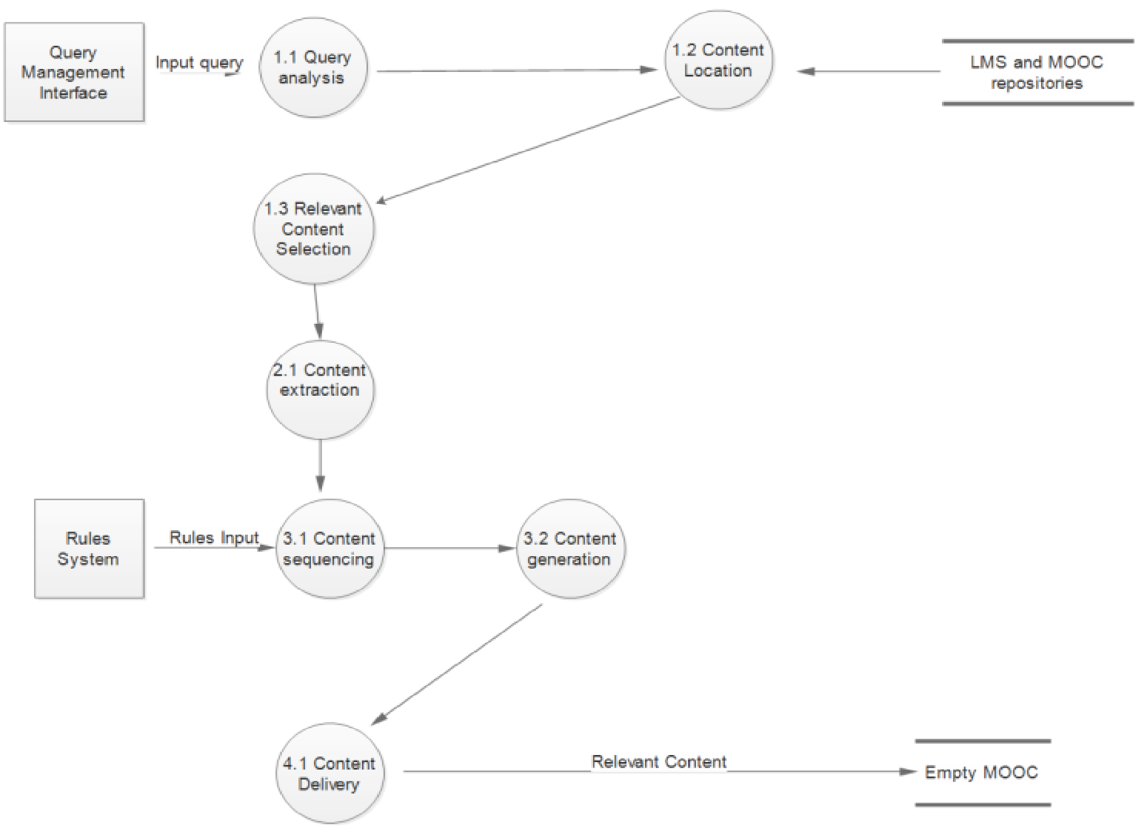

Figure 4-8 Query management interface

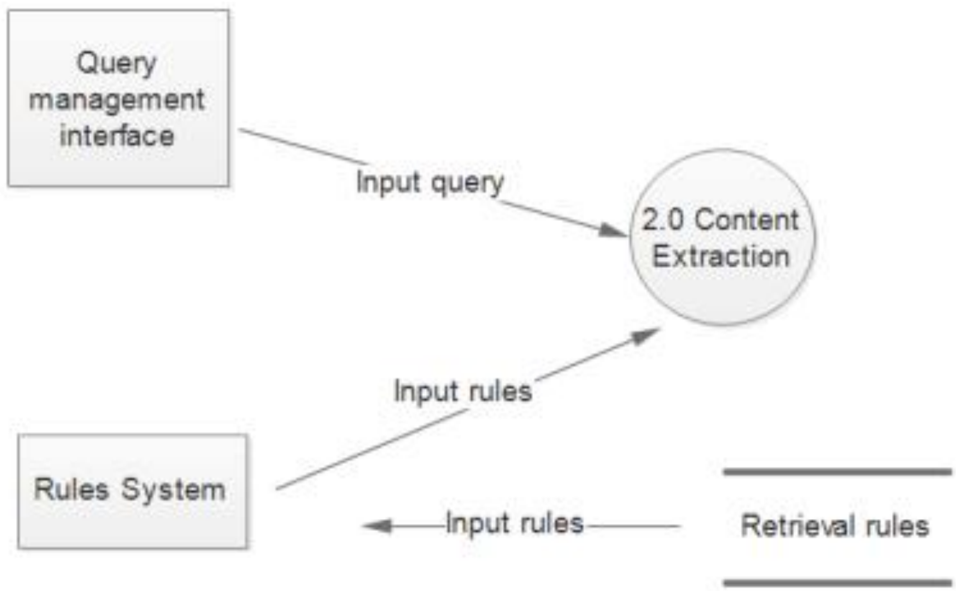

Figure 4-9 Content extraction process

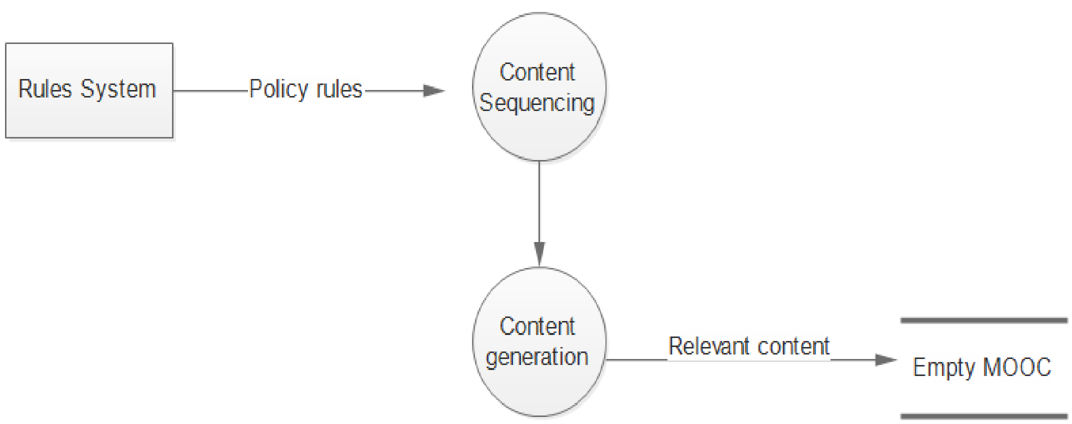

Figure 4-10 Content sequencing

4.5.4.3 Content Sequencing

Content sequencing rules adjust short term ordering of learning content (Gamble, 2014)**.** Rules and policies are required throughout the model to describe both how the design model is structured, and how it operates. In this study, sequencing rules are used by lecturers when embedding teaching strategies into learning content. The automation part in the integrated model is the way that the learning content will be sequenced in the integrated design model.

Figure 4-9 provides details about the content extraction process. It collects content from several massive open online courses' repositories; then, delivery is done to an empty repository. The extraction is rule-based; hence, the input rules from the rules system.

4.5.4.4 Content Delivery

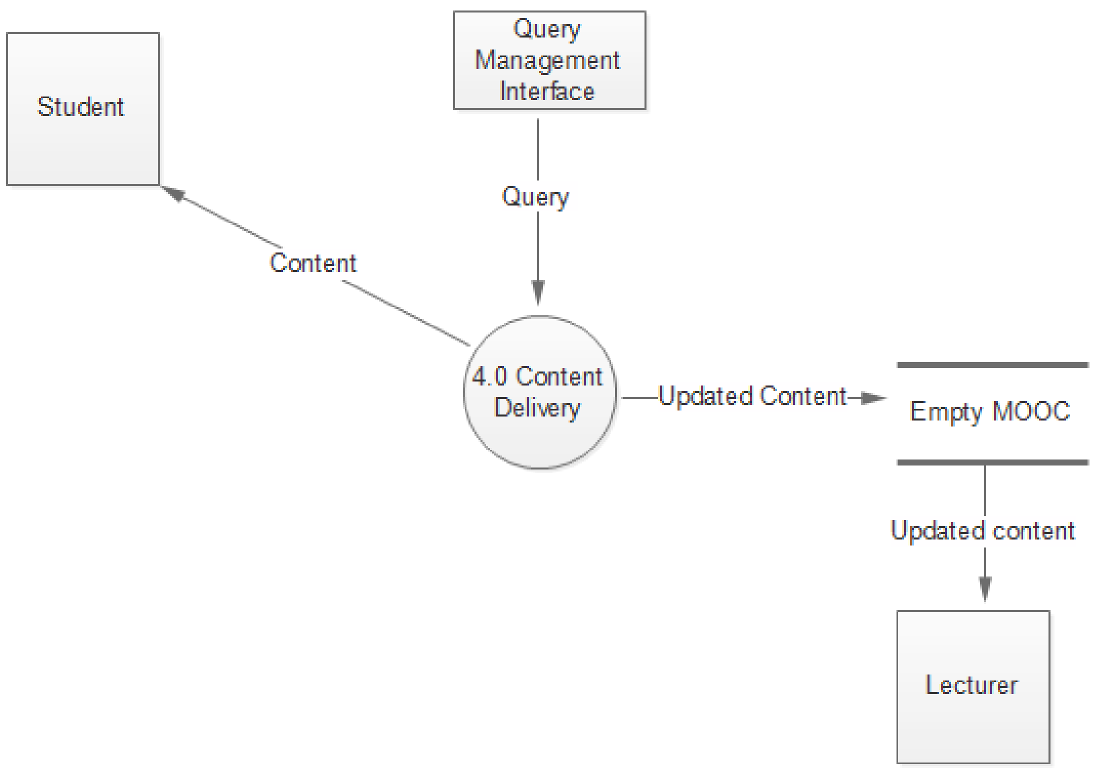

Figure 4-11 Content delivery process

In this study, the model should facilitate the sharing and extraction of learning content. In Figure 4-11, the data flow diagram shows the final processes for the automation of content uploading process. The empty massive open online courses repository overtime would have increased amount of knowledge regarding information on a particular subject. Subsequent users of the integrated design could retrieve information from previously accessed massive open online courses and learning management system resources.

4.5.5 Entity Relationship Model

Entity relationship modeling is a task that is done during the process of constructing a design model about a problem (Weber,2003). In this study, the problem is the design problem for integrating learning systems. Basically, the Entity relationship model is presented graphically, were the lecturers and student needs are presented.

The overall entity set is decomposed into sub entity sets. The first part describes the person entity and relationships with the integrated design model. The lecturer entity provides information about the content, its type and format. The student entities also have information about subject areas they usually seek information for.

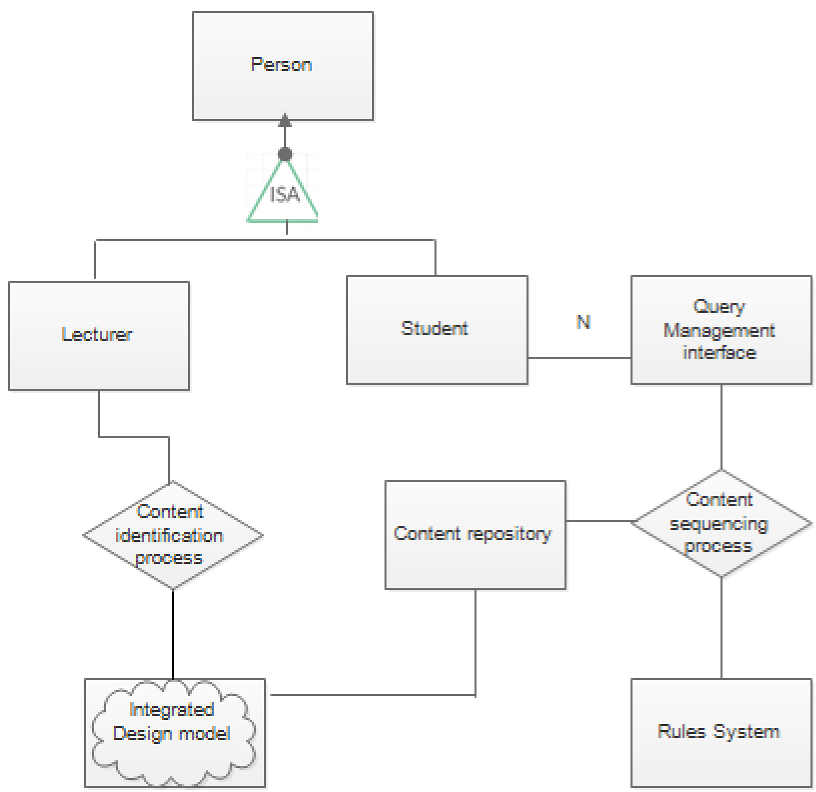

Figure 4-12 Entity relationship Model

The other part directly connects with the entities of system sub-components. The relationships between lecturer and content repository is one-to-many. This entity relationship model provides a high-level presentation of underlying principles of our designs. The content repository show that one repository can belong to several content; nevertheless, content cannot belong to many repositories.

As the integrated design model concept was expressed, the researcher found it necessary to evaluate the possibility of the study with regards to its practicability in learning systems. The software engineering experts had an appreciation of the architectural design; that is, the context diagrams provided during the first iteration. The full comments are provided in appendices. Data flow diagrams illustrated in section 4.7.2, provided the participants with an idea of how the final design model would look like.

4.6 Data flow diagrams and Entity relationship model validation

In line with the study's methodology, which combined design science research and software engineering requirements elicitation methods, the researcher engaged software engineering experts to assess completeness of the model. The outcome here are software designs, addressing the third research question; To what extent are the proposed model designs accepted by practitioners in the software engineering circles and stakeholders around universities in Zimbabwe.

4.6.1 Procedure for validating preliminary designs

In this section, experimental design is looked at to test the completeness of the designs. The researcher works on variables and finding whether the designs can be matched to the quality attributes. The analysis done on the data collected is used for hypothesis testing; hence validating the design model.

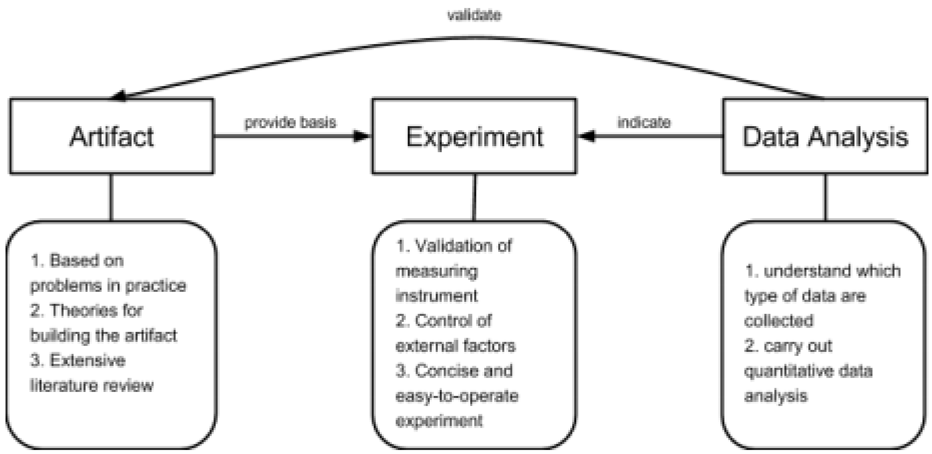

Figure 4-13 Experimental framework in Design Science

The overarching aim of experiment design is to obtain general knowledge about the design model. Therefore, the design process of the integrated model forms the basis of the experimental design. To increase the soundness of the experiment, the researcher used a questionnaire as an instrument to validate the designs. The factors that impact the process of the experiment were kept in check. The researcher aimed to have the experiment relatively easy to understand and complete. An analysis of the data collected from participants was made to ascertain the data type. Information gathered was then used to review and improve the designs (Ge & Helfert, 2014; Mettler, Eurich, & Winter, 2014).

4.6.2 Experimental design

The goal of the experimental design is to show the practical usefulness of the data flow diagrams and entity relationship diagram. The researcher aimed to evaluate the data flow diagram and entity relationship diagram using an experiment. Variables that explain the main aim of the study were defined. The experiment was conducted to quantify the variables complexity, consistency, completeness and scalability. To ensure that the design model fulfilled the requirements collected, hypothesis testing was used.

Data used for the experiment was collected using a questionnaire (see appendix D) Questionnaires used to collect data used in the experiment. The questionnaires included sections on how participants viewed the designs with regards to completeness, consistency, scalability and complexity. The metrics were first defined below in the context of this study.

4.6.3 Metrics for evaluating logical designs

The designs were reviewed for completeness, consistency, complexity, and scalability. In order to conduct the experiment, it was important to explain how the metrics could be used to achieve the goals of this study. Generally, the completeness factor entailed that a system covers all significant features. A software model is complete if it represents appropriate components of the teaching and learning environment (Batini & Scannapieco, 2006) .This is achieved by determining if the components in the diagrams define the diagram features. In this study, the researcher's description of completeness fitted well with international standards organization (ISO) (Basson, Bouneffa, Matsuda, Ahmad, Chung, & Arai, 2016) where focus is on the extent to which functions implemented through the designs, cover specific stakeholder objectives. The design model is meant to meet the requirements as per requirements specification. Functions deemed vital by the software engineering experts should be included, as well as the features to be included. To test for completeness, the software engineering experts were required to investigate missing requirements, if any, as well as inconsistences. The logical designs should present information as per requirements specification (see Chapter 4 section 4.4).

The learning environment is constantly evolving; hence, the need to test and verify a suitable performance of the learning systems and repositories such as increased enrolment, considering massification. The researcher adopted the robustness metric as it helped the stakeholders to become cognizant of the strong points and weak points of the designs and its components, and to manage them actively.

Supposedly, if the demand of learning content escalated, there was need to maintain a smooth flow of operations. The scalability factor was considered, meaning that in the event the demand of content increased, the system was not exhausted. The researcher's overview of literature showed that scalability was the capability of a system to sustain increased workloads. In this study's context, scalability referred to the ability of the integrated design model, when implemented, to sustain workload. Other metrics that could be considered for the logical designs were integrability and interoperability.

The logical designs of the design model should work with the other components. The integration approach characterizes the nature of the integrated design model. Integration from the designer's point of view requires the inclusion of content from various learning management systems. This integration is measured by the number of data conflicts with existing systems (Shahrokni & Feldt, 2013). Conflicts are, inevitable in this study.

The integration is administered by a requirements specification of the design model sub-systems' interactions. This is done to ensure a smooth flow of activities among learning management systems and massive open online courses.

4.6.4 A test for diagram completeness

Chapter 3 section 3.5.2 indicated participants for the evaluation of the designs. The study conveniently worked with software engineering lecturers who were willing to participate, to investigate the perceived completeness, scalability, consistency, and complexity of the logical designs for the integrated design model. The researcher tested whether the participants agree that the designs were complete, scalable, consistent, and complex. The hypothesis in section 4.7 corresponds with the research question about logical designs for the proposed software design model. This links to the question about the extent to which the proposed model designs is accepted by practitioners in the software engineering circles and stakeholders around universities in Zimbabwe.

4.6.5 Variable selection

In this study's experiment, the independent variable for hypothesis 1 and hypothesis 2 is the types of diagrams that we give to the software engineering experts. The dependent variables are the software quality metrics completeness, scalability, complexity, consistency, and the independent variables comprise the entities of diagrams. In this study, the controlled variable was the learning management system.

4.7 Experiment design template

Table 4-8 Experiment design template

Title: An investigation of data flow diagram, entity relationship diagram completeness		
Subjects		The completeness of the diagrams
Materials		Two diagrams
Variables Definition	**Dependent**	The parameters you measure completeness, consistency, scalability, complexity
	Independent	The diagram entities.
	Controlled	Software engineering experts
Hypothesis	**Null**	Null hypothesis H_0: There is no significant difference brought about by the design model presented to the value of learning management systems.
	Alternative	Alternative hypothesis H_1: There is a significant difference brought about by the design model to the value of learning management systems
The procedure		Software engineering experts give an opinion based on the questions presented.

4.7.1 Procedure

The material used for the experiments comprised data flow diagrams and entity relationship diagrams together with a guide explaining the diagram notation.

Experts were requested to complete questionnaires. The designs were shown partially for the first iteration. Participants were given an opportunity to express their views on the completeness of the first set of designs. Questions asked pertained to matching the rules of completeness against the provided diagrams.

For each set of diagrams, the researcher designed questionnaires with questions based on the metrics to be evaluated. The structure of the questionnaires was subject to the experiment. In addition, the questions were designed to measure the metrics as suggested by Beyer (2015). All completeness and scalability questions were picked based on certain criteria. They had to cover different features of the designs to a great extent. Software engineering experts were selected, assigned roles, and instruments for review were prepared. Based on the experimental design process, the instruments were shared with participants through google forms. The software experts checked the completeness of the designs as well as whether the requirements were met. The experts made suggestions on how to improve the designs

The questionnaire was distributed to the software engineering experts for the first iteration. The experts were asked questions which were mainly on the views of experts on the designs. The questions were around diagram completeness. The platform used to share the questionnaire was google forms. The responses were accessed electronically.

The first four questions were designed to test for completeness of the context diagram and to make an evaluation of the integration, complexity and consistency of the designs. Further to that, the reviewers were required to give opinions on scalability factor as well as possible areas that needed to improve. Questions in section one could be reinterpreted as “Are the diagrams complete as per software engineering standards?” In the same manner, the remaining questions; section three and four, required the same data as section one. Only the object of discussion differed.

4.7.2 Experiment work sheet responses

The researcher felt, the most important aspect of the responses were the suggestions for improvements on the present designs. The researcher took note of the suggestions, to make necessary adjustments or discard the suggestions. Expert views on the general designs showed that the logical designs were complete. One participant claimed the context diagram had all features. There were three participants who did not answer some of the questions.

They missed the questions where they were asked to give comments on the metric of the object under review. The same participants did not respond to the question on scalability of the designs as well as the question on suggestions of improvement. Probably, they could not suggest anything since they felt the diagrams had most features. One participant who responded on the scalability question, had no idea on what scalability was all about.

All participants responded to all questions that required them to express level of agreement to statements describing the diagrams. The researcher transcribed the responses in SPSS for easier analysis. To conduct statistical analysis on the results, the likert scale responses were converted into numerical values. The researcher altered the frequency scale; strongly disagree, disagree, undecided, agree and strongly agree, into numerical values 0 through 5. The section that follows presents statistical analysis of the responses gathered form the questionnaire.

4.7.3 Context diagram

The researcher used wide-ranging questions to ascertain the completeness of the designs. The questions were based on the metrics used to measure the attributes of the designs. In the following section, the responses are presented.

How would you rate the context diagram's completeness of features in describing the integrated design model to be developed?

The Mann Whitney U Test

Assumptions

The first assumption was that dependent variables were at least measured on ordinal scale or continuous scale. In this study, the dependent variables are data flow diagram completeness, consistency, scalability, and complexity. Second, independent variables should consist of two categorical, independent groups. In this study, it was level of education which had distinct groups: BSc and MSc. Third, there was independence of observations, which means that there was no relationship between the observations in each group or between the groups themselves.

Last assumption was that the Mann-Whitney U test can be used when your two variables are not normally distributed. Therefore, there was need to examine the distribution of independent variable, level of education (both BSc or MSc) to see if they had the same distribution by having histograms. If they have the same shape, it is ideal to employ the medians comparison of the dependent variable(s). However, if two distributions have a different shape, we can only use the Mann-Whitney U test to compare mean ranks.

Context diagram completeness

The researcher asked how participants rated the completeness of the context diagram's features. From question on diagram completeness, Figure 4-14 shows that the responses on question of diagram completeness was normally distributed for MSc, but for BSc, the responses were skewed (in fact negatively skewed). The mean could be used to test on differences in the Mann Whitney U test.

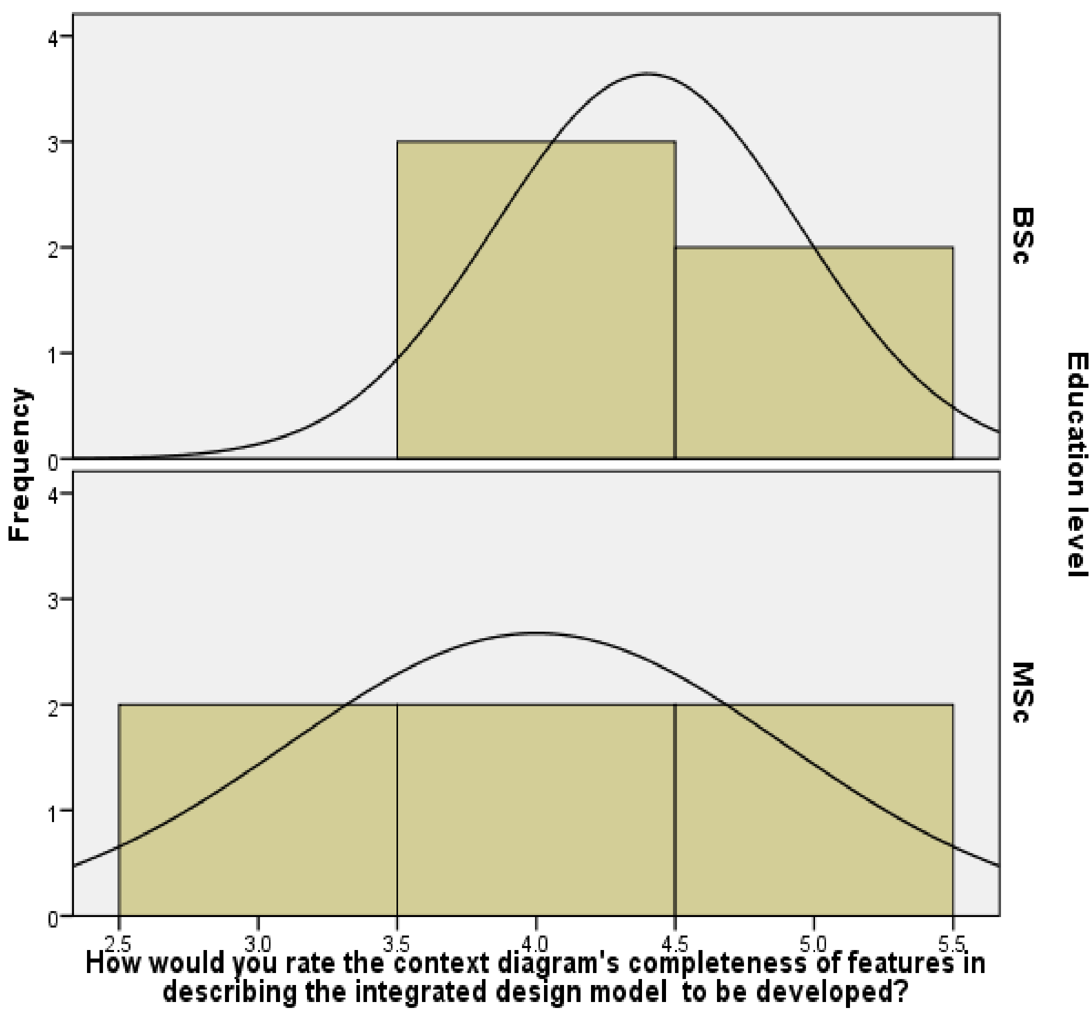

Figure 4-14 Context diagram completeness

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Context diagram functions

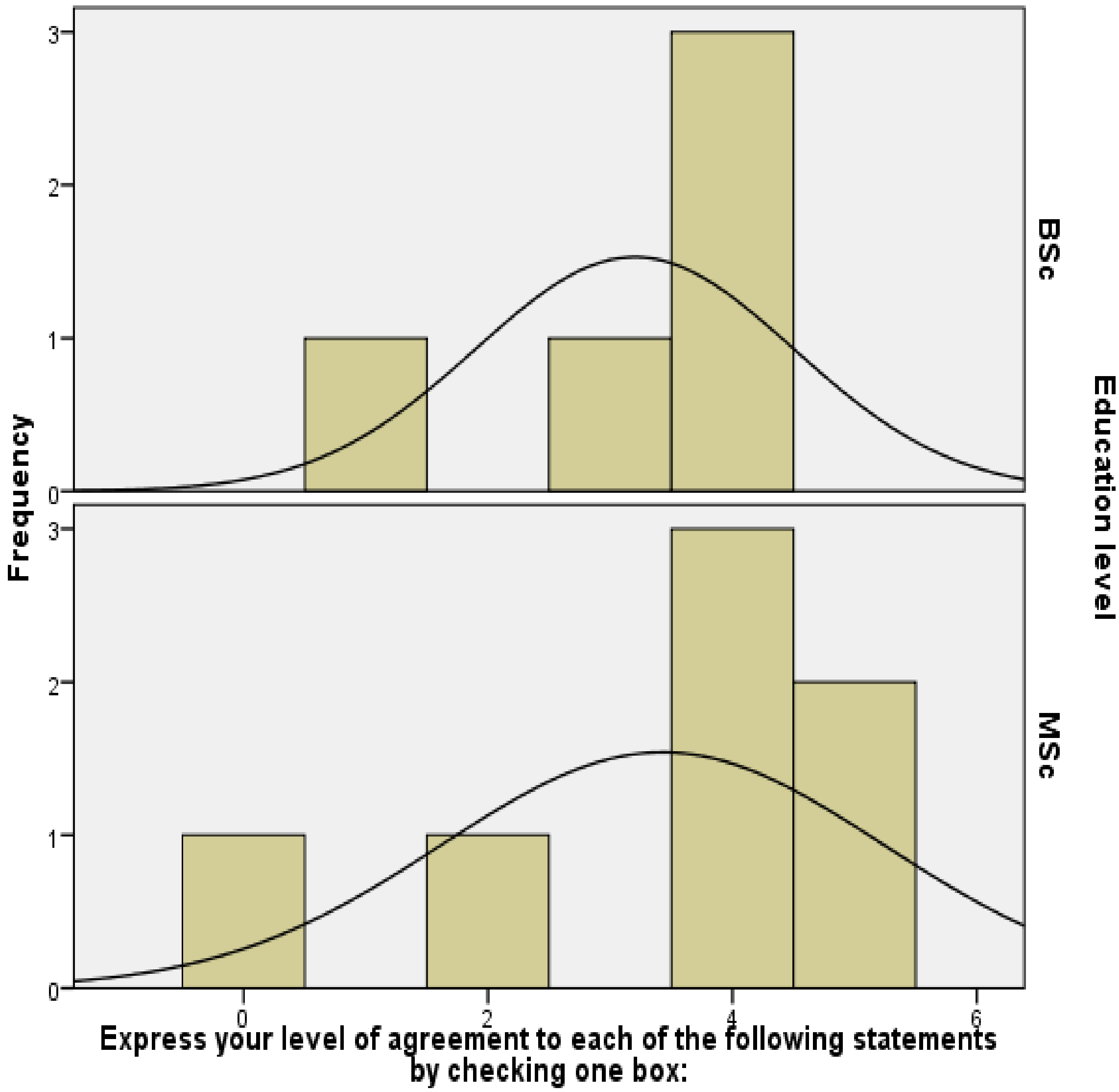

Figure 4-15 Context diagram functions

The distributions depicted in Figure 4-15 seem to be negatively skewed (have same distribution). The median can be employed to test for differences in the Mann Whitney U test.

Context diagram complexity

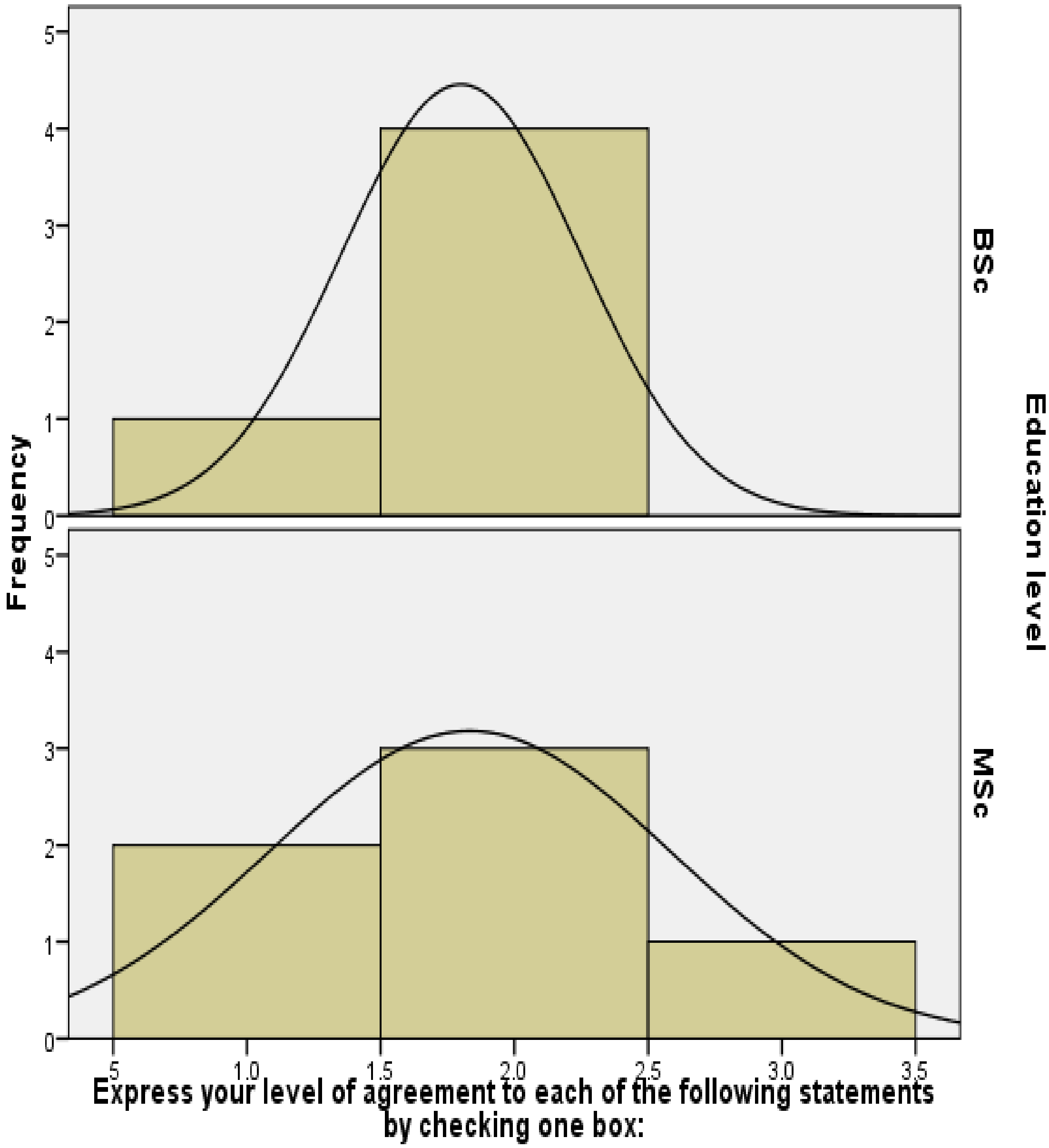

Figure 4-16 Context diagram complexity

The diagrams for both BSc and MSc seemed to have the shape. The median could be employed in the next test.

Context diagram inconsistency

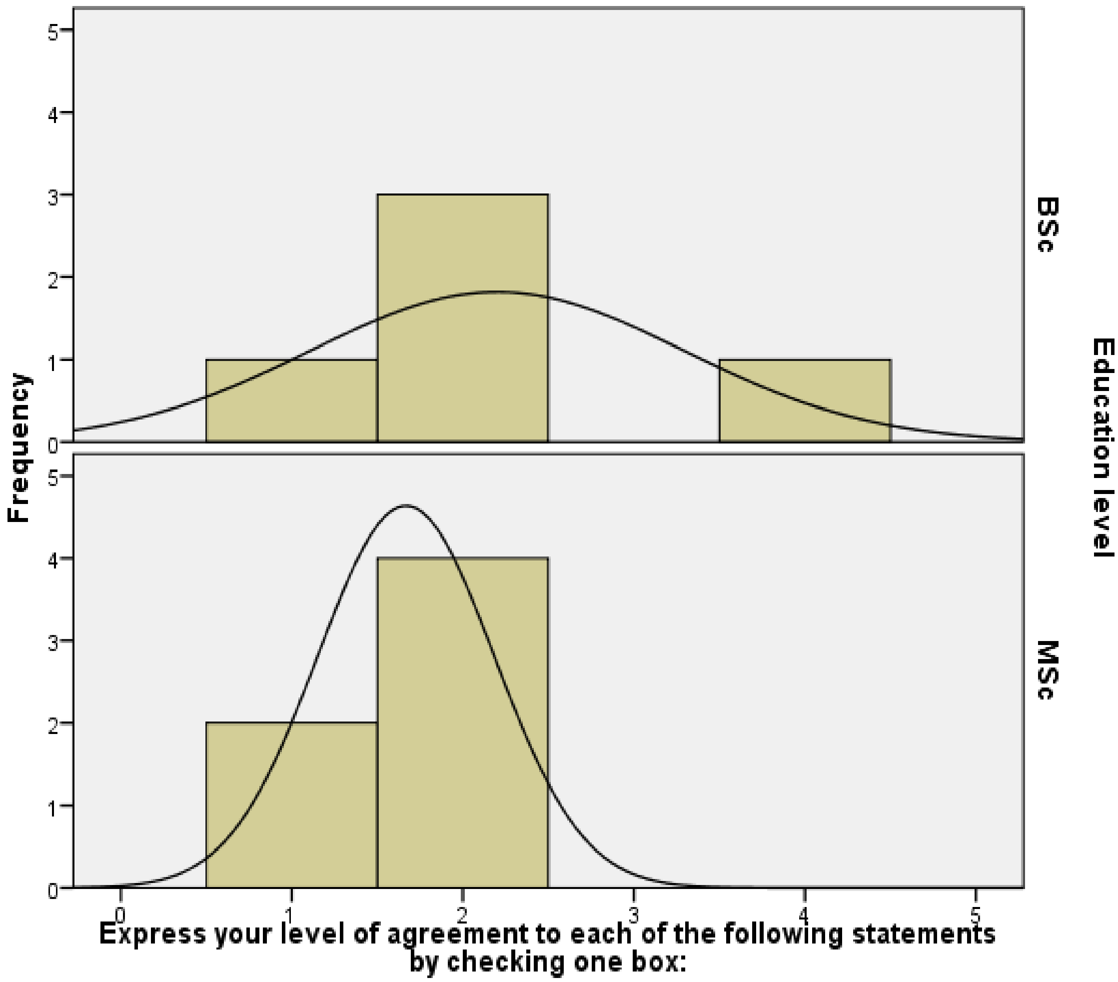

Figure 4-17 Context diagram inconsistency

Both distributions seemed to be positively skewed; hence, the median is employed in next test.

Express your level of agreement for integration, complexity and consistency of the designs

Participants were asked to express the extent to which they agree if the functions of the context diagram were well integrated. Half of the participants agreed that the functions were integratable. The other half were on the extreme sides of neutrality and agreeing strongly. On the complexity attribute, all participants agreed that the diagram was not unnecessarily complex. The last question was on scalability as alluded before, and only one participant responded. The response indicated that there was need to add unique features to the entities to achieve scalability.

4.7.3.2 Data flow diagram level 1

How would you rate the data flow diagram's completeness of features in describing the integrated design model to be developed?

Data flow diagram completeness

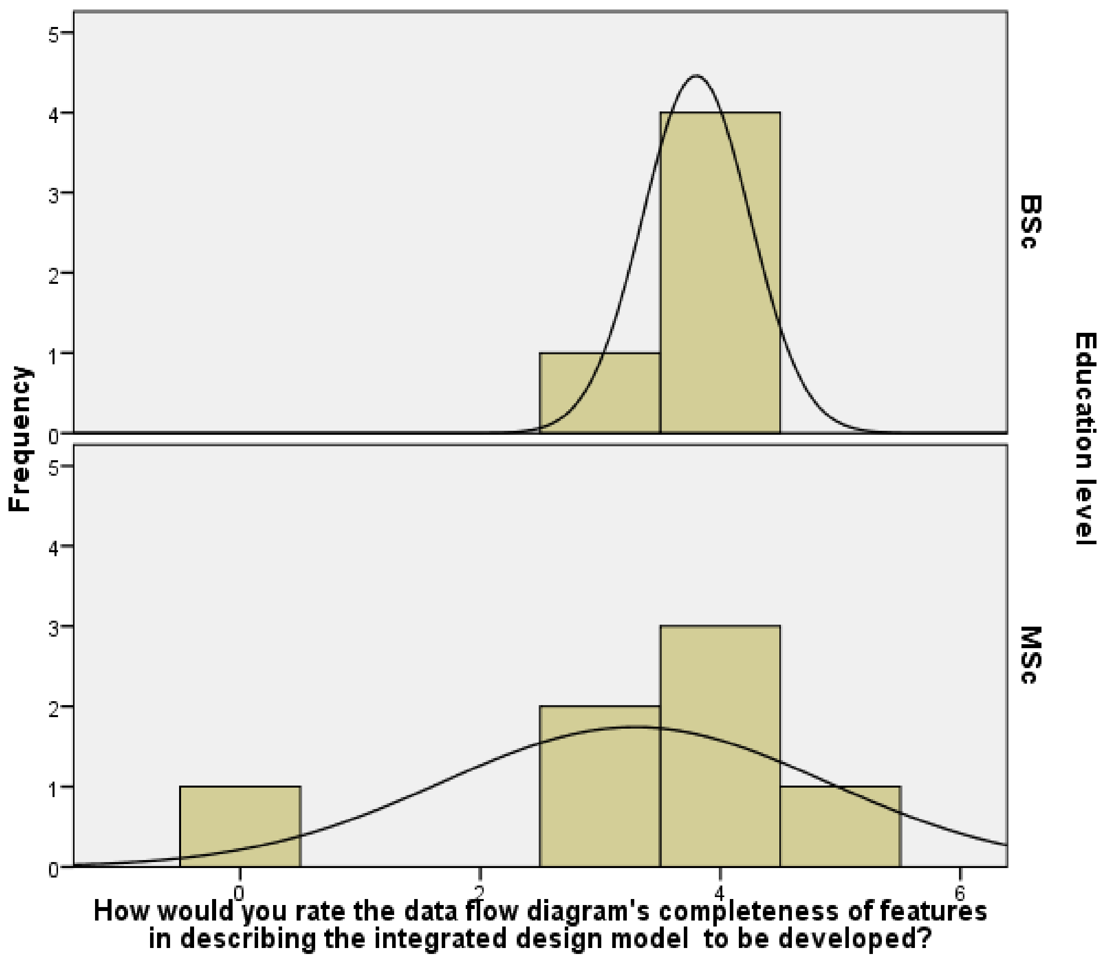

Figure 4-18 Data flow diagram completeness

Participants rated the data flow diagram's completeness with regards to the features presented. About 75% of the participants agreed to the diagram having most of the features. One participant disagreed that the data flow diagram had all features.

From the diagrams, both BSc and MSc responses on dataflow completeness seem to be negatively skewed. The median was employed in next test.

Data flow diagram functions

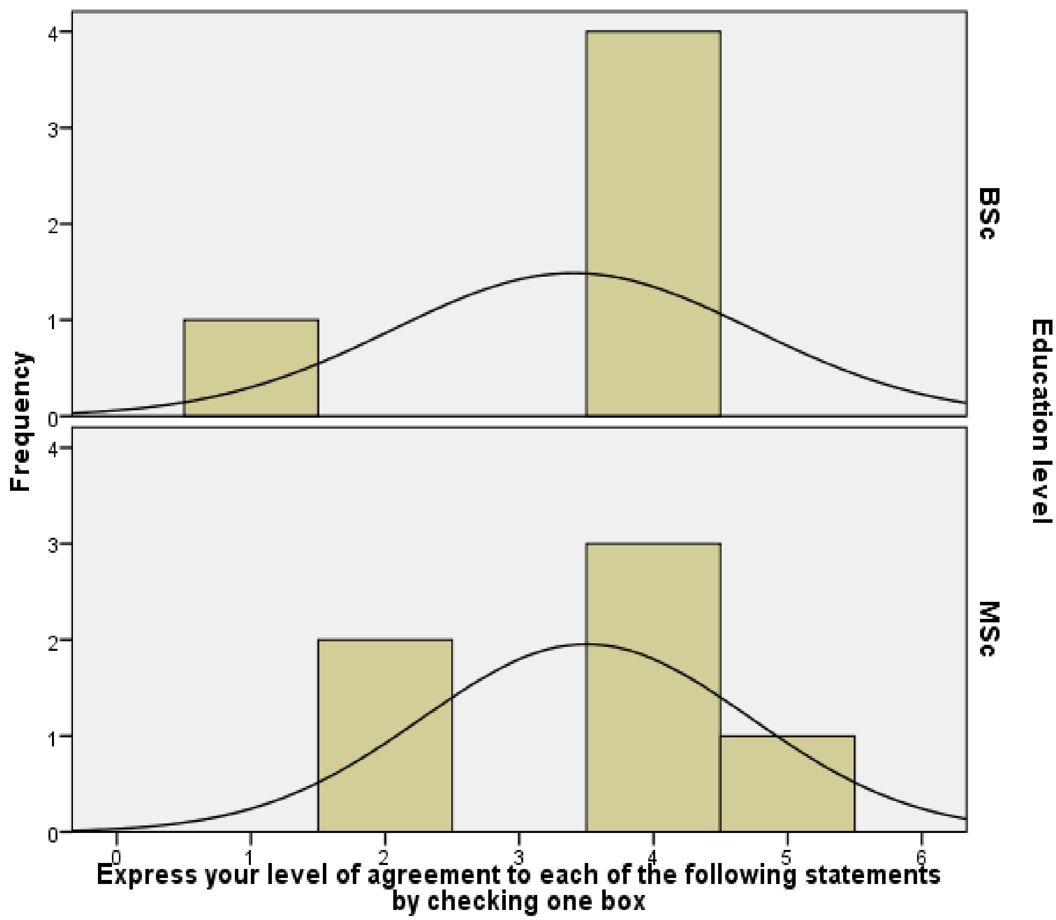

Figure 4-19 Data flow diagram functions

When participants were required to express the extent to which they agreed if the functions of the data flow diagram can be integrated, three quarters of the participants agreed that the functions could be integrated. The remaining quarter disagreed about the entities of the data flow diagram having the capability of integration.

Both distributions on responses of BSc and MSc seemed to be normally distributed. The median would be employed in the next test.

Data flow diagram complexity

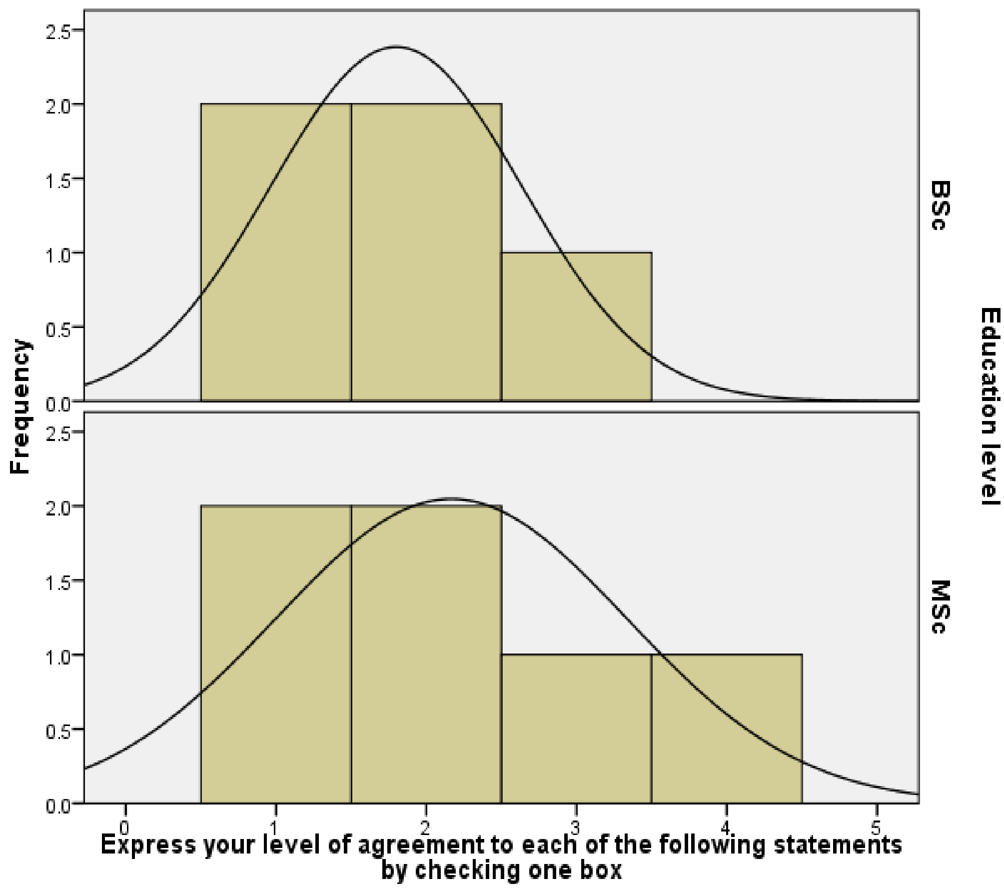

Figure 4-20 Data flow diagram complexity

More than half of the participants agreed that the data flow diagram was not complex. In addition, all participants disagreed that they were inconsistencies in the diagram. No responses were captured on the scalability question save for one participant who recorded that they had no idea. Participants failed to suggest improvements on the diagram. Both distributions seemed to be positively skewed; hence, the median could be employed.

Data flow diagram inconsistency

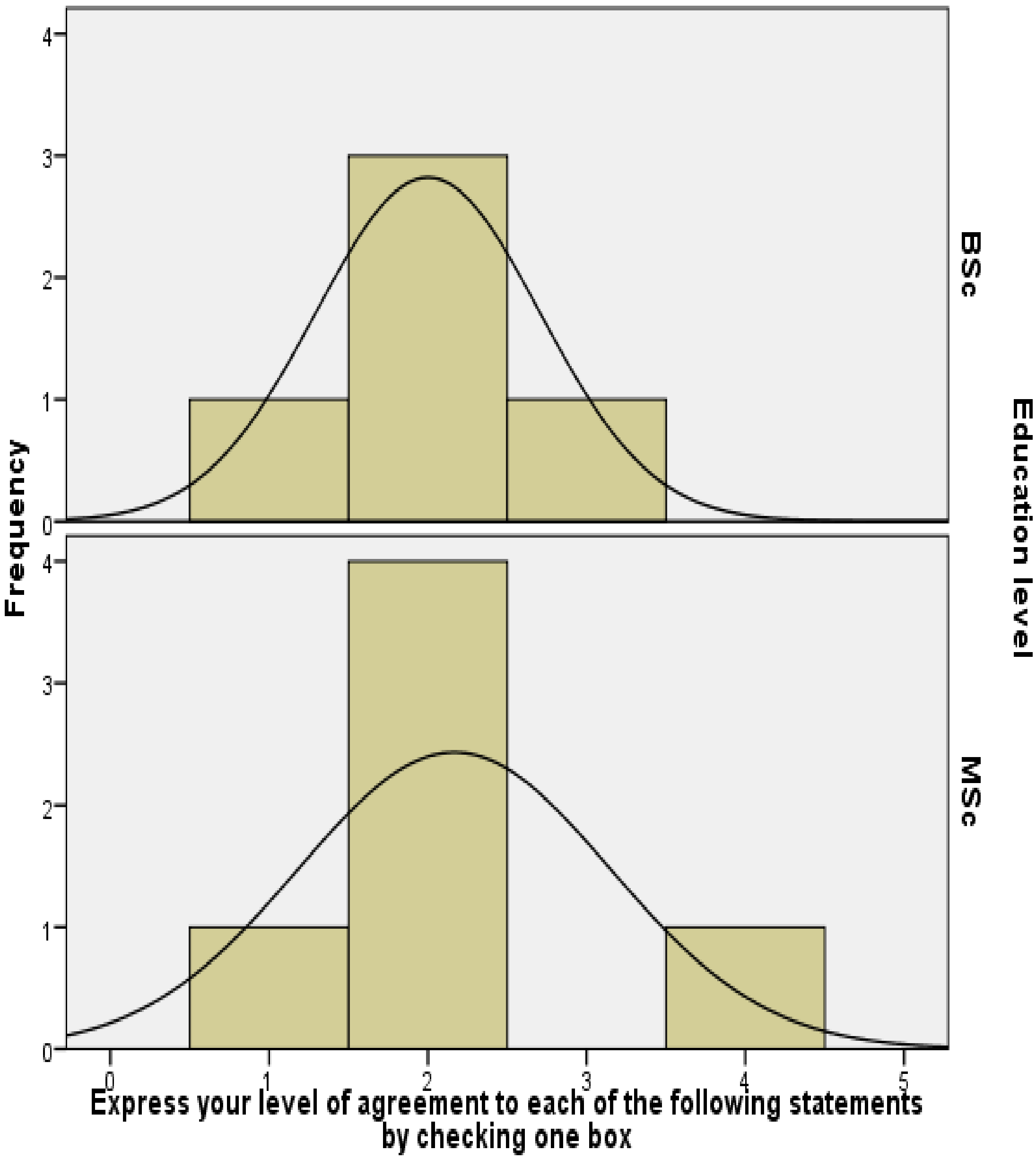

Figure 4-21 Data flow diagram inconsistency

Both distributions seemed to be positively skewed, hence the median can be employed.

Entity relationship diagram

How would you rate the entity relationship diagram's completeness of features in describing the integrated design model to be developed?

4.7.3.2 Entity Relationship Diagram completeness

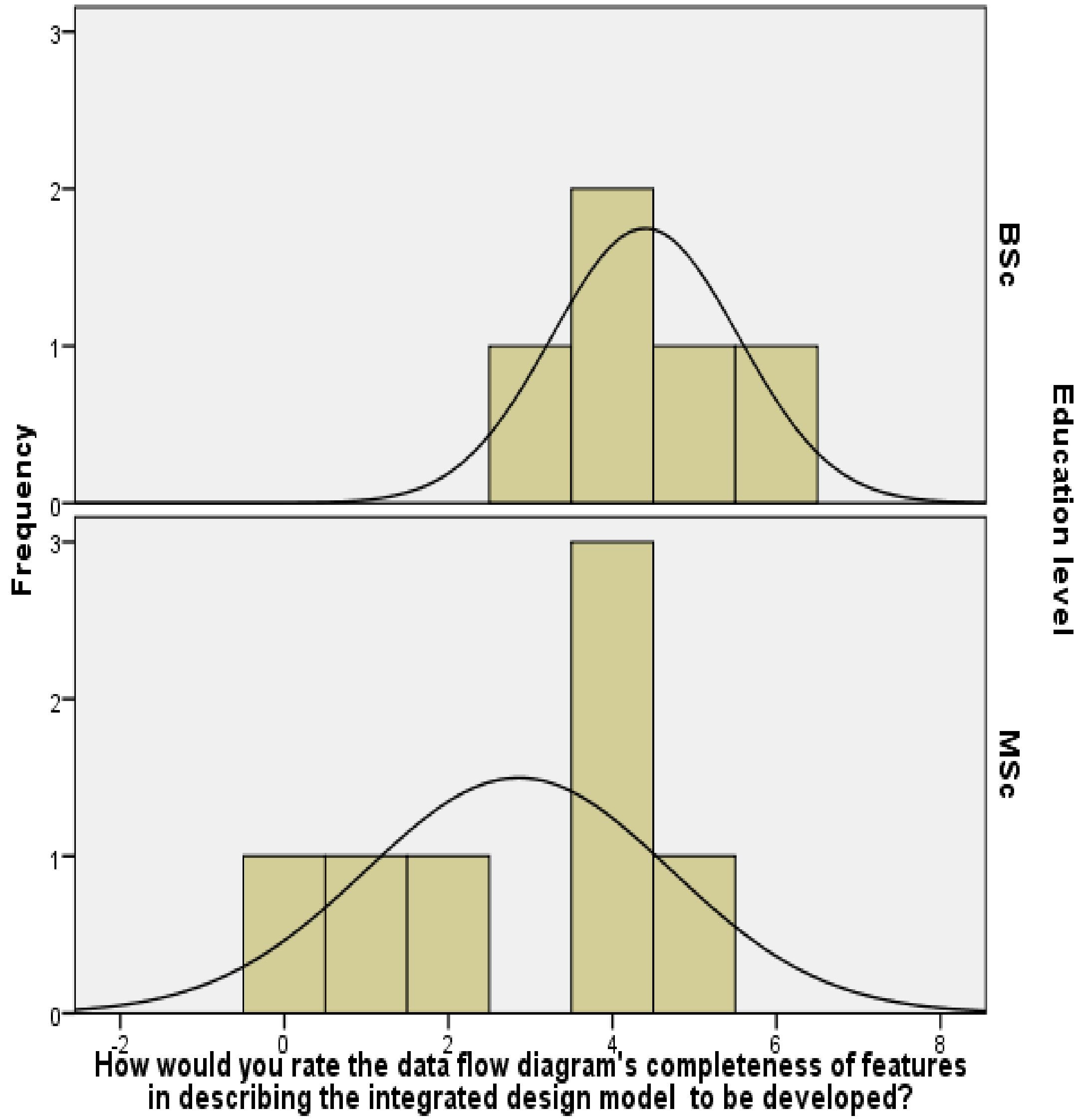

Figure 4-22 Entity Relationship Diagram completeness

Participants shared their opinions about the completeness of the entity relationship diagram's features. More than half of the participants concurred that the entity relationship diagram had most features. The shapes of the distributions seemed to be different and employed the mean in the next test.

Entity relationship diagram functions

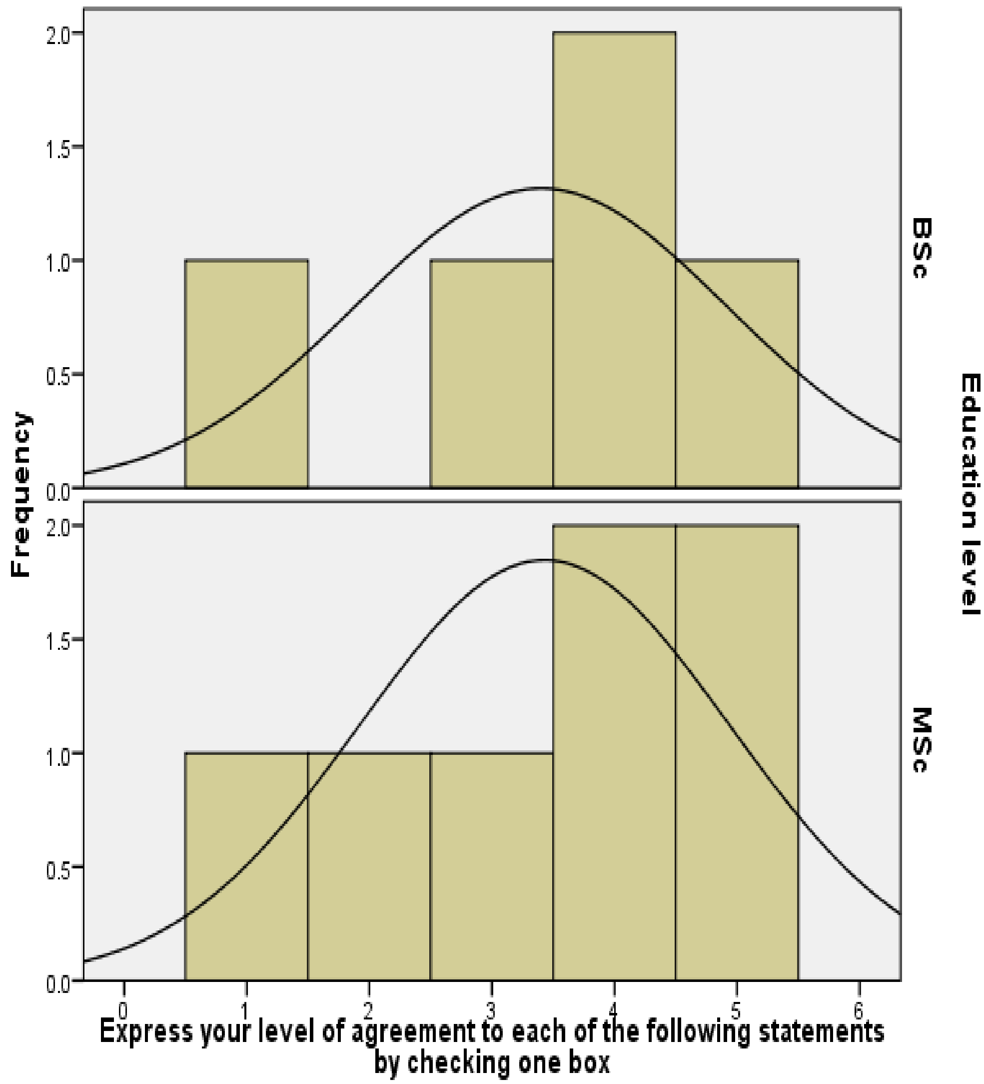

Figure 4-23 Entity relationship diagram functions

The question enabled participants to express the extent to which they agree if the functions of the entity relationship diagram could integrate with other systems. More than two-thirds of the participants agreed on the integration function.

The distributions seemed to be both negatively skewed; hence, employed the median in the next test.

Entity relationship diagram complexity

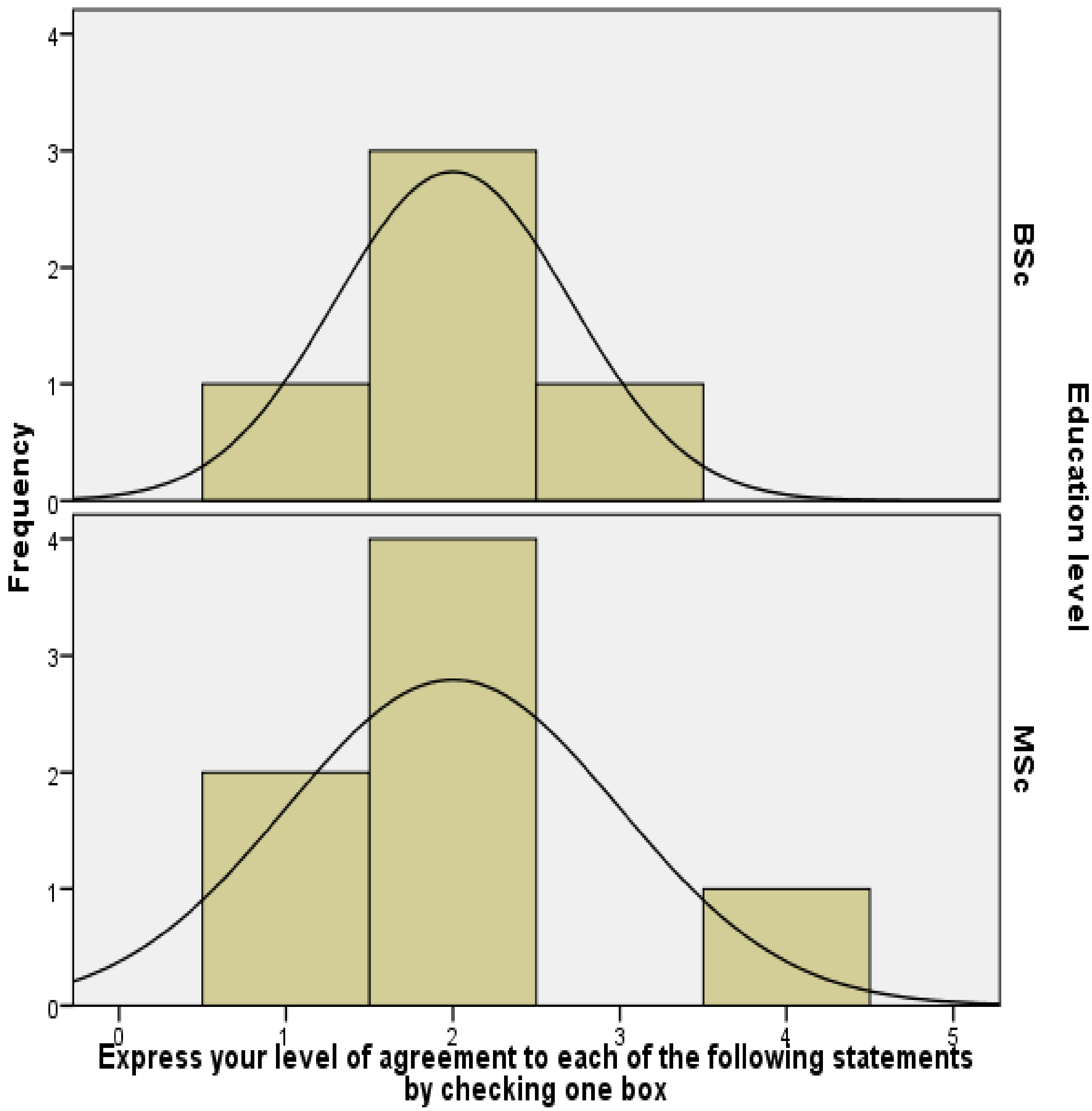

Figure 4-24 Entity relationship diagram complexity

The BSc distribution seems to approximately normally distributed. However, the MSc seems to be positively skewed. The mean is employed in the next test.

Entity relationship diagram inconsistency

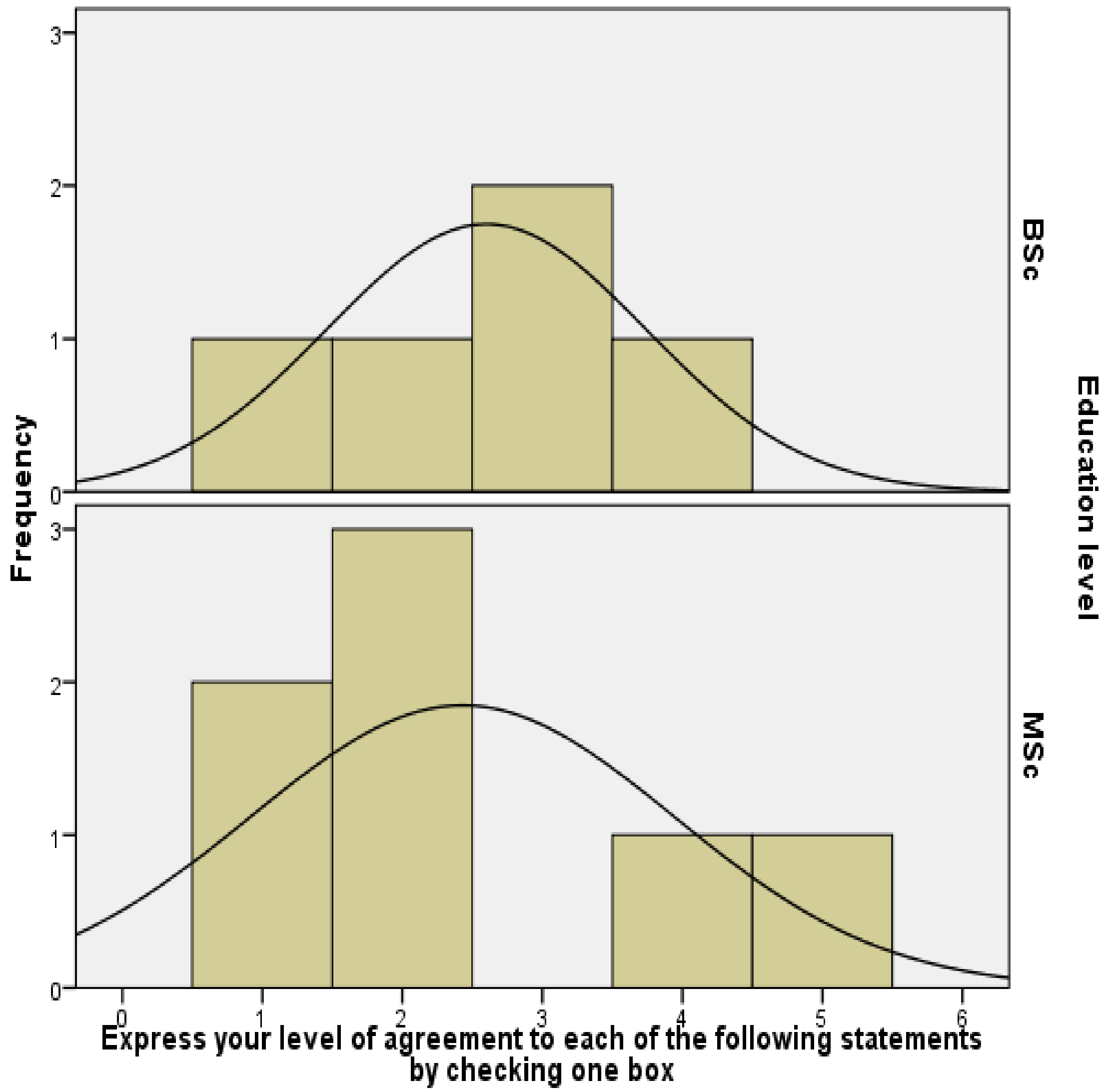

Figure 4-25 Entity relationship diagram inconsistency

The distributions were different. The BSc is negatively skewed whilst the MSc seem to be positively skewed. About three quarters disagreed that the entity relationship diagram was unnecessarily complex. One participant recorded that they were undecided. Also, one participant responded to the scalability question, and said they were not sure of the concept.

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Participants also commented on additional features. One participant mentioned that they did not know how to interpret some of the symbols indicated.

Furthermore, one participant commented that they were not sure about the standard notation used for the entity relationship diagram and put forward a suggestion for the need to investigate it. They saw entities connecting to entities.

The study employed the mean in next test.

Medians by group analysis

The medians by level of education on dataflow diagram completeness is summarized in table below.

Table 4-9 Medians by group analysis

Median	
Education level	**How would you rate the data flow diagram's completeness of features in describing the integrated design model to be developed?**
BSc	4.00
MSc	4.00
Total	4.00

The medians seemed to be the same for both groups.

Mann Whitney U Test on data flow diagram's completeness

The hypotheses are drawn from the main hypothesis in Table 4-8.

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Table 4-10 Hypothesis Test summary table for Mann Whitney U Test

Null Hypothesis	**p-value**	**Decision**
The data flow diagram's completeness of feature is the same across categories all levels of education	0.755[2]	Retain the null hypothesis
The context diagram's completeness of feature is the same across categories all levels of education	0.537	Retain the null hypothesis
The data flow diagram's complexity of feature is the same across categories all levels of education	0.662	Retain the null hypothesis
The data flow diagram's consistency of feature is the same across categories all levels of education	1.000	Retain the null hypothesis
The entity relationship diagram's completeness of feature is the same across categories all levels of education	0.202	Retain the null hypothesis
The entity relationship diagram's complexity of feature is the same across categories all levels of education	0.876	Retain the null hypothesis

There is a significant relationship between context diagram completeness and strong evidence at 5% significance level. These also same goes with data flow diagram complexity with p-value 0.662 There is also moderate positive evidence at 5% significance level data flow diagram consistency with p-value 1. 000. There is a significant relationship for entity relationship completeness and complexity with p-values 0.202 and 0.876 respectively. All relationships depicted in Table 4-10 revealed that there was strong evidence to retain the null hypotheses. Hence, if it has been established that there are no significant differences, then possibly the way the designs are presented for the proposed model is not so much different from the way the current learning management systems are designed. If the result had shown otherwise, it would mean that the designs still require more iterations to match the present design structure of learning management systems. Meaning, there was more to be done on the design model in preparation for a full comprehensive system on a larger scale. If the null

[2] The significance level is 0.05

hypothesis was not supported, it would mean that the designs which were not yet implemented were better than the existing learning management systems.

4.7.4 Second iteration

The second iteration remained the final iteration in this study and resulted in the integrated design model. The model was implemented from the data flow diagrams and entity relationship model presented in this chapter. The iteration was finalized with an evaluation based on the technology acceptance model and task-technology fit model. The two models were incorporated in the Design science research framework.

The evaluation was done with other stakeholders who were not involved in the experimental design stage. This was done to see how the model was viewed in a more accurate manner. The process of integrated design model continues, obtaining requirements of the designs remained an important stage. The study was conducted to ascertain whether the desired model fulfilled the functional requirements based on the standardized software metrics.

The main objectives of the second and final iteration were to refine the data flow diagrams and entity relationship diagram, based on evaluation from first iteration, as well as to identify and design a model based on the functions. The scope of the study was not for software engineering experts to get to implement the designs, but to review the logical designs. The context and data flow diagrams had adequate detail to build the integrated design model. The design model would comprise the automation processes and policy related functions such as governance. However, not all requirements suggested by experts were included in the design but were left for future improvements of the same.

The second level of iteration was the stage where the researcher considered the qualitative comments from the experts and considered them; then came out a proposed software design model which was to be evaluated using the technology acceptance model and task-technology fit model constructs. From the set of context and data flow diagrams presented in section 4, some additional model features were established. The first iteration had syntactical flaws which were discovered and fixed. Suggestions were made not to make the content delivery passive, but real-time interaction. Nevertheless, not all diagrams were evaluated.

Comments from the survey

The questionnaire asked open ended questions which required experts to give their views on diagram completeness, consistency, complexity and scalability. Software engineering experts were to give general comments on diagram completeness and their responses were presented thematically, with various themes coded from repeated analysis of the comments. Table 4.24 shows the details of the comments. The coding process was followed. Open coding: Data was read through several times and labels were created for the data. These were comments that summarized the views of software engineering experts based on the meaning that emerged from the data. Examples of experts' words were recorded, and code properties were established. Axial coding: Relationships among the open codes were identified through axial coding.

Themes on general views and concerns on diagram completeness use Table 4-11 Comments from the survey

Open Code	**Properties**	**Examples of participants' words**
Scalability	The capacity of a system to handle growth.	*What is the scope? Does it cover a single country or the world? Storage and Processing power. As documents are being added to the storage medium, there should be a way to alert for decreasing storage space.* [P8]
Storage/Database	Location for storing learning content.	*The database should have enough capacity to hold information of students even if the number of students continue to grow.* [P10]

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Massive open online courses	Courses developed for online learning environment	*There is no key for this diagram. Does the system only import? Why not Export to other MOOCs as well?* [P8] *MOOCs nowadays are, not only passively delivering content to the requester, but also doing real-time interaction.* [P1]
Artificial intelligence	The capability of computers and other machines to do tasks that would require human intelligence.	*Take into account new agents in the environment like AI.* [P5] *Basing on just human subjects should be eliminated in the 21st century*[P5]
Cardinality	In the context of entity relationship, diagram describes the relationship between two entities in a graphical -numerical format.	*The cardinality is not being shown on the ER diagram.* [P6]
Context diagram	An illustration that shows parts of a system and its boundaries	*The diagram fully explains itself and what the researcher wants to elaborate.* [P7] *Does the system integrate with university libraries, journals, public libraries, Technology hubs? How will you include Professionals from private sector to participate?* [P8]
Data flow diagram	A graphical representation of flow of data in an information system.	*I think a level 2 or 3 DFD would show more processes on which we can judge features* [P8]

		The DFD has arrows showing data input from eternal sources but does not adequately show information output flows from the system. [P9] *Does the student input a query through the Query Management system? There are certain designs where we have one input and one output to a DFD. So, I suggest a way of making sure that all major processes are shown in this DFD.* [P8].
Entity relationship diagram	A diagram that depicts main components that build a system, and their relationship.	*Improve on clarity on the process. Show the Integrated Design Model as processes, rather than a model.* [P9] *I am sure this is not the complete ERD to depict the whole interaction between MOOCs, E-learning platforms and the Integrated system itself*. [P9]

Software engineering experts included some positive comments concerning context diagram. For example, "*The diagram fully explains itself and what the researcher wants to elaborate"* [P7]. However, they would also pose questions which suggested aspects that could be added to the designs. One of the insightful comments pointed to the possibility of integration of learning management systems with library systems. The following comment in form of a question, was about how we could tap into the expertise of professionals from industry.

In addition, software engineering experts emphasized lack of processes on the data flow diagram. This was despite the context diagrams showing all the entities that existed as part of the software design model. Nonetheless, section 4.5.4 shows decomposition of the dataflow diagram into sub processes.

The next frequent comments focused on storage and database capacity. Issues of storage were linked to the continuous growth in number of students enrolling in Zimbabwe universities. One participant said, "*The database should have enough capacity to hold information of students even if the number of students continue to grow*" [P10].

In general, the comments by software engineering experts provided additional insights for the design of software model. Furthermore, no additional factors were recommended that were not already included in the context diagram, data flow diagrams, and entity relationship diagram.

4.8 Objectives of the design model

The initial requirements put forward by the research from the extant literature were to facilitate the automation of selection, uploading, updating and removing content. This was with the goal of supporting lecturers by automating content sequencing, uploading and exporting. The automation could allow access to massive content from global massive open online courses. The idea of integration in this study was to gather content from learning management systems and Massive open online courses based on a query submitted by students. The integration would then ultimately aid the sharing of content among the universities.

4.8.1 Description of the design model components

Light weight devices

The integrated design model in Figure 4-26 comprised nine functional areas. The thrust of the model was that the system to be implemented from the designs would take advantage of existing broad range of light weight devices. The function of light weight devices should clearly show the services that support the devices, to enhance access to teaching and learning resources.

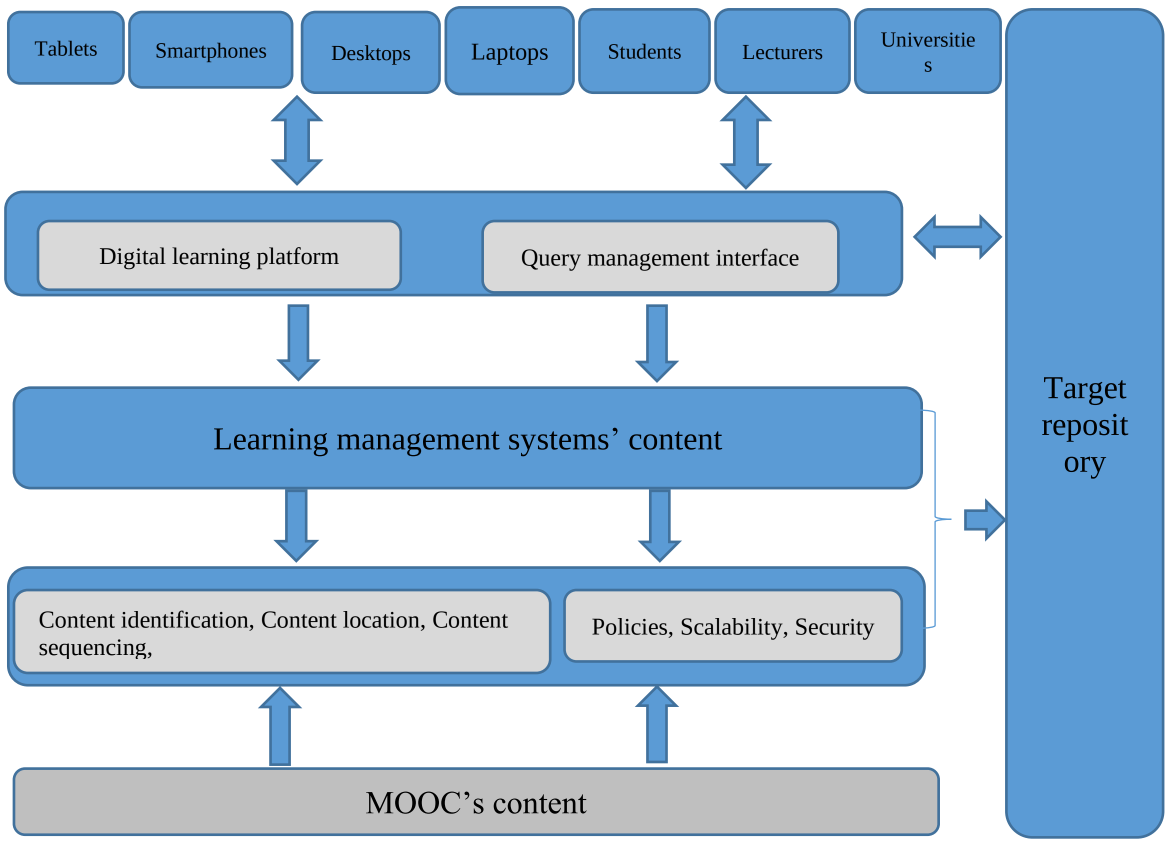

Figure 4-26 The Proposed Design Model

Stakeholders

Integrating learning management systems and massive open online courses affords access to learning content, as well as managing the content uploading process. The integration aimed to assemble lecturers, students, learning management systems, massive open online courses and light weight devices. When such entities were connected, relevant content could be accessed in real-time and more efficiently. In this study, lecturers also uploaded their content manually to the learning management system. When students got feedback from their requests, the relevant content will be accessible to all via the target repository (see Chapter 4 section 4.7.2).

Digital learning platform

The digital learning platform is a function that offers a basis on which access to other technologies and services can be reached (Gawer, 2009). In the context of this study, the digital learning platform interacted with light weight devices as well as other stakeholders. It connected lectures, and students, providing a link and the necessary conditions for content sharing. There is need for the platform to be flexible, enhancing access to learning content repositories. In the case of Zimbabwe universities, the platform forms the architecture which can be utilized by higher education sector. Due to increase in enrolment (Garwe, 2014) in Zimbabwe state Universities, integrated systems should be scalable.

Query management interface

This feature provides a service that supports communication between devices and content repositories Figure 4-26. The interface connects with core services and other supporting components that provide automation for the content uploading processes. The query management interface is the base of the digital learning platform, providing an external view (Zittrain, 2013) of the platform to the learning content repositories including the target repository. The interface described in this study is provided by mobile telecommunication company which specializes in educational digital technologies. The query management interface can be provided by several digital organizations that support the functions of the integrated design model.

Learning management systems' content

The integrated design model has a learning management system content function. This function is to support provision of relevant content to learners in different formats using mobile devices. Learning content is uploaded by lectures for students to access. The challenge, as outlined in literature, is that, not all courses receive the same attention

(Bhalalusesa, Lukwaro, & Clemence, 2013). The design model assists lecturers in that, while they upload learning content, the automation process forwards the content to the target repository as per the submitted query.

Automation processes

The aim was to integrate the learning management systems and massive open online courses to create a design model that represents the automation of uploading content. The automation part allowed content to be uploaded with minimal teacher intervention. This was attained through the interaction of existing content repositories with internet-based services. The activities included in the automation processes were queries submitted by students through the query management interface.

The design model, when implemented, will use technologies for content identification, content location, content sequencing and content delivery functions. The same functions acted on the content from massive open online courses. While lecturers upload their content to the learning management systems repositories, the automation processes forwarded the content to the target repository (see Chapter 4 section 4.7.4). The design model functions needed to fulfil the existing current education systems. It needed to focus on automation components that focus on integration. It would support related platforms to conform with the differences among design components. This functionality is achieved through the adoption of components and services already in existence.

Governing requirements

This function should observe policies to do with content uploading, scalability and security. The platform must be scalable, with the ability to handle increased amount of content generated from massive open online courses and learning management systems. The platform should scale sufficiently to meet the needs of learners throughout their course of study.

Target repository features

The deliverable of this study was supposed to support content that is accessed from different devices. Then the repository would communicate with query management interface (Figure 4-26). Issues of access are dealt with from the institutional learning management system where registered students are the only ones who can access the learning material. Information forwarded to the target repository would go under sequencing (see Chapter 4 section 4.7.4).

The target repository should have the ability to collect learning content material. Indexing of content as put forward by Rodrigues and Shearer (2017) was a future goal for the integrated design model. Moreover, there was need to share content via partners. In this study, the content repository was ideal since content was to be accessed by learners from different learning management systems. The target repository could serve both print content and online content accessed from desktops, smartphones, and tablets from Zimbabwean state universities.

Massive open online courses Content

The overall aim of the integrated designs was to provide the necessary tools and interfaces for integrating learning content between learning management systems and massive open online courses. Massive open online courses' content varies from study materials through discussion forums. Content generated from discussion forums could be integrated as well. The integration approach needs a content repository for storage, management, retrieval of learning content. The processes depicted in Figure 4-26 The Proposed Design Model, extract content from massive open online courses repositories and delivering the content. Content from massive open online courses was integrated together with content generated by lecturers and students.

4.9 Conclusion of the Chapter

This chapter focused on producing the component units of the proposed software design model based on a particular sub-problem of the study's problem statement. The presentation of preliminary designs of the proposed design was provided, emphasizing on the logical (see section 4.7.3 on page 161) and physical (see section 4.9 on page 134) designs. The objective of coming up with the preliminary designs mainly focused on obtaining detailed reviews of the design concept expressed as collections of data flow diagrams (see section 4.7.2 on page 94) and entity relationship model. Software engineering experts were engaged at this stage to elicit for requirements that ultimately helped in improving the existing processes regarding learning content uploading and sequencing in learning management systems. Two iterations were done to create the final software design model.

In line with the study's methodology (see section 3.3 for a detailed description of the design science), software engineering experts assessed completeness component unit designs. A questionnaire was presented (see appendix A). The evaluation was done to show practical usefulness of the components. Section 4.7.3 presented the statistical results for data collected from questionnaire (see Appendix E). The discussion of results is presented in Chapter 6.

The next chapter presents technology acceptance model and task-technology fit model employed as part of design model evaluation.

Chapter 5

Design Model Evaluation

The previous chapter presented the designs of the software design model (see section 4.7.2 for the detailed designs). This chapter investigates the evaluation of the software design model, emphasizing on inferential statistics arising from the technology acceptance evaluation. In this context, the inferential statistics sought included Mann Whitney U test and Kruskal Wallis test. These statistics collectively elucidate the bigger picture regarding acceptance or rejection levels of the software design model by the stakeholders (the lecturers, experts, students, and universities at large).

The findings and discussions arising from statistical analyses are presented in section 5.4 of this chapter. Upon extracting these findings, the objective of this chapter is to carry out a technology acceptance evaluation of the proposed software design model. To achieve this, the chapter describes the evaluation tasks that were performed. In addition, it describes the technology acceptance model and task technology fit model used as a strategy to evaluate the software design model. The hope was to arrive at a point where the software design model was certified according to the functional requirements set. Detailed procedures for statistical validation were demonstrated using the partial least squares path modeling (Sanchez, 2013). In this context, partial least squares path modeling is a multivariate technique which combines causal modeling with data analysis features (Hair Jr, Hult, Ringle, & Sarstedt, 2014). This technique was chosen, among others, because it is robust and powerful to work with small sample sizes (Henseler, Ringle, & Sinkovics, 2009).

5.1 Technology Acceptance Model and Task-Technology Fit for Integrated design model

Aligning this section to the study's theoretical framework, the researcher applied the technology acceptance model to evaluate intention to adopt of the integrated designs by university management. The researcher employed task-technology fit together with technology acceptance model to ascertain whether the universities would adopt integrated design model based on tasks and technology characteristics.

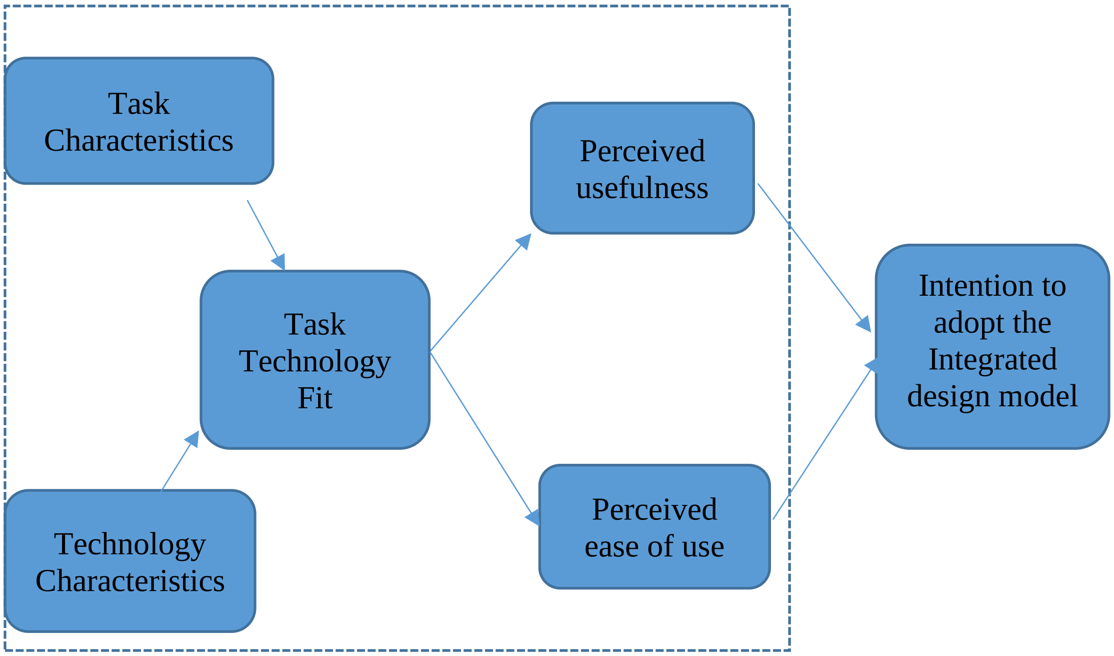

Figure 5-1 Technology Acceptance Model and Task-Technology Fit model Lee et al (2007)

In addition, the researcher conducted a survey on lecturers, experts and students after they had paid some attention to the features of the integrated design model. The aim of integrating technology acceptance model and task- technology fit is for evaluation of the design model, which is necessary to ensure that lecturers' and students' requirements are met. The next sub-sections describe factors for assessing the intention to adopt the design model.

5.1.1 Task characteristics

Task performance is considered as a measure of the success of a technological artefact (Ouyang et al., 2017). Accordingly, the researcher integrated technology acceptance model and task-technology fit for exploring factors that explain software utilization and its links with user performance (Ouyang et al., 2017). In this study, task refers to content uploading processes and related activities. Lecturers' task is to upload content, and learners retrieve the content through the query management interface. Learning content sharing is one task that can be accomplished through the implementation of the integrated designs.

5.1.2 Technology Characteristics

The task-technology fit model reflects on the significance of fitting the features of technology used to the requests occasioned by individual needs (Ganzert, et al., 2017). In this study, technology refers to any software tools used by lecturers and students in carrying out the tasks for accessing and uploading content. The researcher constructs technology features as those that users deem as critical in the usability of a light weight devices.

5.1.3 Perceived usefulness

In digital learning systems domain, perceived usefulness is a common factor employed in technology acceptance model studies (Ariffin et al., 2017). To add to that, technology acceptance model has been used in education (Lopez, 2013). In the same line, other researchers (Alsabawy, Cater-Steel, & Soar (2016); Teo (2011) have investigated the determinants of perceived usefulness in e-learning systems. As such, perceived usefulness is the degree to which a system user is certain that the technology would improve execution of their tasks (Moslehpour, Pham, Wong, & Bilgiçli, 2018). Notably, perceived usefulness is known (Lopez, 2013) to have a strong effect on the use of technology. The same author further attests that perceived usefulness is also influenced by perceived ease of use as well as intention to use. The results of Mohammed (2015) study showed that ease of use was the main determinant of perceived usefulness and was consistent with the technology acceptance model. The empirical study by Alsabawy, Cater-Steel and Soar (2016) found that course delivery and facilitating conditions were the main determinants of perceived usefulness. Therefore, in this study, the researcher proposes that the usefulness of a system in educational technology is interrelated to how lecturers use the available tool to make learners interact with content. Further, the usefulness of integrated learning technologies is one factor to consider for the enhancement of teaching and learning in Zimbabwe universities. Lecturers and students would make use of a new technology if it assists them in obtaining their learning goals.

5.1.4 Perceived ease of use

Perceived ease of use refers to the degree to which an individual trust that using the technology will not be difficult or challenging (Lejonberg, Elstad, & Christophersen, 2018). It is an evaluation of the degree to which users achieve their tasks with ease (Sánchez-Prieto, Olmos-Migueláñez, & García-Peñalvo, 2016). Otherwise, they will stick to their old methods instead of using the new system. This is like previous studies in different contexts and technologies (Fathema, Shannon, & Ross, 2015). Students' attitude towards e-portfolio acceptance have been explored (Shroff, Deneed, & Ng, 2011). Their study showed that Perceived Ease of Use had a significant influence on attitude and a strong influence on Perceived Usefulness. Perceived Ease of Use is an important secondary determinant of intentions. Moreover, perceived Usefulness had a direct significant effect on intention to use computers (Ma et al., 2005).

5.1.5 Intention to adopt

A technology could be adopted by an institution because they are ready for it and are satisfied with its features (Bourrie, Cegielski, Jones-Farmer, & Sankar, 2014). This would probably determine the extent to which the technology is fully utilized. In this study, intention to adopt may be understood as intention to implement the integrated design model.

5.1.6 Task Technology Fit

The task characteristics and technology characteristics, both impact on the task-technology fit construct as depicted in Figure 5-1 The task technology fit construct, ultimately affects the final deliverable, which is task utilization (Khidzir, Diyana, Ghani, Guan, & Ismail, 2017). In this study, the construct of task-technology fit articulates the capability of digital technologies to support teaching and learning tasks. When technology fits the task requirements, then there is a high likelihood that it will be adopted.

5.2 Task-technology fit and Technology Acceptance Model impact on utilization of the integrated design model

The relationship between task technology fit and use of technology exists, since the better the fit, the more the tendency for users to use technology. Utilization is the way one conducts themselves when using a particular technology to complete tasks (Lai, 2017). In this study, utilization is a combination of task-technology fit and the intention to accept the technology by the stakeholders. Earlier studies show that utilization can be perceived as user adoption (Zhou & Wang, 2010).

5.2.1 Technology Acceptance Model and Task-Technology Fit Evaluation Form items

Based on the constructs' information provided, Table 5-1 shows a summary of the form items which were adapted from the references stated. For example, for intention to adopt construct, the measuring items were adapted from Souza, Batista Munay da Silva, and Morais Vieira Ferreira (2017) and Radif, Fan and McLaughlin (2016). The five related items to measure the universities' intention to implement the design model are reflected through intention to use, the recommendation to use, readiness to implement, and students' likelihood to use mobile devices.

Table 5-1 TTF and TAM form items and reference

Construct	**Questions**	**Adaptation**
Task characteristics (TAC)	Please justify your level of agreement based on the statements below: TAC1 Lecturers can be partially relieved from uploading content TAC2 Student can access content anytime, anywhere TAC 3 Automated uploading of content to repositories	(Tripathi & Jigeesh, 2015) (Susanto & Aljoza, 2015)

	TAC 4 Learning content can be shared among repositories TAC 5 Lightweight devices can be compatible with the query management interface	
Technology characteristics (TEC)	Please justify your level of agreement based on the statements below: TEC 1 Communication not sufficient at all TEC 2 Automation very inappropriate TEC 3 Resource sharing very inadequate TEC 4 Digital learning Platform not helpful at all TEC 5 Lightweight devices do not allow for all functionalities TEC 6 University management is likely to invest in infrastructure TEC 7 University management is willing to take risks in the use of integrated repositories.	(Rajan & Baral, 2015).
Perceived usefulness (PU)	Please justify your level of agreement based on the statements below: PU 1 Using this integrated design can enable the learners to interact more with content PU 2 Generally, the system is not practical PU 3 I think the integrated model can facilitate learning PU 4 The integrated designs cannot reduce lecturer workload PU 5 The use of LMS and MOOCs is compatible with existing hardware and software in our universities	(Alsabawy, Cater-Steel, & Soar, 2016)

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	PU 6 The technology infrastructure of our universities is unavailable for supporting the design model. PU 7 The designs facilitate collaboration PU 8 Improved relevant content	
Perceived ease of use (PE)	Please justify your level of agreement based on the statements below: PEU 1 I think it does not need a lot of effort and time to search for info on the platform PEU 2 I think the functions in the model are easy to understand PEU 3 I think the interfaces are ideal for limited bandwidth PEU 4 I think the processes accommodate interrupted communication	(Fathema, Shannon, & Ross, 2015) (Lopez, 2013)
Intention to adopt (IA)	Please justify your level of agreement based on the statements below: 1A 1 Integrated designs should be used as much as possible 1A 2 The use of new technologies in higher education should be recommended 1A 3 Universities ready to implement the integrated model 1A 4 Universities would consider investing in resources for implementation IA 5 Students likelihood to engage mobile services	(Souza, Batista Munay da Silva, & Morais Vieira Ferreira, 2017). (Radif, Fan, & McLaughlin, 2016)
Task Technology Fit (TTF)	Please justify your level of agreement based on the statements below: TTF 1 Model functions are adequate	

	TTF 2 Model functions are appropriate TTF 3 Model functions are useful TTF 4 Model functions are compatible with task TTF 5 Model functions would be sufficient TTF 6 Model functions would make the task very easy TTF 7 Functionalities of model fully meet learner's needs	(Khidzir, Diyana, Ghani, (Guan, & Ismail, 2017)

5.2.2 Hypotheses

Studies of digital learning platforms have established an association among the influence of the technology adoption and the fitness of technology to tasks. Based on these findings, the researcher infers that the Task-technology fit basic constructs will influence the acceptance and ultimately the adoption of the educational technology innovation. Therefore, the following hypotheses are given:

H_1: Technology Acceptance Model predicts intention to adopt the design model.

H_2: Task characteristics of design model are positively related to Task Technology Fit.

H_3: Technology characteristics of the design model are positively related to Task Technology Fit.

H_4: Task technology fitness has an impact on Technology Acceptance of the design model.

H_5: Perceived usefulness of the design model has impact on intention to adopt the model.

H_6: Perceived ease of use of the design model has impact on intention to adopt the model.

5.4 Evaluation Results Analysis

The analysis was done mostly using SPSS version 23 and R version 3.6.1. SPSS was mostly used for descriptive statistics and non-parametric tests, whilst R was mostly used for performing Partial Least squares Path Model. SPSS is a useful package that allows researchers to analyze and transform data. In this study, SPSS assisted me to analyze data collected from questionnaires. The data was captured in a five-point Likert scale.

Partial least squares path model is also good for commands, editing path ways and its graphics on inner and outer models. R is a free open source software for data analysis, statistical computing, and graphics (Sanchez, 2013). R programming is free and has advantages of control, graphics, options, and flexibility as changes can be done through scripts editing. The other reason for choosing R is that it is an extremely powerful program for manipulating and analyzing data. R's persistent popularity has made it the software for statistics and analytics in many disciplines (Sanchez, 2013).

The relationships between latent variables (inner model), indicators (outer model) and bootstrapping procedure, is easily handled through programming in R software. In this context, latent variables are theoretical variables that cannot be measured. However, indicators are variables that are measurable. Bootstrapping procedures include creating a number of samples in order to obtain a number of estimates for each parameter in the partial least squares model. The success (or potential success) of the system designed is mainly based on testing the interrelationships between latent variables and testing of hypotheses. Therefore, the analysis employed partial least squares-path modeling in this analysis. Graphics, direction of pathways, conclusions, limitations, and recommendations are included in the next section.

5.4.1 Descriptive analysis

As presented in section 1.6 on sample size, the sample required for a statistically significant analysis was estimated to be in the range of 80-180 participants (Haenlein, & Kaplan,2004). By using partial least squares path modeling for the evaluation of the software design model, the significant results could be collected at a lower number of that range. This follows that partial least squares path modeling works with small sample sizes (Benitez, Henseler, Castillo, & Schuberth, 2019). It was important to take into consideration, risks such as non-response. In that regard, a sample size was set to approximately 200 participants. Effort was made to design questionnaires well to ensure minimum non-response.

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Data presentation

Table 5-2 Participants by Qualification

		Frequency	Percent	Valid Percent
Valid	Bachelors	87	74.4	75.7
	Masters	21	17.9	18.3
	Doctorate	7	6.0	6.1
	Total	115	98.3	100.0
Missing	System	2	1.7	
Total		117	100.0	

Table 5-3 Participants by Gender

		Frequency	Percent	Valid Percent
Valid	Male	86	73.5	74.1
	Female	30	25.6	25.9
	Total	116	99.1	100.0
Missing	System	1	.9	
Total		117	100.0	

The analysis began by looking at demographic statistics of respondents in the research. From Table 5-2 to Table 5-3 the greater proportion of respondents were undergraduate students made up of 87 out of 117, which was 75.6%; and 86 out of a total of 117 respondents were males, which constituted 74.1%.

Responses from technology adoption form (see Appendix E) were mostly based on Technology Acceptance Model and Task Technology Fit models. The technology acceptance model was made up of Perceived Usefulness, Perceived Ease of Use and Intention to adopt latent variables, whereas the task technology fit is mostly made up of Task characteristics, Technology characteristics and Task Technology Fit latent variables. The responses were captured on a Likert scale (ordinal scale) based on a 1-5 scale.

5.4.2 Non-Parametric Tests: The Mann Whitney U test and Kruskall Wallis Tests

The study employs non-parametric tests since the feedback about the designs from participants is not normally distributed. Non-parametric techniques are usually based on ranks or signs rather than the actual data, and are usually less powerful than parametric tests (Awang, Afthanorhan, & Mamat, 2016).

5.4.2.1 The Mann Whitney U test

The Mann Whitney U test is more suitable if the data is not normally distributed. It tests the hypothesis that the two distributions are the same. The sum of the ranks for each group is used to calculate a single number that can be used to conduct a hypothesis test. If there is no difference between the groups, the sum of the ranks will be similar.

Non-parametric tests can also be used when other assumptions are not met. Non-parametric tests are used for small samples as it is difficult to assess normality (Perme, & Manevski, 2019). The decision rule is based on the significance or non-significance of the p-value. The p- value helps to determine whether the statistical results are significant or not significant. If the p-value is less than 0.05, reject the Null Hypothesis and conclude that results are statistically significance. If the p-value is greater than 0.05, results are not statistically significant so there is weak evidence against null hypothesis.

The Mann Whitney U test was used since it is regarded as a reliable test to compare mean scores when the dependent variable is of an ordinal scale and not normally distributed (Statistics solutions, nd).

Secondary research question

a) Is there significant difference between combined technology acceptance model and task technology fit model results on learning management systems without massive open online courses?

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b) Is there significant difference between combined technology acceptance model and task technology fit model results on learning management systems integrated with massive open online courses?

The Null Hypothesis: There is no significant difference in the acceptance of learning management system without massive open online courses and learning management systems integrated with massive open online courses.

Mann Whitney U test on Technology acceptance model (Intention to adopt)

H_0: There is no significant difference in the intention to adopt learning management systems integrated with massive open online courses and learning management system without massive open online courses.

H_1: There is significant difference in the intention to adopt learning management systems with massive open online courses and learning management system without massive open online courses.

Mathematical formulation

H_0: $\mu 1 = \mu 2$ (Intention to adopt levels are the same)

H_1: $\mu 1 > \mu 2$ (The intention to adopt existing learning management systems is higher than acceptance levels of learning management with massive open online courses. Existing designs are overrated)

H_1: $\mu 1 < \mu 2$ (The intention to adopt existing learning management systems is lower than integrated designs. Existing systems are underrated)

Table 5-4 Mann Whitney U test on Intention to adopt model Test across qualification group

	Integrated designs should be used as much as possible	The use of new technologies in higher education should be recommended	Universities could be ready to implement the integrated model	Universities would consider investing in resources for implementing the designs	Students are likely to engage mobile services
Mann-Whitney U	849.000	865.000	801.000	830.500	906.000
Wilcoxon W	4677.000	4693.000	1032.000	1061.500	1137.000
Z	-.544	-.409	-.947	-.736	-.063
p-value	.586	.682	.344	.462	.950

Grouping Variable: Qualification

Conclusion: Table 5-4 reveals that the p-values are more than 0.05 which presents strong evidence to conclude at a 95% level of confidence there are no significant differences between TAM/TTF results on learning management system alone and TAM/TTF outcomes on the integrated software model H0: μ 1= μ 2, H1: μ 1> μ 2 (underrating), H1: μ 1< μ 2 (overrating designs). This outcome is acceptable on two philosophical opinions. If the outcome had been H1: μ 1> μ 2, it would have meant that the proposed learning management system integrated with massive open online courses would need to exist for a while before they reach the levels at which current learning management systems are accepted. That does not bring much hope. If the results supported alternative hypothesis H1: μ 1< μ 2, this would have meant overrating the designs before implementation. The problem of underrating the designs is with the time it would take for the integrated designs to reach the same level at which learning management systems are, before we can derive an implication. It is not certain how long it would take for the integrated designs to reach the same level as existing learning management system because software designs generally have a life span of five years. If it takes more than five years, it means designs would get obsolete before the universities reap from technological investment results, which is a problem in software engineering circles.

The next part of Mann Whitney U tests will explore if there are significant differences in mean/median responses across qualification and gender groups on task technology fit.

Mann Whitney U test on Task characteristics (TAC)

H_0: There is no significant difference in the intention to adopt learning management systems integrated with massive open online courses and learning management system without massive open online courses

H_1: There is significant difference in the intention to adopt learning management systems with massive open online courses and learning management system without massive open online courses.

Mathematical formulation

H0: $\mu 1 = \mu 2$(Intention to adopt levels are the same)

H_1: $\mu 1 > \mu 2$(The intention to adopt existing learning management systems is higher than acceptance levels of learning management with massive open online courses. Existing designs are overrated)

H1: $\mu 1 < \mu 2$(The intention to adopt of existing learning management systems is lower than acceptance levels of integrated designs. Existing systems are underrated)

Table 5-5 Mann Whitney U test on TAC characteristics

	Lecturers can be partially relieved from uploading content	Student can access content anytime, anywhere	Automated uploading of content to repositories	Learning content can be shared among repositories	Lightweight devices can be compatible with the query management interface
Mann-Whitney U	303.500	248.000	216.500	246.000	143.500
Wilcoxon W	331.500	4076.000	244.500	274.000	171.500
Z	-.015	-.886	-1.341	-.909	-2.464
p-value	.988	.376	.180	.363	.014

a. Grouping Variable: Qualification

The p-values in Table 5-5 are more than 0.05, showing that there is strong evidence that the effect of integrating learning management system with massive open online courses towards acceptance does not hold much for the acceptance of learning management system alone. This means that the integration is well paired at the same level and still performs the same before implementation. That gives us hope that after implementation it is likely to go to the positive side if it managed to move from nowhere to being equal to existing learning management systems, showing no significant difference at 95% level of confidence. Which means should there be differences on designs at this point, that would hold only 5 percent.

The next part of Mann Whitney U tests will explore if there are significant differences in mean/median responses across qualification and gender groups on task technology fit.

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Mann Whitney U test on Task Technology Fit Test Statistics

H_0: There is no significant difference in the intention to adopt of learning management systems integrated with massive open online courses and learning management system without massive open online courses

H_1: There is significant difference in the intention to adopt learning management systems with massive open online courses and learning management system without massive open online courses.

Mathematical formulation

H_0: $\mu 1 = \mu 2$(Intention to adopt levels are the same)

H_1: $\mu 1 > \mu 2$(The intention to adopt existing learning management systems are higher than acceptance levels of learning management with massive open online courses. Existing designs are overrated).

H_1: $\mu 1 < \mu 2$(The intention to adopt of existing learning management systems is lower than acceptance levels of integrated designs. Existing systems are underrated).

Table 5-6 Mann Whitney U test on TTF qualification MSc and Doctoral Test Statistics

	Model functions are adequate	Model functions are appropriate	Model functions are useful	Model functions are compatible with task	Model functions would make the task very easy	Functionalities of model meet learner needs
Mann-Whitney U	52.000	48.000	69.000	60.000	31.500	64.000
Wilcoxon W	80.000	76.000	300.000	88.000	59.500	295.000
Z	-1.245	-1.559	-.291	-.782	-2.614	-.541
p-value	.213	.119	.771	.434	.009	.588

a. Grouping Variable: Qualification

Conclusion: Table 5-6 reveals that the p-values are more than 0.05.This presents strong evidence to conclude at a 95% level of confidence there are no significant differences between combined TAM and TTF results on learning management system alone and combined TAM and TTF outcomes on the integrated software model. We retain the null hypothesis-values from Table 5-6 which shows favorable results. This is good in that these are design models which we do not expect to outperform learning management systems that have been tried and tested. Since these are still models it allows us to retain the null hypothesis that there is no significant difference. So, people still see the integrated model as equally important the same way they have invested in deploying learning management system which is likely to move in the positive should we implement the design model.

Rejecting means software design model outclasses the learning management system. If present learning management system outclasses our integrated design model, then it means our software models have a long journey to get to acceptance levels of learning management system is which dilutes our efforts. If our learning management systems integrated with massive open online courses go above, it means they are overrated for them to get there even before implementations. Thus, getting to retain the null hypothesis which is equality (H_0: $\mu1= \mu2$) was more promising.

Conclusion on Mann Whitney U tests

The results generally show that p-values that are more than 0.05 serve for one instance where p-value is 0. 023. Hence, there is strong evidence to conclude at a 95% level of confidence that there is no significant difference between technology acceptance model and task-technology fit results on learning management system alone, against the integrated version. Not having significant difference means the idea is equally accepted as something that is already on the ground, which is a promising result. No underrating of software model or overrating is a positive outcome.

P-values bigger than 0.05 tell us that we have strong evidence to accept the null hypothesis. The null hypothesis is, there is no significant difference in the intention to adopt learning management without massive open online courses and learning management system integrated with massive open online courses. Therefore, there is no significant difference with regards to how they are accepted by students, software engineering experts and lecturers. The way they see learning management system value to teaching and learning is the very same way they see learning management system integrated with massive open online courses' value to teaching and learning so the results show no significant difference between the two. If that is the case, we have strong evidence to accept that it means we are on the right track. Suppose we had the other result, where $p < 0.05$[3], it would mean either learning management system integrated with massive open online courses is accepted better or learning management system without massive open online courses is accepted better. Either way, it would mean starting too far from the level of being accepted before we can outperform what is in existence, and that is not promising.

5.4.2.2 The Kruskall-Wallis Non-Parametric Tests

The Kruskall-Wallis test is a non-parametric test applied to test if there are significant differences in the dependent ordinal variable when one has three or more independent categorical factors. Kruskal-Wallis compares the medians of two or more samples to determine if the samples came from different populations. It is an extension of the Mann–Whitney U test to three or more groups. The distributions do not have to be normal and the variances do not have to be equal. In the current research the Kruskal–Wallis test is applied to test if there are significant differences in the mean responses on Intention to adopt, Perceived Usefulness, Perceived Ease of Use and Task-Technology Fit.

[3] There is one instance where p-value is 0. 023

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Integrated designs should be used as much as possible is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.602	Retain the null hypothesis.
2	The distribution of The use of new technologies in higher education should be recommended is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.770	Retain the null hypothesis.
3	The distribution of Universities could be ready to implement the integrated model is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.233	Retain the null hypothesis.
4	The distribution of Universities would consider investing in resources for implementing the designs is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.323	Retain the null hypothesis.
5	The distribution of Students are likely to engage mobile services is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.915	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Using this integrated design can enable the learners to interact more with content is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.913	Retain the null hypothesis.
2	The distribution of Generally, the system is not practical is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.835	Retain the null hypothesis.
3	The distribution of I think the integrated model can facilitate learning is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.936	Retain the null hypothesis.
4	The distribution of The integrated designs cannot reduce lecturer workload is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.850	Retain the null hypothesis.
5	The distribution of The use of Learning Management Systems and MOOCs is compatible with existing hardware and software in our universities is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.514	Retain the null hypothesis.
6	The distribution of The technology infrastructure of our universities is unavailable for supporting the design model is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.050	Retain the null hypothesis.
7	The distribution of The designs facilitate collaboration is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.480	Retain the null hypothesis.
8	The distribution of Improved relevant content is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.380	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Table 5-7 The Kruskal-Wallis test on Perceived Ease of Use on equality of medians across Qualification

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Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of I think it does not need a lot of effort and time to search for information on the platform is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.644	Retain the null hypothesis.
2	The distribution of I think the functions in the model are easy to understand is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.790	Retain the null hypothesis.
3	The distribution of I think the interfaces are ideal for limited bandwidth is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.048	Reject the null hypothesis.
4	The distribution of I think the processes accommodate interrupted communication is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.207	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Null Hypothesis: There is no significant difference among the mean/median responses on Dependent variables (Intention to adopt, Perceived Usefulness, Perceived Ease of Use and Task-Technology fitness).

Table 5-8 The Kruskal-Wallis test on Intention to adopt on equality of medians across Qualification

The Kruskal-Wallis test results at the 5% level of significance, and all the p-values are more than 0.05 in value. It can be concluded that there is strong evidence to retain the null hypothesis.

Table 5-9 The Kruskal-Wallis test on Perceived Usefulness on equality of medians across Qualification

The results from Table 5-7 above revealed that the Kruskall-Wallis test indicators for testing equality of medians across the qualification group was insignificant since p-values were more than 0.05 except for the indicator on interface distribution being ideal for limited bandwidth. In this indicator, the p-value is 0.048<0.05; hence, we reject the Null hypothesis on equality of medians across the qualification grouping.

Table 5-10 The Kruskal-Wallis test on Task Characteristics on equality of medians across Qualification

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Lecturers can be partially relieved from uploading content is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.644	Retain the null hypothesis.
2	The distribution of Student can access content anytime,anywhere is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.154	Retain the null hypothesis.
3	The distribution of Automated uploading of content to repositories is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.298	Retain the null hypothesis.
4	The distribution of Learning content can be shared among repositories is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.618	Retain the null hypothesis.
5	The distribution of Lightweight devices can be compatible with the query management interface is the same across categories of Qualification.	Independent-Samples Kruskal-Wallis Test	.027	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

The Kruskal-Wallis test on Task Characteristics reveal that only the indicator variable distribution of light weight devices being compatible with query management interface was significantly different across the qualification group since the p-value was less than 0.05.

5.5 Combined Technology Acceptance Model and Task-Technology Fit Analysis

The analysis for the evaluation of the design model, employed the Partial Least Squares-Path Modeling is a statistical data analysis methodology that is found at the intersection of Regression Models, Structural Equation Models, and Multiple Table Analysis methods. From past studies, Chin (2010) reported that partial least squares-path modeling more likely required a smaller sample size for modeling. ‘‘Partial least squares is most appropriate when sample sizes are small, when assumptions of multivariate normality and interval scaled data cannot be made, and when the researcher is primarily concerned with prediction of the dependent variable’’ (pp. 646–647) (Birkinshaw, Morrison & Hulland, 1995). Partial least squares path modeling has features suitable for prediction-oriented research (Henseler et al., 2009); hence, it is applicable to this study since the study wanted to ascertain the extent of the proposed integrated software design model’s compliance with known technology adoption models for potential implementation and installation in universities in Zimbabwe.

In this study, there are basically six constructs or factors, namely: Task Characteristics, Technology Characteristics, Task Technology Fit, Perceived Usefulness, Perceived Ease of Use and Intention to Adopt Model. Each construct has manifest or observed variables. Manifest variables can be measured or observed. The Partial least squares path modeling is split into the measurement model (also called the outer model) where relationships between latent variables and manifest variables are analysed, and the structural model (also called the inner model), where relationships between latent variables (LR) are analyzed too.

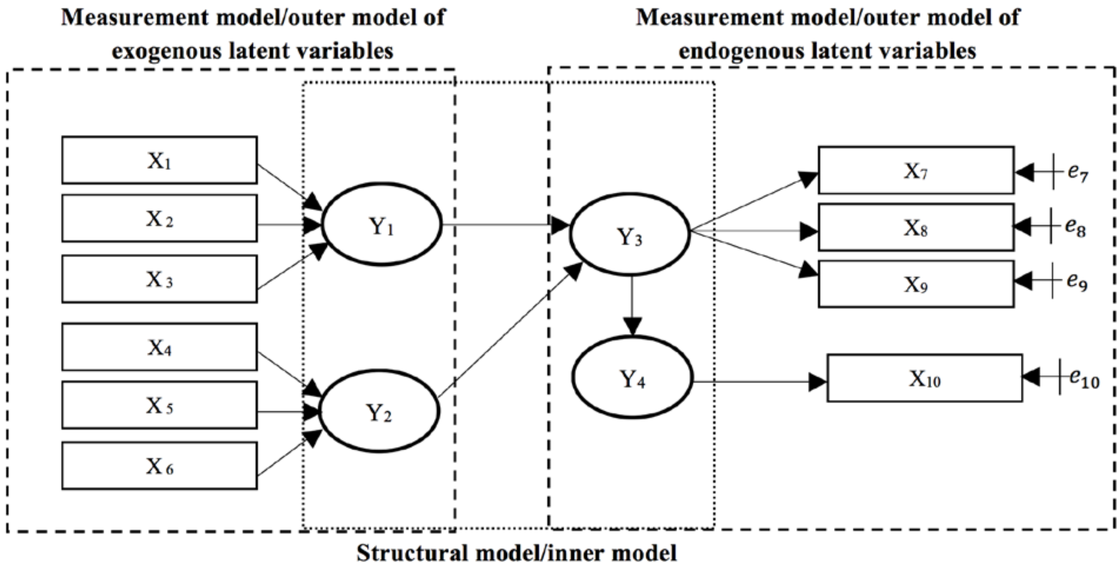

Figure 5-2 An example of a path model (Hair Jr, Hult, Ringle, & Sarstedt, 2014)

In the path models, diagrams are used to provide a visual impact of the hypotheses and relations based on theory among variables. In Figure 5-2, the latent constructs are labelled Y_1 through Y_4), the manifest variables are labelled X_1 through X_{10} indicators. Arrows represent relations between indicators and constructs, and between constructs and constructs. In the context of partial least squares path modeling, arrows that point unidirectional show a predictive relation and that indicates causal relationship. E_7 through E_{10} show error terms that are linked to the endogenous construct whose values are determined by other variables (Hair et al., 2014).

The measuring theory stipulates how the latent variables (constructs) are measured. There exist two measuring scales in the structuring equation domain that is reflexive and formative. Reflective measures are influenced by latent variables whereas formative variables influence latent variables. The reflexive indicators are the most used in the literature (Rodgers & Guiral, 2011). A popular example of a reflective model Information systems research is ‘perceived ease of use’ (Davis et al., 1989). Perceived ease of use is described as the level to which one thinks using a technology would be effortless. Perceived ease of use is measured by six constructs (easy to learn, controllable, clear and understandable, flexible, easy to become, and easy to use (Freeze & Raschke, 2007). Thus, an increase in perceived ease of use is reflected by an increase in all the six measures. All measures are expected to correlate.

The analysis in the current research employed reflective measures (Mode A). The partial least squares path modeling analysis in the current research was split into four parts, namely:

- the original hypothesized framework (Figure 5-1);
- the modified framework where latent variables or blocks (Technology Task characteristics [Task_char] is an independent variable to Perceived Usefulness [Perc_usef],Perceived Ease of Use [Perc_eas], and Intention to adopt [Int_adop_mod];Latent variables Task characteristics and Technology characteristics [Tech_char] are also independents for predicting Perceived Usefulness and Perceived Ease of use,
- bootstrapping the original sample; and
- bootstrapping the modified model framework.

5.6 A The original Partial Least Squares path modeling model based on Figure 5-1

To start the process of building the partial least squares path modeling model, the main ingredients were prepared for partial least squares path modeling function, plspm(). The model’s parameters comprised of the inner model, the list of blocks, and the vector modes. Table 5-11 depicts the inner model which is presented in matrix format.

Table 5-11 The inner model: path matrix

Task_char [4]= c(0, 0, 0, 0, 0, 0)
Tech_char = c(0, 0, 0, 0, 0, 0)
Task_tech_fit=c(1, 1, 0, 0, 0 ,0)
Perc_usef=c(0, 0, 1, 0, 0, 0)

[4] Task_char(Task characteristics);Tech_char (Technology characteristics);Task_tech_fit (Task technology fit); Perc_usef (Perceived usefulness); Perc_eas(Perceived ease of use);Int_adop_mod(Intention to adopt model)

Perc_eas=c(0, 0, 1, 0, 0, 0)

Int_adop_mod=c(0, 0, 0, 1, 1, 0)

TAM_TTF_path

	Task_char	Tech_char	Task_tech_fit	Perc_usef	Perc_eas	Int_adop_mod
Task_char	0	0	0	0	0	0
Tech_char	0	0	0	0	0	0
Task_tech_fit	1	1	0	0	0	0
Perc_usef	0	0	1	0	0	0
Perc_eas	0	0	1	0	0	0
Int_adop_mod	0	0	0	1	1	0

TAM_TTF_path=rbind(Task_char, Tech_char, Task_tech_fit, Perc_usef, Perc_eas, Int_adop_mod)

A path diagram for the inner model is drawn in R to visualize the situation.

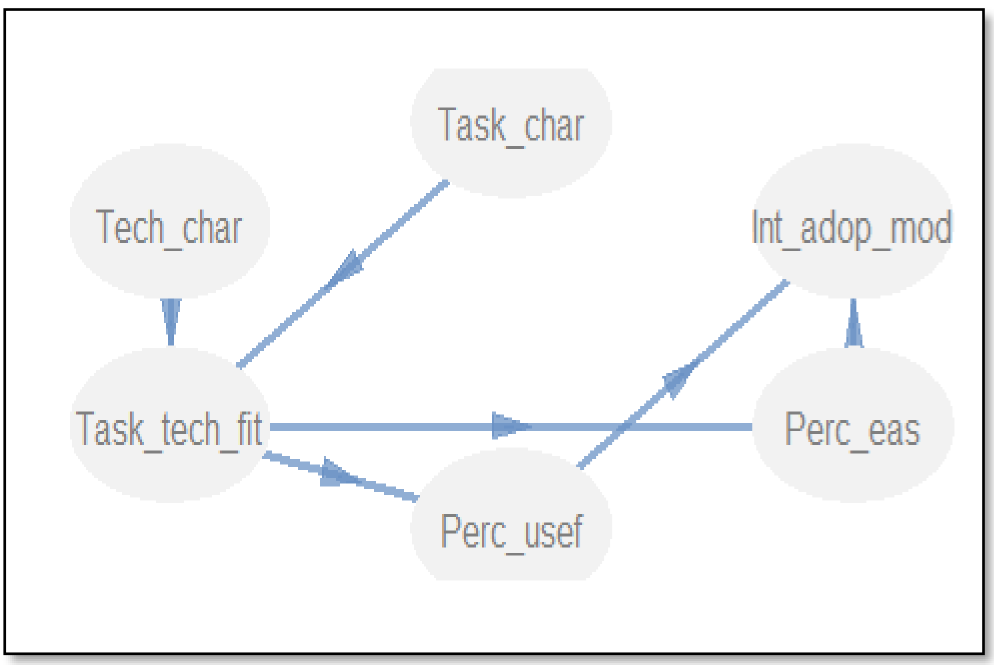

Figure 5-3 Visualizing the path diagram of the inner model with innerplot

The second ingredient for plspm () is the list defining the blocks of the measurement (outer) model and the measurement type to be used (reflective indicators in this case):

The diagnosis of a partial least squares-path model begins with assessing the quality of the measurement model. Reflective indicators were used in the analysis. The manifest variables or indicators in a reflective block are considered as being caused by their latent variable (i.e. reflective manifest variables are indicating the same latent variable).

Table 5-12 Unidimensionality of blocks

BLOCKS DEFINITION

	Block	Type	Size	Mode
1	Task_char	Exogenous[5]	5	A
2	Tech_char	Exogenous	7	A
3	Task_tech_fit	Endogenous	6	A
4	Perc_usef	Endogenous	8	A
5	Perc_eas	Endogenous	4	A
6	Int_adop_mod	Endogenous	5	A

Table 5-12 results analysis top part shows summary statistics of each latent variable and mode type. The number of indicators/manifest variables is shown as size for example construct or block Task characteristics has five indictors. All the relationships between latents and indicators are treated as reflective; hence, mode A. It can be noted in the inner model analysis that some blocks or latents are treated as independents. These include Task characteristics and Technology characteristics, whereas Task technology fit is treated as a dependent variable for the first inner model prediction. Also, some variables act as both independents and dependents. Task_tech fit is an independent variable which is also employed to predict Perceived usefulness and Perceived ease of use. An inner plot of each block through visualizing the loadings/correlations is shown in Figure 5-4 below. The two blocks; Perceived Ease of use and Intention to adopt, have been shown to be problematic with red arrows on the respective indicators PE1 and IA4 respectively. They show negative loadings with their respective constructs.

[5] An exogenous variable is a latent variable which never appears as a dependent variable. Otherwise it is called an endogenous variable.

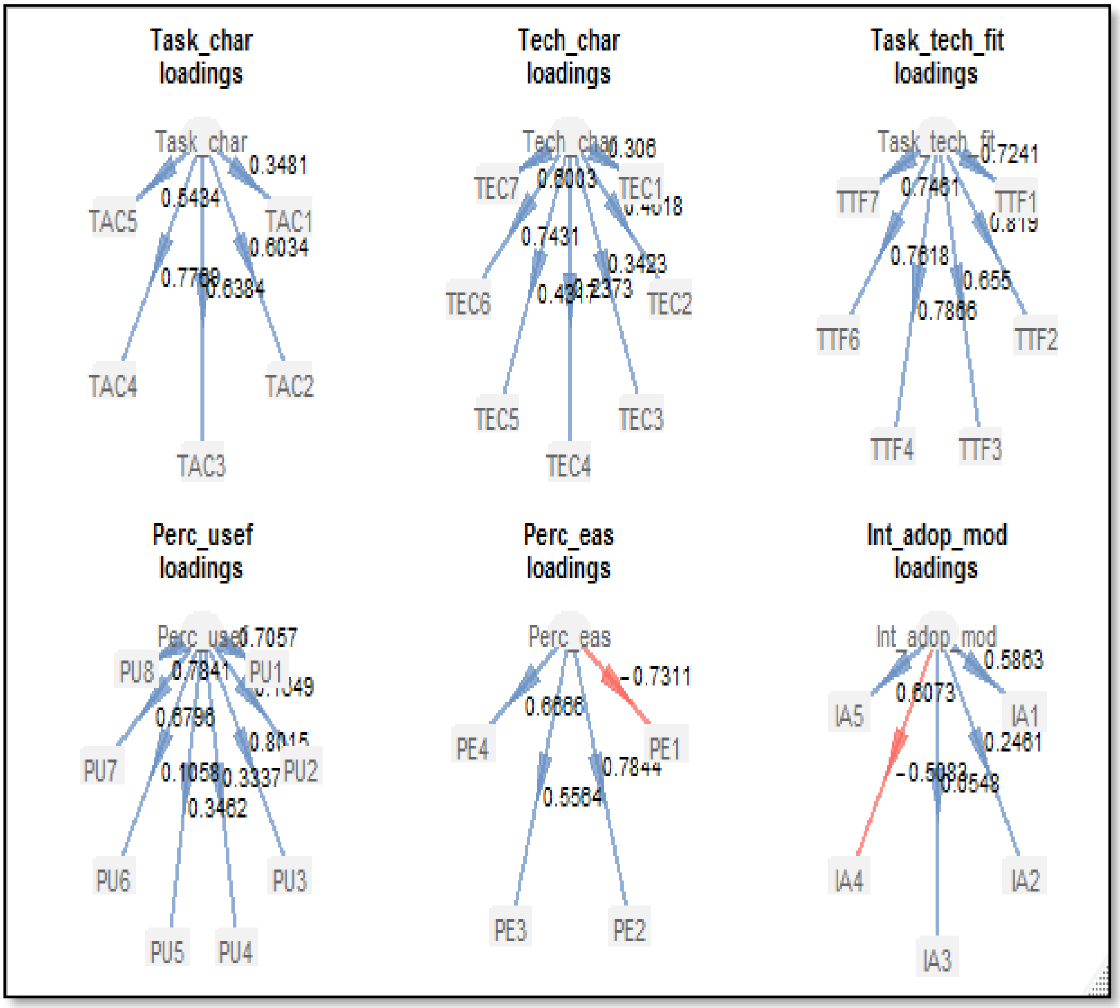

Figure 5-4 Visualization of loadings/correlations in each block

5.7 Partial least squares-path modeling Round 2

What can be done to change these indicators? They need to be rephrased; for example, a) I think it does not need a lot of effort and time to search for information on the platform (PE1) > It needs little effort and time to search information (PE1a).

b) Universities would consider investing in resources for implementation (IA4)>Universities should actually invest resources for implementation (IA4a).

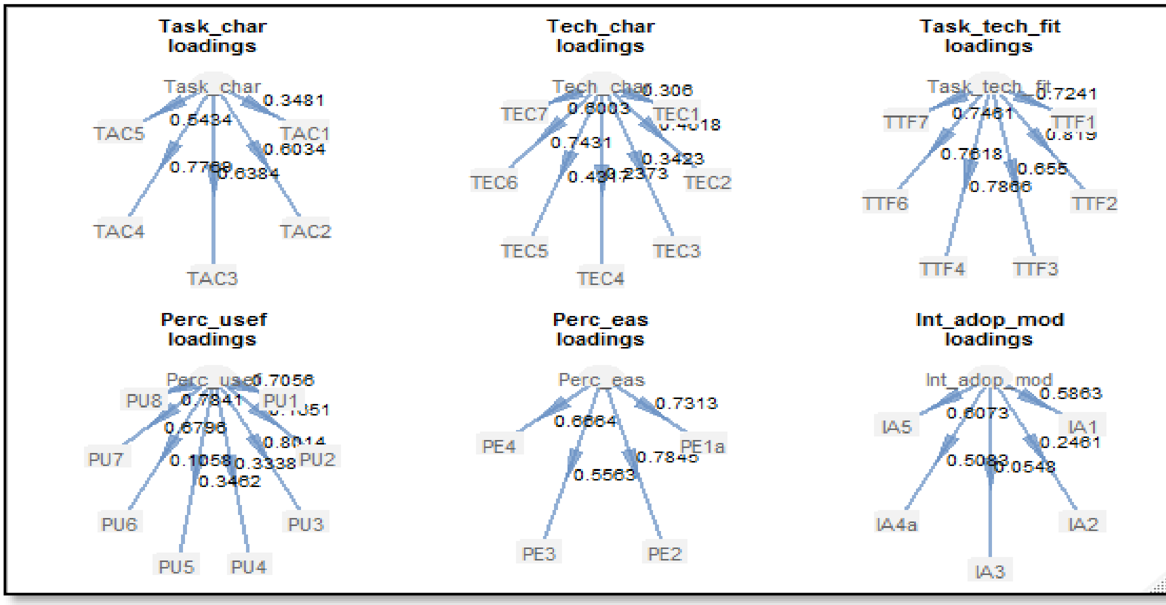

Figure 5-5 Visualization of loadings/correlations in each block

From Figure 5-5, it can be observed that after redefining variables PE to PE1a, and IA4 to IA4a, the arrows seem to point in one direction. However, the results show that it can be observed that variable IA3 has a low loading. At this point in time, it also important to analyse the cross loadings.

5.8 Cross-loadings

At this stage, loadings of indicators and their latent variables are reviewed. This is done with the rest of latent variables to ensure that trait indicators are removed. Any loading in these sections is expected to be higher than all other loadings with other constructs. If an indicator loads higher with other constructs than the one it is intended to measure, then it means it may not be suitable to include it in the model. Such an indicator does not clearly show which construct it is reflecting. Ideally, reflective indicators[6] need to be aligned with their latent variables, showing that they belong to a sole latent variable. Otherwise, if one indicator loads higher on a specific construct, then they become traitor indicators[7] .

[6] Reflective indicators are caused by construct; they can be directly measured and are correlated among each other (IGI Global,nd)

[7] A traitor indicator or variable is an indicator that loads higher with other constructs than the one it is intended to measure

The results in Appendix F show cross-loadings of original path model variables highlighted; namely, TEC4 (under technology characteristics block), PU2, PU4, PU5 (all under Perceived usefulness block) and IA3 (under Int_to_adop_mod block), as traitor variables since their loadings are less than loadings in a different block they block to. Such variables should be dropped. The next analysis will look at both the inner (structural model) and the outer model (measurement model) without these variables as part of the analysis in round 3.

5.9 Partial least squares path modeling Round 3: dropping traitor variables

After dropping the variables mentioned in section 5.7 from second round of the path model analysis, it can be observed that the variable PU6 also has a low loading with its block, and it should be a candidate of removal from the path modeling analysis. Appendix G presents round 3 without traitor variables.

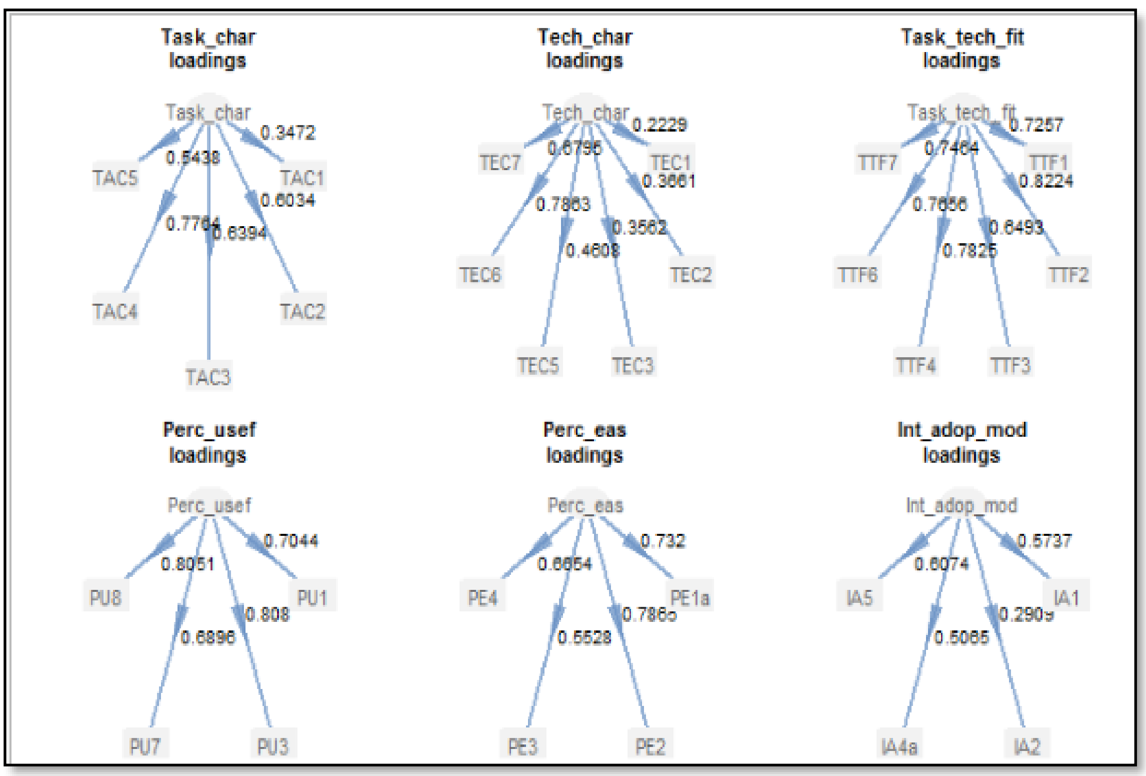

Figure 5-6 Visualization of loadings without 'traitor' loadings

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The outer model (Measurement model)

The cross loadings column removed ambiguity of traitor variables. The outer model plot (measurement model) in Figure 5-6 no longer has indicators pointing in opposite direction. Most indicators have loadings of at least 0.45 in value and can be good.

The inner model (the structural model)

The inner model analysis in Table 5-13 reveals that the relationships between the latents are positive and significant since p-values are less than 0.05 with the exception of Int_adop_mod and Perc_eas of use relationship which is negative and insignificant since p-value is more than 0.05. The model can be taken as acceptable and better under these circumstances.

Table 5-13 consists of four columns that provide measures of the significance of the path coefficients. The columns are estimate, standard error, t-value and probability p (> |t|). Estimate is partial least squares path modeling estimate of path coefficient. Standard Error is the statistical standard deviation of the path coefficient estimates mean. T value is a single-tailed t-test showing the standardized t score. The last column Probability p (> |t|) is the probability calculated from t value at the 95% significance level.

Table 5-13 Inner model coefficients table results

Inner Model

$Task_tech_fit

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	5.76e-17	0.0770	7.49e-16	1.00e+00
Task_char	4.08e-01	0.0796	5.13e+00	1.22e-06
Tech_char	3.08e-01	0.0796	3.87e+00	1.84e-04

$Perc_usef

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	7.29e-18	0.076	9.59e-17	1.00e+00
Task_tech_fit	5.80e-01	0.076	7.64e+00	7.11e-12

$Perc_eas

	Estimate	Std. Error	t value	Pr(>|t|)

Intercept	4.88e-17	0.0812	6.01e-16	1.00e+00
Task_tech_fit	4.91e-01	0.0812	6.05e+00	1.88e-08

$Int_adop_mod

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	1.45e-16	0.0884	1.64e-15	1.000000
Perc_usef	3.68e-01	0.1011	3.64e+00	0.000413
Perc_eas	-1.04e-01	0.1011	-1.03e+00	0.304112

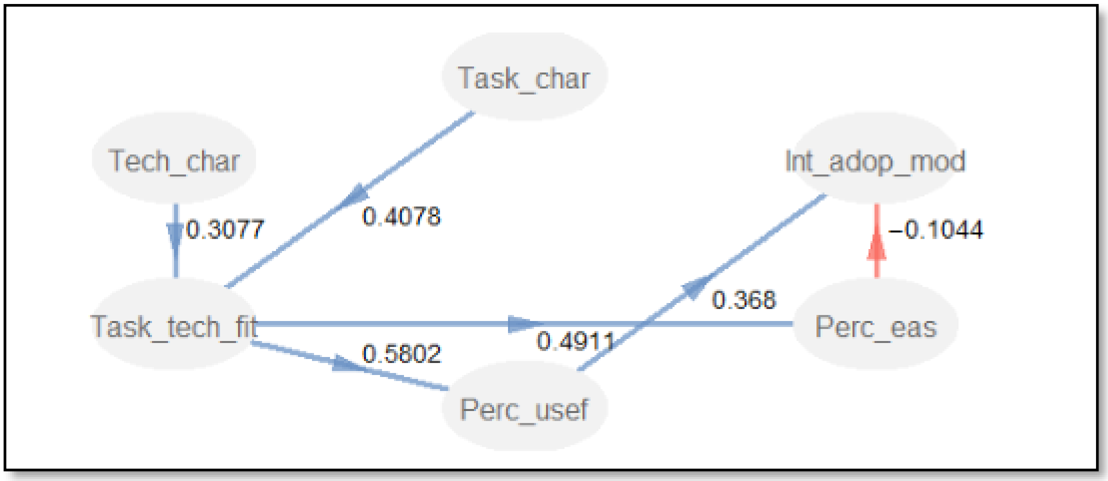

Figure 5-7 The inner model with path coefficients

Table 5-14 presents the table of effects. This table contains the effects that each construct has on the rest of constructs by taking into consideration the total number of connections in the inner model. The direct effects are given by the path coefficients. But there are also indirect effects and the total effects. An indirect effect is the influence of one construct on another construct by taking an indirect path. The total effects are the sum of both the direct and indirect effects.

Total Path Effects: the effects that a construct has on other constructs in the inner model. The direct effects (path coefficients) and the indirect effects (effect via an indirect path) can be summed to calculate the total effect.

Table 5-14 Direct, Indirect and Total Effects

TOTAL EFFECTS

	relationships	direct	indirect	total
1	Task_char -> Tech_char	0.000	0.0000	0.0000
2	Task_char -> Task_tech_fit	0.408	0.0000	0.4078
3	Task_char -> Perc_usef	0.000	0.2366	0.2366
4	Task_char -> Perc_eas	0.000	0.2003	0.2003
5	Task_char -> Int_adop_mod	0.000	0.0662	0.0662
6	Tech_char -> Task_tech_fit	0.308	0.0000	0.3077
7	Tech_char -> Perc_usef	0.000	0.1785	0.1785
8	Tech_char -> Perc_eas	0.000	0.1511	0.1511
9	Tech_char -> Int_adop_mod	0.000	0.0499	0.0499
10	Task_tech_fit -> Perc_usef	0.580	0.0000	0.5802
11	Task_tech_fit -> Perc_eas	0.491	0.0000	0.4911
12	Task_tech_fit -> Int_adop_mod	0.000	0.1622	0.1622
13	Perc_usef -> Perc_eas	0.000	0.0000	0.0000
14	Perc_usef -> Int_adop_mod	0.368	0.0000	0.3680
15	Perc_eas -> Int_adop_mod	-0.104	0.0000	-0.1044

The table of results, Table 5 15, shows that most of the direct and indirect effects relationships are positive apart from perceived ease of use and Intention to adopt model which are negative. This validates the point that the theoretical model is better and suitable to model the interrelationships between the blocks or latents.

5.10 The modified model framework B

The modified framework were latent variables/blocks namely:

i) Technology Task characteristics is an independent variable to both Perceived Usefulness, Perceived Ease of Use, and Intention to adopt.

ii) ii) Latent variables Task characteristics and Technology characteristics are also independents for predicting Perceived Usefulness and Perceived Ease of use.

To start the path model building process, there was need to prepare the main ingredients for plspm():the path matrix, the list of blocks, and the vector modes.

The inner model: path matrix

Task_char=c(0, 0, 0, 0, 0, 0)

Tech_char=c(0, 0, 0, 0, 0, 0)

Task_tech_fit=c(1, 1, 0, 0, 0 ,0)

Perc_usef=c(1, 1, 1, 0, 0, 0)

Perc_eas=c(1, 1, 1, 0, 0, 0)

Int_adop_mod=c(0, 0, 1, 1, 1, 0)

TAM_TTF_path=rbind(Task_char, Tech_char, Task_tech_fit, Perc_usef, Perc_eas, Int_adop_mod)

A path diagram for the inner model is drawn in R to visualize the situation.

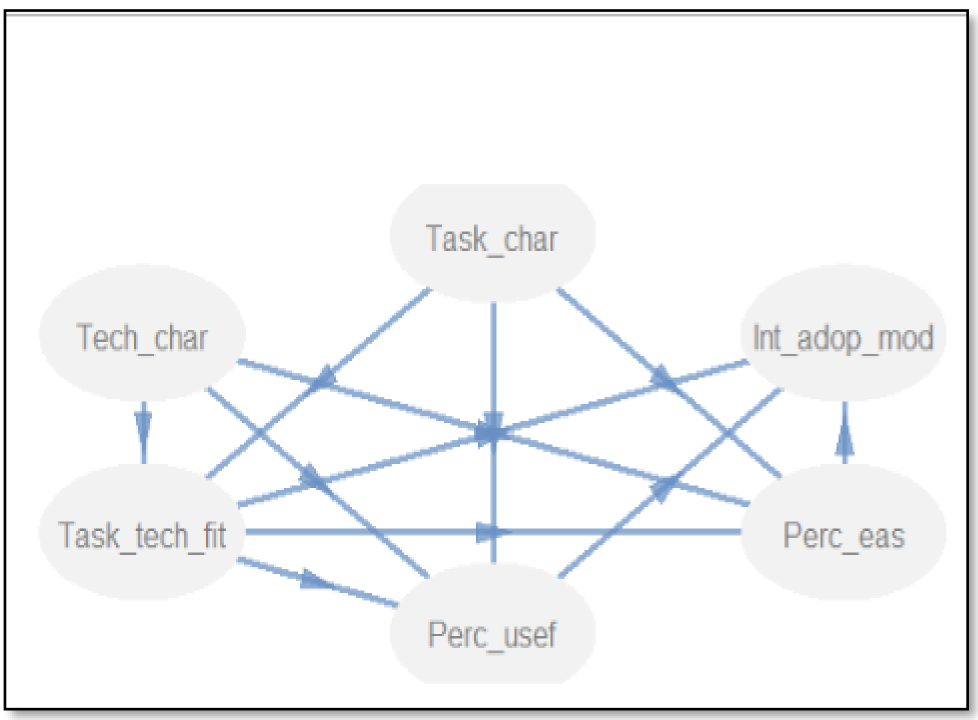

Figure 5-8 Modified model path diagram of the inner model

The unidimensionality of the block matrix

The analysis of a partial least squares-path model starts with evaluating the quality of the measurement model. Since they were reflective indicators, the unidimensionality of the blocks needed to be checked. Unidimensional suggests that the reflective indicators must be connected point to point in a measurable space. The manifest variables in a reflective block are considered as being caused by their latent variable (i.e. reflective manifest variables are indicating the same latent variable).

5.11 Partial Least Squares Path Modeling

Changing constructs PE1 to PE1a and IA to IAa yielded loadings plots visualizations as shown in Figure 5-9. The modified framework diagram in Figure 5-9 shows that indicator variable PU6 had a very low loading of 0.0579, and could be considered for removal from the model.

Table 5-15 Partial Least Squares Path Modeling (PLS-PM)

The table focuses on unidimensionality analysis; mainly looking at validity of each block/latent by looking at Cronbach's alpha and Dillon-Goldstein's rho.

MODEL SPECIFICATION

1	Number of Cases	117
2	Latent Variables	6
3	Manifest Variables	30
4	Scale of Data	Standardized Data
5	Non-Metric PLS	FALSE
6	Weighting Scheme	centroid
7	Tolerance Crit	1e-06
8	Max Num Iters	100
9	Convergence Iters	7
10	Bootstrapping	FALSE
11	Bootstrap samples	NULL

BLOCKS DEFINITION

.

	Block	Type	Size	Mode
1	Task_char	Exogenous	5	A
2	Tech_char	Exogenous	6	A
3	Task_tech_fit	Endogenous	6	A
4	Perc_usef	Endogenous	5	A
5	Perc_eas	Endogenous	4	A
6	Int_adop_mod	Endogenous	4	A

BLOCKS UNIDIMENSIONALITY

	Mode	MVs	C.alpha	DG.rho	eig.1st	eig.2nd
Task_char	A	5	0.5241	0.718	1.81	1.134
Tech_char	A	6	0.5638	0.728	1.96	1.102
Task_tech_fit	A	6	0.8444	0.886	3.39	0.866
Perc_usef	A	5	0.6671	0.790	2.29	0.998
Perc_eas	A	4	0.6425	0.788	1.94	1.089
Int_adop_mod	A	4	0.0713	0.391	1.16	1.068

A good block/latent must have a minimum of 0.7 (on at least one of the two measures). It can be noted that the most problematic block is the Intention to adopt model which has low value 0.0713.To have a better idea, inner plot of each block through visualizing the loadings/correlations is shown in Figure 5-9.

Using the same approach on changing variables, PE1 to PE1a and IA to IAa yields loadings plots visualizations as in Figure 5-9. The modified framework diagram in *Figure 5-9* shows that indicator variable PU6 had a very low loading of 0.0579 and could be considered for removal from the model.

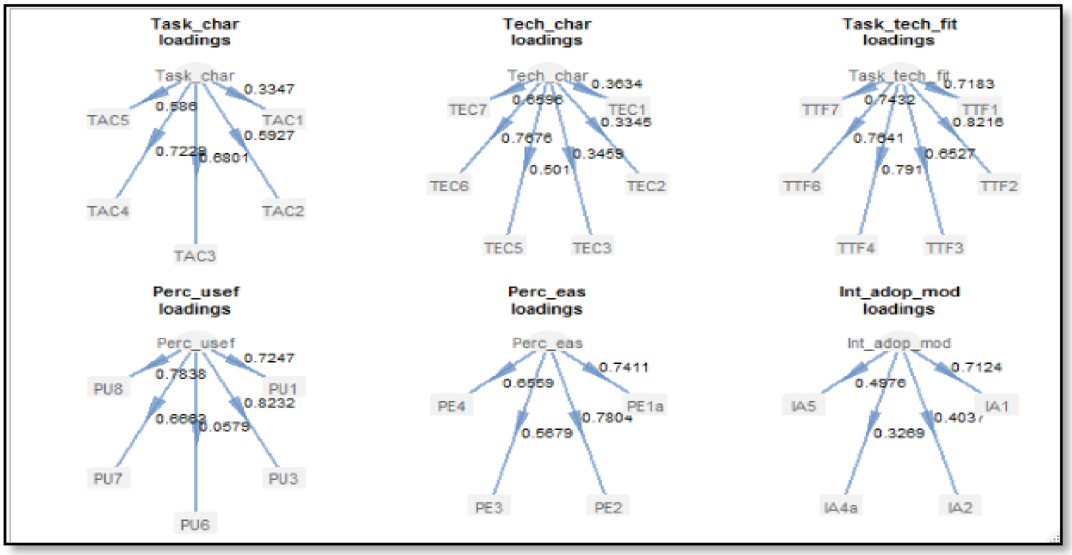

Figure 5-9 Visualisations loadings plots of modified framework

The next step involved dropping the 'traitor variables'; variables which cross loads with latents or blocks beyond their original ones. Also considered was dropping variable PU6 from the modified framework of the partial least squares path modelling since it had very small insignificant loading.

outer model8

modes (reflective blocks)

TAM_TTF_adop_modes = rep ("A", 6)

TAM_TTF_adop_blocks2 = list (1:5, c (6, 7, 8, 10, 11,12), 25:30, c (13, 15, 19,20), c(38,22 , 23, 24), c(31, 32,39,35))

apply plsp_mod2

TAM_TTF_adop_pls_mod2 = plspm(Tech_adop, TAM_TTF_path, TAM_TTF_adop_bloc ks2,modes = TAM_TTF_adop_modes)

Summary (TAM_TTF_adop_pls_mod2)

#outer model8

> # modes (reflective blocks)

> TAM_TTF_adop_modes = rep("A", 6)

> TAM_TTF_adop_blocks2 = list(1:5, c(6, 7, 8, 10, 11,12), 25:30, c(13, 15, 19,20),c(38,22 , 23, 24), c(31, 32,39,35))

> # apply plsp_mod2

> TAM_TTF_adop_pls_mod2 = plspm(Tech_adop, TAM_TTF_path, TAM_TTF_adop_blocks2,modes = TAM_TTF_adop_modes)

> summary (TAM_TTF_adop_pls_mod2)

Appendix H presents final partial least squares path modeling output for modified partial least squares path modeling. Table of summary results reveals no more cross loadings since ‘traitor’ variables had been dropped. The cross loadings column has removed ambiguity of traitor variables. The outer model plot (measurement model) in Figure 5-10, no longer has indicators pointing in the opposite direction. Most indicators have loadings of at least 0.45 in value, and can be good.

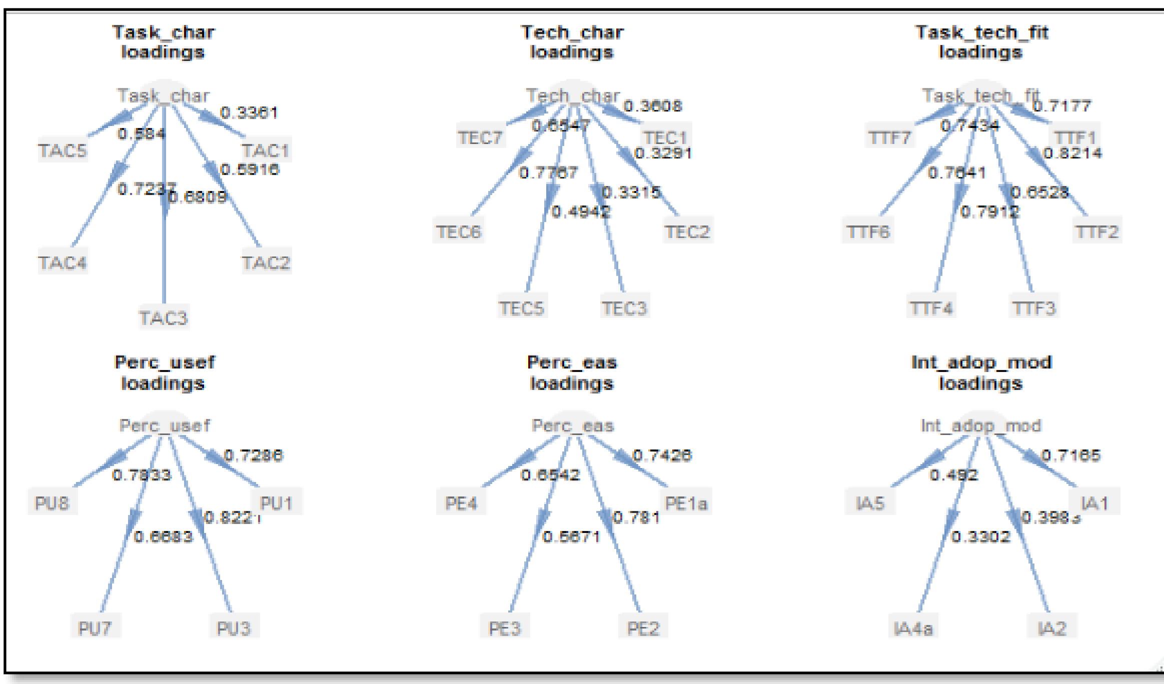

Figure 5-10 Visualizations plots of loadings in modified PLS_PM model

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The inner (structural) model

Firstly, an inner model (structural model), that is the determination of path relationships between latent variables is done. Estimates of loadings between latent variables/ blocks and p-values are done. A parameter is significant if a p-value is less than 0.05.

Table 5-16 consists of four columns that provide measures of the significance of the path coefficients. The columns are estimate, standard error, t value and probability p (> |t|). Estimate is PLS-PM estimate of path coefficient. Standard Error is the statistical standard deviation of the path coefficient estimates mean. T value is a single-tailed t-test showing the standardized t score. The last column Probability p (> |t|) is the probability calculated from t value at the 95% significance level.

Table 5-16 Inner Model Of PLS-PM Modified

$Task_tech_fit

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	5.90e-17	0.0777	7.60e-16	1.00e+00
Task_char	4.03e-01	0.0803	5.02e+00	1.93e-06
Tech_char	2.98e-01	0.0803	3.71e+00	3.25e-04

$Perc_usef

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-4.88e-17	0.0742	-6.58e-16	1.00e+00
Task_char	2.21e-01	0.0848	2.61e+00	1.04e-02
Tech_char	3.07e-02	0.0813	3.78e-01	7.06e-01
Task_tech_fit	4.63e-01	0.0895	5.17e+00	1.01e-06

$Perc_eas

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-9.64e-17	0.0790	-1.22e-15	1.000000
Task_char	2.68e-01	0.0903	2.97e+00	0.003688
Tech_char	-3.17e-02	0.0865	-3.67e-01	0.714348
Task_tech_fit	3.74e-01	0.0953	3.93e+00	0.000148

$Int_adop_mod

.

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	2.07e-16	0.0881	2.35e-15	1.000
Task_tech_fit	1.55e-01	0.1132	1.37e+00	0.173
Perc_usef	3.00e-01	0.1127	2.66e+00	0.009
Perc_eas	-1.55e-01	0.1052	-1.47e+00	0.143

The inner model analysis in Table 5-16 reveals that the relationships between the latents are positive and significant since p-values are less than 0.05, with the exception of Intention to adopt model, and perceived ease of use relationship which is negative and insignificant since p-value is more than 0.05. The model can be taken as acceptable and better under these circumstances.

Table 5-16 results reveal that in the partial least squares path modeling modified framework:

i) Both Task_characteristics and Tech_characteristics Latent variables are significant in predicting Task_Tech_Fit since p-values are 1.93e-06 and 3.25e-04 which are less than 0.05 at 5% level of significance.

ii) Task characterstics and and Task_tech_fit have positive and significant effect in predicting Perceived usefulness since p-values are less than 0.05. However, Tech characteristics is not significant since p-value is 0.706 >0.05.

iii) Task characterstics and and Task_tech_fit have positive and significant effect in predicting Perceived Ease of use since p-values are less than 0.05. However, Tech characteristics is negative and not significant since p-value is 0.714 >0.05.

iv) Only Perceived usefulness has positive and significant effect in predicting intention to adopt since p-value is 0.09. However, Perceived ease of use is negative and insignificant whilst Task_tech characteristics is also not significant since they have p-values of 0.143 and 0.713 respectively which are not significant at 5%.

Table 5-17 Direct Indirect and total effects of PLS_PM modified framework

TOTAL EFFECTS

	relationships	direct	indirect	total
1	Task_char -> Tech_char	0.0000	0.0000	0.0000
2	Task_char -> Task_tech_fit	0.4031	0.0000	0.4031
3	Task_char -> Perc_usef	0.2210	0.1867	0.4077
4	Task_char -> Perc_eas	0.2677	0.1509	0.4185
5	Task_char -> Int_adop_mod	0.0000	0.1199	0.1199
6	Tech_char -> Task_tech_fit	0.2978	0.0000	0.2978
7	Tech_char -> Perc_usef	0.0307	0.1379	0.1686
8	Tech_char -> Perc_eas	-0.0317	0.1114	0.0797
9	Tech_char -> Int_adop_mod	0.0000	0.0844	0.0844
10	Task_tech_fit -> Perc_usef	0.4631	0.0000	0.4631
11	Task_tech_fit -> Perc_eas	0.3742	0.0000	0.3742
12	Task_tech_fit -> Int_adop_mod	0.1554	0.0808	0.2361
13	Perc_usef -> Perc_eas	0.0000	0.0000	0.0000
14	Perc_usef -> Int_adop_mod	0.2996	0.0000	0.2996
15	Perc_eas -> Int_adop_mod	-0.1550	0.0000	-0.1550

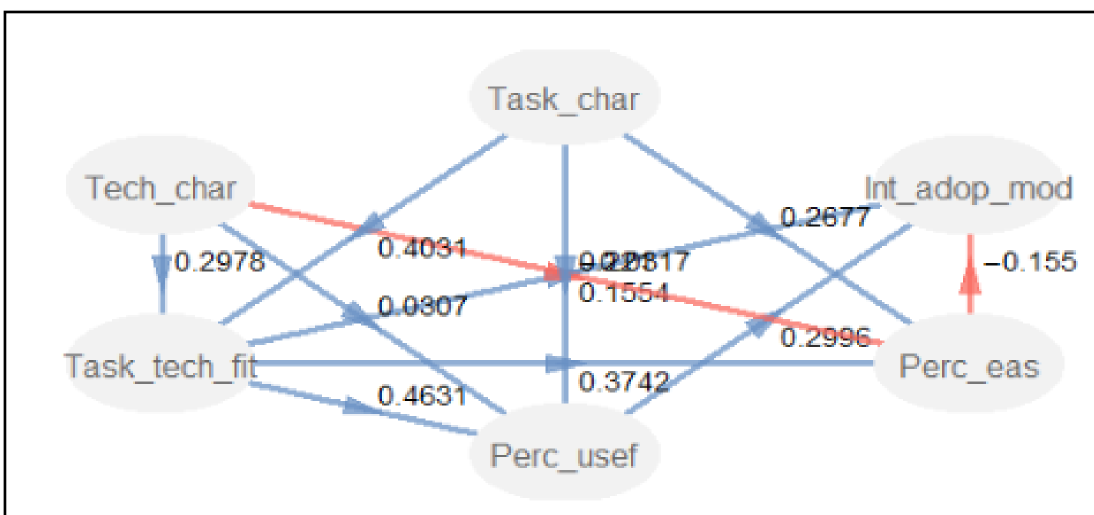

Figure 5-11 Partial least squares path modeling modified plot inner plot diagram

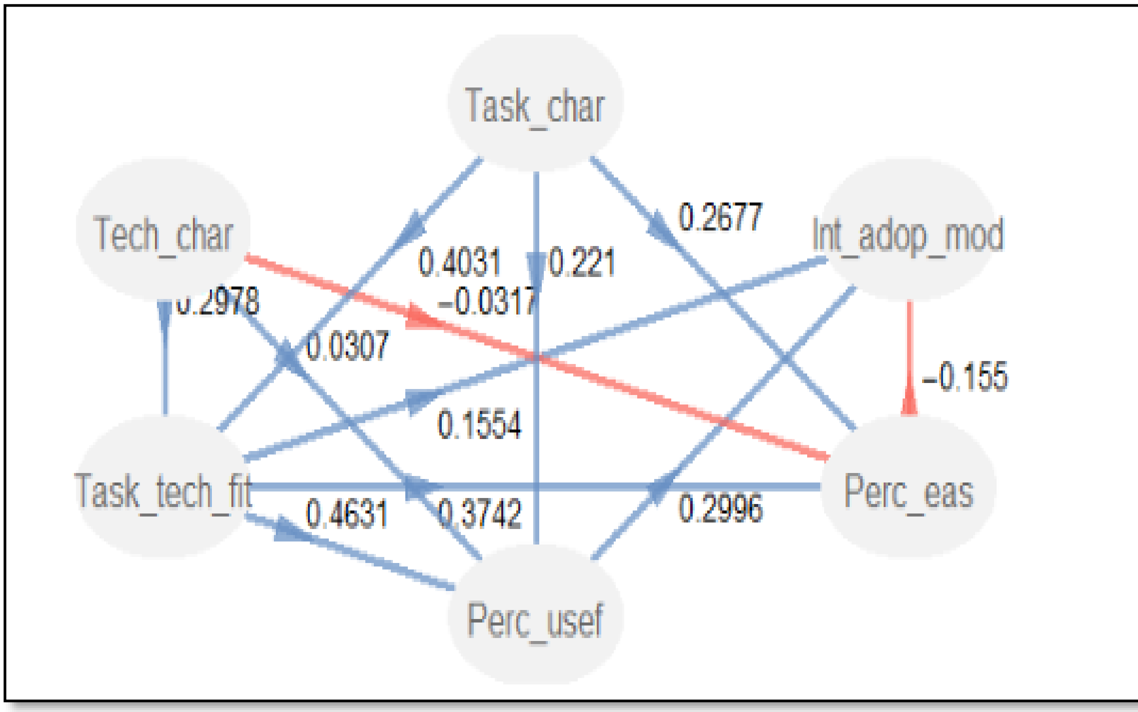

Figure 5-12 Modified Partial least squares path modelling non overlapping inner plot diagram

Table 5 20 results show that most of the direct and indirect effects relationships are positive, with the exception of (Tech_characterstics, Perceived ease of use) and (Perceived ease of use, Int_adop_mod) pair relationships which are negative. Figure 5.12 shows the partial least squares path modeling modified inner plot visualisation.

Modified Partial least squares path modelling B Model (After Removing Negative Relationships)

The previous step (see section 5.11) was done to modify the measurement model to reduce unwanted correlations among latent variables. This was achieved by removing negative relationships. See Appendix I which represents partial least squares modeling without negative relationships.

Inner model path matrix

>Task_tech_fit=c (1, 1, 0, 0, 0 ,0)

> Perc_usef=c (1, 1, 1, 0, 0, 0)

```
> Perc_eas2=c (1, 0, 1, 0, 0, 0)
> Int_adop_mod2=c (0, 0, 1, 1, 0, 0)
> Task_char=c (0, 0, 0, 0, 0, 0)
> Tech_char=c (0, 0, 0, 0, 0, 0)
> Task_tech_fit=c (1, 1, 0, 0, 0 ,0)
> Perc_usef=c (1, 1, 1, 0, 0, 0)
> Perc_eas2=c (1, 0, 1, 0, 0, 0)
> Int_adop_mod2=c (0, 0, 1, 1, 0, 0)
> summary (TAM_TTF_adop_pls_modB)
```

The inner model path matrix shown after negative indicators are removed, provides an understanding of how some attributes of design model are perceived differently than others.

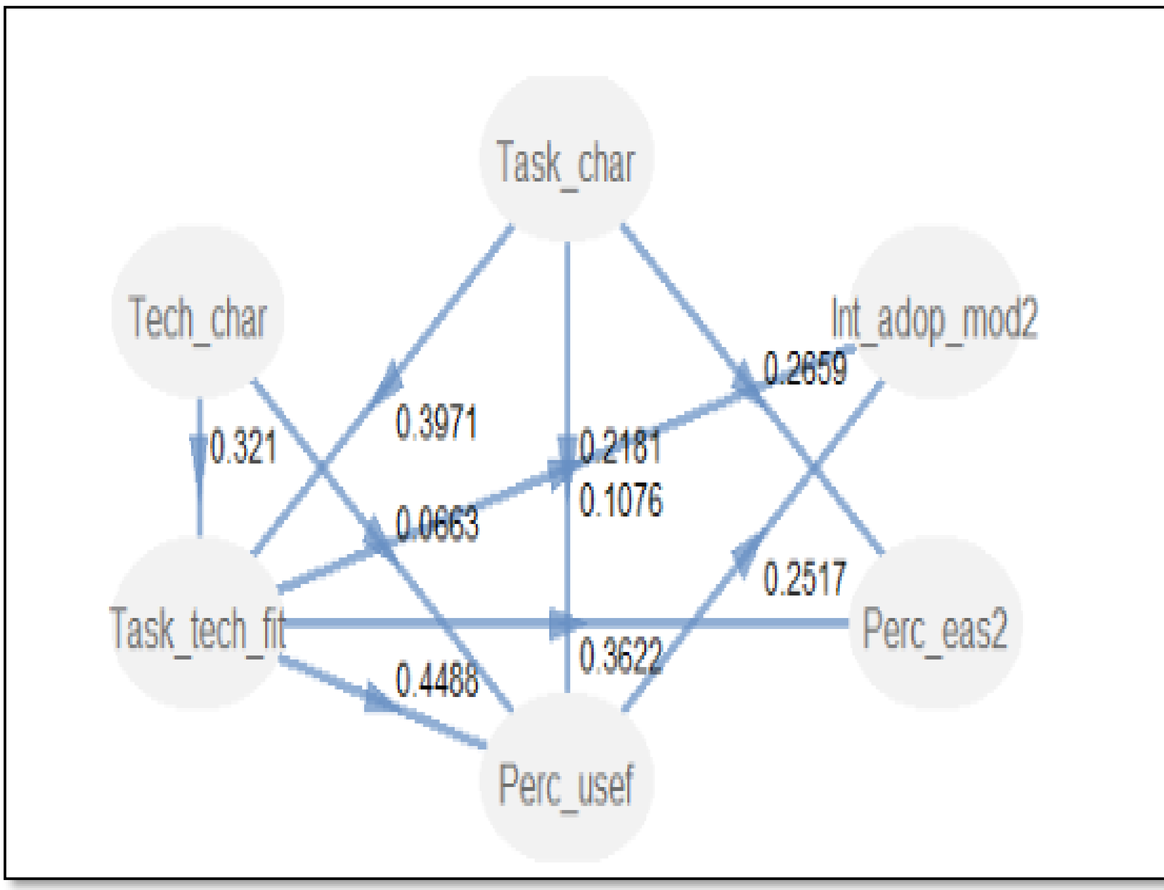

Figure 5-13 Inner plot diagram of modified model after removing negative relationships

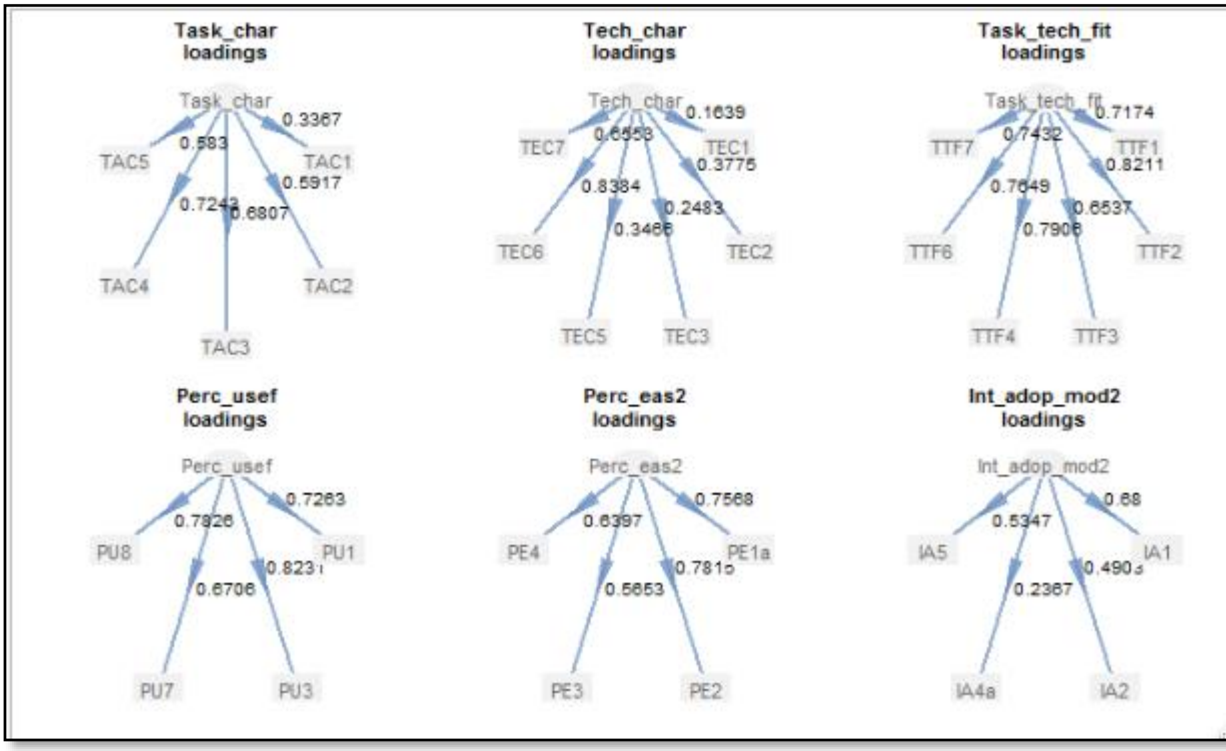

Figure 5-14 Outer plot diagram of modified diagram after removing negative relationships

To provide an approximation of the inconsistency of the parameter estimates, a resampling technique called bootstrapping was used.

5.12 Bootstrap Validation

Given that partial least squares path modeling is not based on any distributional assumptions, resampling techniques were used to predict typical errors and confidence intervals (Sanchez, 2013). Bootstrap method is used to make such predictions. The partial least squares function plspm() provides bootstrap resampling to get confidence intervals for evaluating the correctness of the partial least squares parameter estimates. So far, no bootstrap validation had been required because there was need to first check that the results of the outer and inner models made sense. Since the results were obtained, the bootstrap validation proceeded. The argument boot.val = TRUE is used to indicate that the researcher wishes to perform bootstrap validation. By default, plspm() runs 100 resamples but a different number can be specified. For instance, let us get a validation with br =200 resamples:

Bootstrapped results were obtained, for the outer weights, the loadings, the path coefficients, the *R*2 and the total effects. For each of the results shown, the study inspected the bootstrap confidence interval (95%). This was especially important for path coefficients. The path coefficients represent the direct effects between the domains performed according to the partial least squares path modeling approach.

Table 5-18 Bootstrapping results of modified model

Table 5-19 displays the original value that came out from the first partial least squares path modeling analysis (see section 5.6), then compares the value Mean Bootstrapped value (mean.boot) with the bootstrap sample. Standard error (Std.error) is displayed to give an indication of standard deviation and mean. Lower percentiles (perc.0.25) and upper percentiles (perc.975) of the 95% bootstrap confidence intervals are given to show the significance.

$paths

	Original	Mean.Boot	Std.Error	perc.025	perc.975
Task_char->Task_tech_fit	0.39712366	0.41369009	0.1081091	0.22075904	0.6183440
Task_char->Perc_usef	0.21805796	0.26174020	0.1406654	0.01430743	0.5114069
Task_char->Perc_eas2	0.26587558	0.30225246	0.1245929	0.08563261	0.5392544
Tech_char->Task_tech_fit	0.32103406	0.25504937	0.2441067	-0.44463542	0.4888449
Tech_char->Perc_usef	0.06633719	0.06328044	0.1191405	-0.22291219	0.2491271
Task_tech_fit->Perc_usef	0.44881634	0.40251423	0.1657703	0.08071773	0.6619284
Task_tech_fit->Perc_eas2	0.36219019	0.33976424	0.1415013	0.06987278	0.5860020
Task_tech_fit->Int_adop_mod2	0.10758122	0.11802460	0.1310418	-0.21734819	0.3362773
Perc_usef -> Int_adop_mod2	0.25171586	0.24660694	0.1416010	-0.15471956	0.4592753

$total.efs

.

	Original	Mean.Boot	Std.Error	perc.025	perc.975
Task_char ->Tech_char	0.00000000	0.00000000	0.00000000	0.00000000	0.0000000
Task_char ->Task_tech_fit	0.39712366	0.41369009	0.10810909	0.22075904	0.6183440
Task_char ->Perc_usef	0.39629355	0.41801715	0.11223724	0.20558959	0.6257855
Task_char ->Perc_eas2	0.40970987	0.43821707	0.09545433	0.23677113	0.6154673
Task_char ->Int_adop_mod2	0.14247642	0.15250287	0.08425325	-0.06015758	0.2785377
Tech_char ->Task_tech_fit	0.32103406	0.25504937	0.24410673	-0.44463542	0.4888449
Tech_char ->Perc_usef	0.21042252	0.16751142	0.20478066	-0.40316542	0.4058453
Tech_char ->Perc_eas2	0.11627538	0.08354084	0.10448467	-0.20928049	0.2429982
Tech_char ->Int_adop_mod2	0.08750392	0.06821473	0.09348850	-0.18766653	0.1998461
Task_tech_fit ->Perc_usef	0.44881634	0.40251423	0.16577027	0.08071773	0.6619284
Task_tech_fit ->Perc_eas2	0.36219019	0.33976424	0.14150134	0.06987278	0.5860020
Task_tech_fit->Int_adop_mod2	0.22055542	0.22006020	0.12474325	-0.17987340	0.4121805
Perc_usef -> Perc_eas2	0.00000000	0.00000000	0.00000000	0.00000000	0.0000000
Perc_usef -> Int_adop_mod2	0.25171586	0.24660694	0.14160104	-0.15471956	0.4592753
Perc_eas2 -> Int_adop_mod2	0.00000000	0.00000000	0.00000000	0.00000000	0.0000000

Table 5 21 showed that bootstrap intervals for the path coefficients of Tech_characteristics on both Task_Tech_fit and Perceived usefulness contain a zero since the confidence interva l has negative values on lower percentile. Also, Task_Tech_fit on Int_adop_mod and Perc_ usef on Int_adop_model also contained a zero in their confidence intervals; hence, the results are not significant at 5% level. Other results which did not contain negative values were significant at 5%.

5.13 Hypothesis Testing

After an analysis of both the original model, modified model, and bootstrapped models, it was convenient to test hypotheses based on the outer and inner models of the three models above. The hypotheses to be tested were as follows:

H_1: Technology Acceptance Model predicts intention to adopt the design model.

H_2: Task characteristics of design model are positively related to Task Technology Fit.

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H_3: Technology characteristics of the design model are positively related to Task Technology Fit.

H_4: Task technology fitness has an impact on Technology Acceptance of the design model.

H_5: Perceived usefulness of the design model has impact on intention to adopt the design model.

H_6: Perceived ease of use of the design model has impact on intention to adopt the design model.

Model A: Original model

In section 5.2.2, six hypotheses formed the technology acceptance model and task-technology fit model to be used for evaluation of the software design model. In this section, each of the research hypotheses is discussed in light of the research analysis results. In Table Table 5-19, each hypothesized path effect was considered using the partial least squares path modeling path coefficient and a measure of its statistical significance (see Table 5-16)

Table 5-19 Inner model path coefficients table results

Inner Model

$Task_tech_fit

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	5.76e-17	0.0770	7.49e-16	1.00e+00
Task_char	4.08e-01	0.0796	5.13e+00	1.22e-06
Tech_char	3.08e-01	0.0796	3.87e+00	1.84e-04

$Perc_usef

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	7.29e-18	0.076	9.59e-17	1.00e+00
Task_tech_fit	5.80e-01	0.076	7.64e+00	7.11e-12

$Perc_eas

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	4.88e-17	0.0812	6.01e-16	1.00e+00
Task_tech_fit	4.91e-01	0.0812	6.05e+00	1.88e-08

$Int_adop_mod

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	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	1.45e-16	0.0884	1.64e-15	1.000000
Perc_usef	3.68e-01	0.1011	3.64e+00	0.000413
Perc_eas	-1.04e-01	0.1011	-1.03e+00	0.304112

Technology acceptance model was made up of Perceived Usefulness, Perceived ease of use and Intention to adopt latent variables. Task-technology fit was made up of Task Technology Fit, Task Characteristics and Technology characteristics.

To test each hypothesis, the inner model (structural model) results were mainly used (see. The results based on the coefficient sign assessed and p-value (if less than 0.05) were considered significant at 5% level.

H_1: Technology Acceptance Model predicts intention to adopt the design model.

H_5: Perceived usefulness of the design model has impact on intention to adopt the model.

H_6: Perceived ease of use of the design model has impact on intention to adopt the model.

In comparing path coefficients, perceived usefulness was the most predictor of intention to adopt design model. The coefficient value 0.368 (Table 5-14) showed positive moderate relationship between perceived usefulness and intention to adopt. Nonetheless, there was a negative weak relationship (coefficient -0.104) between perceived ease of use and intention to adopt. Perceived ease of use had a weaker effect on university intentions to adopting the design model.

H_2: Task characteristics of design model were positively related to Task Technology Fit.

H_3: Technology characteristics of the design model were positively related to Task Technology Fit.

Both Task characteristics and Technology characteristics had positive (0.408 and 0.308 respectively) coefficients. It was therefore, concluded that there was a positive and strong relationship between task characteristic and task technology fit. In addition, there was a positive moderate relationship between technology characteristics and task- technology fit.

H_4: Task technology fitness had an impact on Technology Acceptance of the design model.

Task Technology fitness had a positive and significant effect on Technology acceptance model (mainly Perceived usefulness and Ease of Use) since the coefficients were positive. The coefficients were 0.58 and 0.491 respectively.

Model B: Modified model: Inner Model

$Task_tech_fit

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	5.90e-17	0.0777	7.60e-16	1.00e+00
Task_char	4.03e-01	0.0803	5.02e+00	1.93e-06
Tech_char	2.98e-01	0.0803	3.71e+00	3.25e-04

$Perc_usef

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-4.88e-17	0.0742	-6.58e-16	1.00e+00
Task_char	2.21e-01	0.0848	2.61e+00	1.04e-02
Tech_char	3.07e-02	0.0813	3.78e-01	7.06e-01
Task_tech_fit	4.63e-01	0.0895	5.17e+00	1.01e-06

$Perc_eas

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-9.64e-17	0.0790	-1.22e-15	1.000000
Task_char	2.68e-01	0.0903	2.97e+00	0.003688
Tech_char	-3.17e-02	0.0865	-3.67e-01	0.714348
Task_tech_fit	3.74e-01	0.0953	3.93e+00	0.000148

$Int_adop_mod

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	2.07e-16	0.0881	2.35e-15	1.000
Task_tech_fit	1.55e-01	0.1132	1.37e+00	0.173
Perc_usef	3.00e-01	0.1127	2.66e+00	0.009
Perc_eas	-1.55e-01	0.1052	-1.47e+00	0.143

H_1: Technology Acceptance Model predicts intention to adopt the design model

In the modified model, only Perceived Usefulness had a positive (0.30) and significant effect on intention to adopt. Task Tech fit which had been added (modified has a positive but insignificant effect on intention to adopt) and Perceived ease of use, had a negative effect on intention to adopt.

H_2: Task characteristics of design model are positively related to Task Technology Fit

H_3: Characteristics of the design model are positively related to Task Technology Fit

Both task characteristics and technology characteristics had positive and significant effect on Task technology fit.

H_4: Task technology fitness had an impact on Technology Acceptance of the design model.

Task Technology fit had a positive and significant effect on Technology acceptance model (both Perceived usefulness and Perceived Ease of use) since coefficients were positive (0.4634 and 0.374 respectively). However, it did not have a significant effect on Intention to adopt in the modified model framework.

5.14 Conclusion of the Chapter

The chapter described evaluation tasks that were performed. The researcher described the technology acceptance model and task technology fit model used as strategies to evaluate the software design model as per requirements obtained in Chapter 4 section 4.4.

Following that, partial least squares path modeling was introduced as a technique for the design model evaluation data. The partial least squares path modeling analysis began with the outer (measurement) model. It was statistically checked to ensure that unidimensionality measures were within acceptable range. The inner (structural) model was measured too, then the Partial least squares path modeling coefficients were calculated. The basis of these steps was to warrant drawing the conclusion about the inner model from questionnaire with necessary attributes of design model. Bootstrap validation was used to evaluate the results of partial least squares path modeling. With the validated model established, the hypothesis in section 5.13 was accepted with the aim to determine how the partial least squares path modeling model supported the hypothesized path relationship. The implications of these results are considered in the next chapter.

Chapter 6

Discussions

This chapter focuses on the key findings of the thesis and the discussion of the results thereof. It addresses the research questions posed in chapter 1 through interpreting the results and explaining how the findings answered the questions. The findings are presented in terms of current knowledge in the computer science education domain; paying attention to the proposed software design model. Comments and philosophical observations are then given grounded in the design science research theoretical framework.

As stated in chapter 1, this thesis has four research objectives. The first objective was to conduct a requirements elicitation and specification exercise towards the design of the proposed software model with which to integrate a particular learning management system and massive open online courses on a specific digital learning platform. The second objective was about proposing logical designs of the proposed software design model. The third objective pointed to carrying out a technology acceptance evaluation of the proposed software design model. Lastly, the fourth objective required tailor designing and recommending a hybrid technology adoption model to serve as a tool in university policy making.

In Chapter 4, responses and action to the first and second objectives were presented. The third and fourth objectives were handled in Chapter 5. The findings associated with requirements elicitation are summarized in Chapter 4. The deliverables of the first objective, that is the requirements specifications, are outlined in Chapter 4. The deliverables for the second objective, that is the logical designs, are also illustrated in Chapter 4. The proposed integrated software design model was presented in the fourth chapter as well. The technology acceptance evaluation model, which talks to the last objective is detailed in Chapter 5. I summarize these findings objective by objective, question by question, in the following subsections.

6.1 Research question 1: What are the requirements specifications for a software design model for integrating a particular learning management system and Massive open online courses on the EcoNet e-learning platform?

Before requirements elicitation, an audit was conducted on who uses what in terms of the learning management system. Learning management systems are the base feature of the integrated design model. The audit enabled the researcher to ascertain the readiness of the institutions to consider the integrated design model. The institutional audit also ascertained the status quo in terms of infrastructure that is in place. This was in line with Webster and Gadner (2019) who found out that institutional readiness and technology innovation correlate.

The first stages of the study formed the foundation of the integrated design model based on the information gathered from software engineering practitioners, lecturers and students. The ideal model was designed based on existing knowledge. When given to experts, the design triggered thoughts on the objectives and acceptable features of the proposed integrated design model. The design assumed that the model was built upon existing infrastructure and standards. The objectives turned out to be optimistic among the software engineering experts. The initial designs had to be improved to the requirements of the stakeholders, so that they could be believed to be useful when implemented in universities.

Most of the experts who took part in the initial design investigations emphasized the scope of the model. The model basically showed interaction of lecturers, students, and lightweight devices with an interface that runs on a digital learning platform. Not only experts were elicited for requirements, but the lecturers and students as well. All participants voiced their expectations. They seemingly showed concern related to challenges with the existing content uploading procedure. From the data collected, crosstabs were used as responses were checked for similar questions asked to the two groups of stakeholders. Lecturers, particularly those who were technical, voiced general sentiments about the need for automation.

Reliability should be considered as an important utility in educational technology development. Participants revealed that the integration of learning management systems with other systems must be seamless, reliable, efficient and user friendly. It should take into consideration human factors. Opinions presented by experts could justify the findings associated with risks. There were inherent issues that came with integration, such as system performance issues. Issues such as the risk of system failure in terms of data synchronization and networking were highlighted. Whilst participants raised a possibility of wrong expectations from the user's side, users showed their need for integrated systems. The needs ranged from a model that is specific to program requirements, to a model that enhances teaching and learning experience. One lecturer directly stated the need for *"…access to applications like Tophat interactive participation with students during lectures or websites like WebWorks for automated homework or assignments evaluation"* (P22). The overarching aim of this study was automating parts of the teaching experience. Students observed that the whole system could be improved if information is posted on time.

There exist standards for technology designs in the area of learning technologies. In this study, the focus was on producing designs which are based on acceptable software engineering practices and principles. To come up with the logical designs for the proposed software design model, software engineering methods were applied. The researcher used levelled diagrams; context diagram, data flow diagrams and entity relationship diagram. Evaluations with software engineering experts were valuable and assisted in producing a complete integrated design model.

Using software engineering methods to design software models, involved the development of software design models. The problem addressed in this study was how to design an integrated design model for learning technologies. The deliverable was the integrated design model. The design cycle, as explained in Chapter 3, describes how the integrated model was developed and evaluated. A key part of the design process was the requirements elicitation stage from which the specifications were incorporated in the logical designs. From the design evaluations conducted in Chapter 4, the findings pointed to technical aspects of the designs such as scalability issues, diagram conventions, and integration with other information systems. The results from the design evaluations classified database capacity as an essential scalability aspect to be considered in model design since the users and content were poised to expand in the future. One of the experts clearly stated that: "*The database should have enough capacity to hold information of students even if the number of students continue to grow*." (P5). The core function of the designs was to integrate Massive open online courses and learning management systems. The results from experts showed that there was need to possibly expand the model, so it could integrate with other technologies or information systems. Lecturers and students echoed the same sentiments as they gave examples of the applications they wanted integrated in the same designs. Another suggestion was to export content to other Massive open online courses as well, and not only import from them. For the design model, the experts emphasized choosing correct model elements, adhering to the standard naming conventions, and linking elements properly. The diagram components should be named according to software engineering best practices. Technology standards play an important role in educational settings. The use of educational technology in schools encompasses both technological infrastructure and educational software, which are influenced by content as well as by the computers that run the software and the networks that connect the computers.

The integrated design model was expected to be reliable and resilient in the face of system failures. This would necessitate the uninterrupted service provision to lecturers and learners who would require system uptime and interaction with content 24/7. This was so, since the results of the study showed that there was risk of system failure with integrated systems which those who implemented the designs needed to consider (see Table 4-11). This raised the need to build fault tolerant learning management systems. The proposed strategy was in line with the views of Mbabazi and Ali (2016) who echoed the importance of reliability characteristic as an International Organization for Standardization (ISO) requirement. ISO describes reliability in terms of fault tolerance. Therefore, in the context of this study, the integrated system was supposed to have error handling mechanism.

The ultimate success of a system used in teaching and learning depends on users' expectations and perceptions of the artifact. The results from this study showed that the designs should take into consideration unrealistic expectations from users. The opinions shared by experts addressed design issues related to user involvement and are articulated by Linda (2012) who confirms that user requirements are constantly changing.

The importance of integrating information systems is worth giving some thought, particularly in educational technologies. The lack of integration could possibly limit the scope of the overall functionality of learning management systems. Results from the study reveal that lecturers and students require a learning platform that communicates with other existing information systems. The principle of free sharing of data among systems that exist in a university is important within stakeholder circles.

6.2 Research question 2: What are the logical designs for the proposed software design model?

The logical designs of the integrated model were presented in Chapter 4. The designs comprised the features described below:

Student and lecturer

The researcher took the initiative to apply a software engineering model for proposed designs. The models provide a framework that facilitate the development of quality integrated designs for teaching and learning environment. In addition, the software engineering framework provides a platform that in turn encourages stakeholders to provide meaningful input. In this study, the stakeholders who were an important feature of the proposed model were lecturers, students and information technology support staff.

To produce the logical designs, the researcher identified the stakeholders. The requirements elicitation stage depended on the stakeholders' input (Romero, Ballejos, Gutierrez, & Caliusco, 2015) (see Chapter 4 section 4.3.5).

Content location

The aim of this study was to make simpler the process of developing learning content repositories to enable newer content to be merged into existing repositories with less manual effort. In this study, the researcher included the content location functionality which provided a base for the arrangement of queries submitted by students. Ultimately, the success of educational technology depended on the content location feature to facilitate automated access to relevant content (see Chapter 4 section 4.4.4).

Content delivery

The content delivery feature would include that which would be done to present content that engaged learners. The implemented designs should enable stakeholders to have a good experience on the platform. The interfaces, search facilities and the content comprised the content delivery feature.

Query Management Interface

The query management interface feature was related to the content delivery feature. It is the QMI that connects the lightweight devices, the learning management systems and massive open online courses repositories. In that way, the design features were relatively easier to administer and use. One software engineering expert asked: *"Does the lecturer also not use a query management interface?"* (P9). The suggestion implies that lecturer role for uploading content in this semi-automated design was still significant; hence, the need to provide a connector built into the model structure.

Rules system

In this study, particular attention was paid to rules as an input into the model with an emphasis on sequencing rules. *"Does not seem to show how the system learns from content that is absent during the time when content is not there."* (P12) *"Rules Systems is not clear"* (P15). The above comments were in line with Instructional Management Systems (IMS) Global specification that digital technology systems used in teaching and learning have to sequence learning content in a constant way. Besides IMS global, Shareable Content Object Reference Model also has a specification for sequencing. Since standards were already in existence, it was of paramount importance to adhere to the same when designing learning technology systems.

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Learning content resources

Part of the goal of this study was to take advantage of the existing infrastructure and standards to improve the existing digital technologies used in computer science education. There was probably a need for institutions to reap from their technological investments. Considering that, the aim was that the proposed design model could become the foundation for learning content repositories. The researcher made assumptions that the learning management system and massive open online courses repositories support content identification, offer content management and generally are governed by institutional policies.

Qualitative results revealed the need for the content knowledge to evolve. This called for database capacity planning which is a process whereby the storage required for the learning management system is computed and compared against requirements. As the learning repositories continue to grow, there is need to adjust resources and monitor other variables such as data and users of the system. Due to massification in Zimbabwe university education, it is inevitable that data requirements will grow (Selyutin, Kalashnikova, Danilova, & Frolova, 2017). Institutions need to assess the cost implications of scaling up existing infrastructure.

Content sharing with other Massive open online courses

The proposed model showed emphasis on massive open online courses. The study aim was for learning content to be shared among content providers. However, the researcher did not overlook the fact that most of the existing massive open online courses do not readily allow their content to be shared or transferred. There was need for the formulation of some governing policies (Asiimwe et al., 2017) to enable learning management systems to share content with any chosen massive open online courses. (Escher et al., 2014) speculates that if lectures for university wide foundation courses could be provided in a massive open online courses fashion, that would free up lecturers' time so they would focus on other teaching and learning activities.

Standardization

The necessity for standards in learning content-based systems cannot be overlooked. Learning resources and systems abound and, as a result, there is a clear need for some form of standardization. Earlier studies (Fleischmann, 2007) inform that technology standards are of great value in the design of educational technologies. In the absence of standards, it would be difficult for learning management systems, massive open online courses and digital learning platforms to interface.

6.4 Research question 3: To what extent are the proposed model designs accepted by practitioners in the software engineering circles and stakeholders around universities in Zimbabwe?

The research question refers to technology acceptance, that is the intended use of technologies. For an artefact to be useful and usable, the users have to accept it and be confident about it. In this study, acceptance referred to a “positive decision to use an innovation” (Taherdoost, 2019). To measure the extent to which the designs were accepted by software engineering practitioners, a mixed-method approach was used. The approach was chosen because of the exploratory nature of the study and the challenge of obtaining software engineering experts to participate in experiments. The data flow diagrams and entity relationship models were developed in two iterations involving software engineering experts, bachelors degree holders and post graduate professionals. Data from experts was captured using google forms as part of the spiral model process. The experts did not reach the implementation phase, but review of the design model and the results showed that the diagrams had sufficient information for the development of the model.

From earlier studies (Lange & Chaudron, 2004), completeness of a model from an end users’ perspective is one that covers all requirements and warrants that the model to be presented be in line with requirements specification. Generally, use of experts and students in software engineering experiments has been in existence (Lange & Chaudron, 2004; Tu, 2014 ; Feldt et al., 2018). In the current study, when one had gone through undergraduate studies in Information Technology or computer science then post graduate, that was regarded as professional experience. In Lange and Chaudron (2006) software engineering experimental investigation, professionals with more than two years' experience were considered to have enough expertise to evaluate software models.

In order to ascertain whether the experts confirmed diagram completeness, and covered all attributes required for the integrated design model; the researcher formulated the null hypothesis for Mann Whitney U Test. The Mann-Whitney U test, which is the nonparametric alternative to the t-test, used particularly when sample sizes are small and when data is ordinal Likert scale (Alanazi et al., 2016). An additional advantage of the Mann-Whitney U test was that it could be used to compare ordinal data, as well as continuous data. The aim of the statistical analysis was to reject the null hypotheses and possibly accept the alternative ones. The Mann-Whitney U test was applied on questionnaire data, to determine if there were differences in opinion on the design completeness, based on the level of education of the experts. The sample size was relatively on the small end, since the population of software engineering experts in Zimbabwe universities is not large.The respondents comprised of 15 software engineering experts (see Chapter 3 section 3.5.2).

In this study, the dependent variable(s) was at least measured on ordinal scale or continuous scale. In this case, the dependent variables were data flow diagram completeness, metrics of acceptance, scalability, completeness and robustness. The independent variables consisted of independent groups which are level of education which has two distinct groups BSc and MSc. There is independence of observations, which means that there was no relationship between the observations in each group or within the groups themselves.

The p-values presented in Table 4-10 are more than 0.05, showing that all hypotheses were retained, meaning that there were no significant differences on the logical designs of the present learning management systems and the integrated learning management systems with massive open online courses' designs. Next question was if it had been established that there were no significant differences, would there be greater proportion in agreement or disagreement. The results revealed that at this design point level, at a 95% level of confidence, one could agree to the hypothesis that learning management system integrated with massive open online courses is almost at the level of learning management system without massive open online courses. This means upon implementation of the integrated designs, learning content issues can only get better, which is the envisaged contribution of this work.

Other possible reasons to explain such a finding could be that providing information visually to users and stakeholders enabled them to make informed decisions (Tu, 2014) or there was adequate content on software standards, so much that practitioners found it relatively easier to interpret the software model diagrams. However, whilst most participants agreed to the designs, the few who opposed were not the first since innovation had been resisted even now in the massive open online courses' era (Ma & Lee ,2019).

Even though there was confirmation of the completeness of the designs, improvements could be done on the experimental model in preparation for a full comprehensive system at a larger scale. Based on the qualitative comments, the comment on artificial intelligence *"Incorporate artificial intelligence that help self-learning from interactions between learners and lecturers"* (P9) was in line with Miranda, Mangione, Orciuoli, Gaeta and Loia (2013) who shared sentiments that lecturers would appreciate efforts which resulted in automation of content related tasks.

"I am not sure this is not the complete ERD to depict the whole interaction between massive open online courses, e-learning platforms and the integrated system itself" (P12) The diagram was reviewed for its logic, and the experts' opinion was that the diagram be expanded; adding more attributes and relationships. Since the designs must be implemented on a large scale, adoption ideally comes first, so there can be comprehensible designs.

6.5 Research question 4: To what extent is the software design model compliant with known technology adoption models for potential installation in universities around Zimbabwe?

The researcher evaluated the design model by showing it to the possible users of the integrated learning management system who were lecturers and students. Evaluation of an artifact is a way of measuring the utility of the artifact (Hevner et al., 2004). In this study, participants analyzed the artifact and then submitted their views by answering an online questionnaire. The questionnaire was based on technology acceptance model and Task-Technology Fit constructs described in Table 5-1. The questions used a 5-point Likert scale, with 1 being strongly disagree and 5 strongly agree.

Data for the study was collected from software engineering practitioners and computer science students who had done software engineering as a course. The minimum required sample size (Chin & Newsted, 1999) was based on the study's research model. The final sample size was 117. Potential participants were invited to complete a google form via email. The questionnaire used for this study comprised items adapted from existing literature (Alsabawy et al., 2016). A google form was distributed among software engineering experts, lecturers and computer science students. Some responded, others failed to respond, probably because of the electricity outages and the costs related to internet access. The survey instrument was structured according to the technology acceptance model (Venkatesh, 2015) as well as task technology fit model (Wu & Chen, 2017). The models addressed the task characteristics, technology characteristics, perceived usefulness, intention to adopt, perceived ease of use and task technology fit.

Partial least squares path modeling technique was chosen as the analysis method for the evaluation. Based on the results presented the researcher accepts H_1: TAM predicts intention to adopt the model. H_2 and H_3 were also accepted; that is, task characteristics is positively related to task technology fit and Technology characteristics is positively related to task technology fit. Ultimately, the researcher accepted H4; task technology fitness has an impact on TAM. Further to that, based on the results' analysis, the researcher found statistical support to explain perceived usefulness and perceived ease of use on the intention to adopt the design model.

The study's results showed that task characteristics and technology characteristics (both task-technology fit constructs) had a significant effect on technology acceptance model. This meant they were crucial for influencing technology adoption. These results were consistent with the initial hypothesis that task technology fitness had an impact on technology acceptance. Tripathi and Jigeesh (2015) employed the task-technology fit theory and suggests that technology drives users to engage in tasks and activities. As such, the inherent nature of technology was that, if it is not implemented technically, its utility to the Universities will not be there. The encouraging part, reflected in Venkatesh et al. (2003), was that users of the integrated designs had experiences of working with other technologies, so they needed not to be trained to use a new technology. Therefore, the perceived ease of use was a significant construct in explaining the adoption when compared to perceived usefulness.

Furthermore, perceived usefulness seemed to explain that the proposed integrated model could facilitate learning and reduce lecturer’s workload. Perceived ease of use did not seem to have an effect on intention to adopt. This contradicted the original technology acceptance model (Davis, Bagozzi, & Warshaw, 1989). The original model posits that information technology adoption was influenced by two perceptions; usefulness and ease-of-use. However, the findings in this study indicated that lecturers may not have the same perceptions.

The researcher summarises the findings as follows. When designing systems to be implemented in universities to facilitate teaching and learning, emphasis should be put on support that the university would offer to lecturers and students to perform their tasks. When the university management is willing to take the risk in the implementation of integrated repositories, resource sharing is improved, and access to learning content via lightweight devices is enhanced.

6.5 Design science process

As shown in section 3.2.1, the researcher applied the design science approach from which a design model artifact was developed and evaluated by software engineering experts. The Design science research approach (Hevner et al., 2004) recommends that the findings brought out in the design cycle should be availed as functional artefacts in the relevance cycle, rigor cycle and change and impact cycle. The Design Science Research framework depicted in

Figure 2-9 was expressed as presented in Figure 3-3. The diagram shows events as well as relationships among the three phases (see section 3.2.1). The events are shown in the Design Science Research framework cycle to demonstrate how the design model was created and how the evaluation events were influenced by rigor and relevance.

The relevance cycle

The relevance cycle speaks to affordances and issues in the real application domain. In this study, the problem of designing integrated systems was demonstrated with logical designs which presented possible opportunities in the technology domain that could be taken advantaged of and benefit computer science education. The design model artefact was decided on by educational software developers when universities decided to implement the design model.

The rigor cycle-research contribution

The rigor cycle should ensure that the artefact characterizes tangible innovation and provides assurance that the designs created are research contributions (Hevner, et al. 2004). In this study, significant factors that contributed to the designs included expertise from software engineering experts, and knowledge from information retrieval models used in educational technology domain. Most of these technologies are slow to be implemented probably due to their seemingly complexity. In this study, the researcher put effort in making the integrated designs relatively easy to understand.

The model evaluation results show that the integrated designs were, to an extent, successful in showing simplicity. The novel and interesting contributions to the body of knowledge were threefold. The integrated design model artefact could address the lecturer workload issue by partially automating the uploading of content. The automation part was presented using software engineering modeling, which extends the knowledge base about the use of software models. Novice software developers would implement the designs into functional prototypes.

6.6 Conclusion of the Chapter

This chapter discussed the findings of the research and provided clarification of their worth. It discussed the findings from the preliminary survey, experimental design and evaluation of design model. The key research questions were answered using inferential statistics. The results obtained from the studies, which are in line with the research objectives and hypotheses, indicated that software engineering practitioners were satisfied with the design model for the integration of a learning management system and massive open online courses on a particular platform. I conclude the thesis in the next chapter.

Chapter 7
Conclusions

This thesis presented a design model that integrated a particular learning management system and massive open online courses on a digital learning platform towards automated processes in content selection, content sequencing and teaching and learning in general. The model designs are deliverables required and used by system developers at implementation stage. This chapter draws conclusions from three angles; (a)the requirements elicitation exercise that was used to gather functional requirements of the design model, (b) the experimental exercise that was done to evaluate designs, as well as (c) the evaluation of design model based on technology acceptance model and task-technology fit model. The remainder of this chapter acknowledges and discusses these conclusions.

7.1 Overview of research

The thesis was based on the premise that relieving lecturers from the duty of selecting content for uploading on learning management systems would improve access to content, reduce subjectivity in selecting content, and add quality to content. The resulting artifact proposed was described as a software design model that could validate content sequencing and relevance, ultimately enhancing teaching and learning. The software design models yielded are implementable and have direct implications to improved teaching and learning, and reduction of problems related to lack of learning resources (Meier, 2016).

Based on the motivation, presented in section 1.2 of this thesis, as well as the findings yielded from a preliminary study conducted in Chapter 4 on obtaining stakeholder needs, the software design model was explicitly presented in Chapter 4. The main goal of the software design model was to support the implementation of integrated products that would support lecturers and the teaching and learning processes in general. Particularly, the software design model guided implementers tasked to develop complete learning management systems towards achieving student centered content selection and sequencing. Although the same software design model was evaluated through an empirical study, as presented in Chapter 5, by assessing its potential in helping university stakeholders in policy decision making, its impact to the development of improved hybrid learning management systems in terms of design functionality, requirements elicitation, development for the 4th industrial revolution, dependability, reliability, resilience, and the entire agile methods, cannot go unmentioned. An empirical study with a group of 117 participants holding degrees in Computer Science or related disciplines found out that the proposed software design model could be adopted for implementation as discussed and concluded in Chapter 5.

Data collected through a questionnaire survey was inspected for statistical normality using statistical methods in order to ascertain and establish how the measurement items extracted reflected on their intended target constructs. The measurement items must be statistically unidimensional by having the same measurement dimensions, to adequately reflect their latent constructs. Measurement items were tested for consistency. Measurement items that did not group well, particularly those that were reviewed for possibility of sources of error, were removed from the final measurement model. The remainder of the measurement items were then kept as the basis for the final analysis, presented using partial least squares path modeling (Sanchez, 2013).

In this study, as applied in other studies (Ameen, 2014; Gorai, Tuluri, & Tchounwou, 2015), partial least squares path modeling was regarded as two distinct models. The models were inner and outer model (see Chapter 5 section 5.6). The outer or measurement model comprised the relationship between measurement items and their constructs. The inner or structural model comprised relationship between constructs.

Based on what was found out in Chapter 5 about the blocks, evaluation results showed that the reduced set of measurements loaded successfully. The study recorded measures of loadings of all manifest variables which were strong; indicating a strong measurement model. This was so because these measures were above accepted values. Inspecting the outer model measurement characteristics requires values greater than 0.7 (Tubadji & Nijkamp, 2015) to reflect the loadings of acceptable level (see Appendix G) values. To add to that, statistical measures of unidimensionality Appendix H were in the range of acceptable values.

The outer model provided a statistical foundation for measuring the inner model, thereby providing answer to research question 4.

The inner model was then evaluated. The assessment offered an analysis of direct and indirect effects between latent variables, the fitness of the model and boot-strapping results. This enlightened us on the general relevance of the model for the university management. In other words, the main hypothesis was tested. The partial least squares path modeling model computed path coefficients for each hypothesized path using bootstrapping. As found in Chapter 5 section 5.12, path coefficients for each hypothesized path were computed to give coefficients which revealed deviations, should there be any, from the expectations.

The data collected through a survey and the measurements thereof, supported four of the six hypothesized path effects (see chapter 5 section 5.13for a detailed description of these path effects). The three most important constructs influencing use that emerged from this research were, in order of importance; perceived usefulness, perceived ease of use, and intention to adopt as shown in Chapter 5 section 5.13. Perceived usefulness was the most powerful construct due to its total effect size (see Table 5-14), proving the importance of useful technology in higher education setting. This finding is consistent with other research findings (Pappas, Giannakos & Mikalef, 2017).

The answer to research question 1 *"What are the functional requirements of a software model with which to integrate a particular learning management systems and Massive open online courses on the EcoNet e-learning platform?"* data was obtained by conducting a requirements elicitation exercise. Prior the elicitation process, in Chapter 2, the study reviewed related works. This study revealed that it was different from most similar research presented in the literature in that it integrated massive open online courses and a learning management system on a locally supported digital learning platform. That alone enhanced accessibility, availability, affordability, and compatibility with the mobile technology around. Related work ascertained that, though learning management systems have advantages, there was lack of stakeholder involvement in their design (Seale, 2014). This showed that there could be a gap between designers of educational technologies and the users.

To work around that issue, lecturers, students and software engineering experts were engaged in an elicitation exercise as examined in Chapter 4. The results of the elicitation process as described in section 4.4.5, showed that lecturers needed their tasks to be automated. The need for automation was also confirmed from the results of the preliminary study conducted in chapter 4, where software experts agreed to the objectives of the proposed software design model. As a result, the functional requirements that were presented formed the basis for creating the proposed software design model.

Research question 2 "*What are the component units and design levels of the logical designs of the proposed software model?*" was answered by the results obtained from the designs created based on the requirements elicitation exercise administered and presented in Chapter 4. The exercise was done to ascertain the needs of the stakeholders and software engineering experts. Based on requirements specification output, functional components such as scalability were identified. The results are consistent with related work. The study findings showed challenges of integrated systems such as scalability (Palanivel & Kuppuswami, 2014). Qualitative results from experimental design evaluation confirmed scalability as an issue to be considered when integrating learning management systems with other platforms. To add to that, results gave further insights into integration challenges. Though these may have existed, use of standards addresses most of them (Ochoa & Ternier, 2017).

The answer to research question 3 "*To what extent are the proposed model designs accepted by practitioners in the software engineering circles and stakeholders around universities in Zimbabwe?"* was that proposed designs where accepted to a greater extent. In chapter 4, an experimental design was done to evaluate component units and design levels of the logical designs of the proposed software design model. Component units were created with an emphasis on eight functions gathered from requirements specification, which included; content sequencing, security and scalability. After the designs were created, section 4.5 evaluated the components by conducting an experiment, ultimately with a group of fifteen software engineering experts, to find out whether the component units had complete features or whether they required further improvement. The results showed that most experts were satisfied with the designs. Empirically, there was no statistical differences among the groups of experts on their opinions of the designs as evidenced by the p-values which were greater than 0.05 (see Table 4-10 for the values of means yielded in the tests). The results meant that software engineering experts saw no difference between the present learning management systems and when learning management systems are integrated with massive open online courses. Otherwise, if the study had found that learning management systems integrated with massive open online courses are much better than present learning management systems without the massive open online courses, that would be a highly pitched view at this stage of design. It would mean an over estimation of the value of learning management systems with massive open online courses before implementation. The outcome would not be a true reflection of reality.

Research question 4, "*To what extent is the proposed integrated software design model compliant with known technology adoption models for potential installation in universities around Zimbabwe?*" was answered in Chapter 5. The adoption of the design model was evaluated by conducting an empirical study. The title of the thesis indicates design of an artifact grounded on the design science research theoretical framework (Hevner et al., 2004). This artifact had to be evaluated. Since there are no guidelines on how to conduct the evaluation (Peffers et al., 2006), the study used technology acceptance model combined with task-technology fit model, and the software design model was validated using the partial least squares path modeling model. For these evaluations, the researcher engaged participants with different education levels starting from undergraduate. The researcher was able to do non-parametric tests on the data obtained during evaluation of the software design model. The Mann Whitney u test and Kruskall-Wallis test results showed that all participants, regardless of level of education or gender, shared the same opinion of intention to adopt the software design model for enhanced services. However, not many participants gave valid feedback on query management interface being ideal for limited bandwidth, in resource constrained universities.

7.2 Contributions made

In recent years, most of the studies conducted approach learning management and massive open online courses from a technical perspective (Sein-Echaluce, Fidalgo-Blanco, García-Peñalvo, & Conde, 2016; Fidalgo-Blanco, Sein-Echaluce, & García-Peñalvo, 2017). While some of the works include the development of pedagogical nature of learning management system (Sankey & Hunt, 2017) as well as their technical challenges, not much of the work establish Design Science Research and software engineering in computer science education. This study, as well as the study by Goumopoulos et al. (2018), focus on computer science education.

In this study, the researcher combined design practice with theoretical software engineering principles. This facilitated requirements elicitation from students, lecturers and software engineering experts. Stakeholders were engaged from the preliminary stages of the study, through to the evaluation of the proposed integrated designs. As a result, designing a model based on software engineering modeling provided significant contribution for laying out the functionality of design components as they would relate to other components in the domain of educational digital technology systems. Further to that, focusing on the characteristics of software engineering artefacts has been of help in understanding the structure of e-learning management systems. Thus, the importance of this study lies in looking into the bigger picture of computer science education through design science research methods.

The findings of this study offer practical contribution for developers and other stakeholders who engage in the design of technology-enabled teaching and learning tools in general, and computer science education, specifically. Firstly, the study assists in the understanding of the SWOT analysis of learning management system and massive open online courses related to integration with other third-party systems. While every design situation has its own inherent problems, the problem highlighted in this study would help software creators who design learning content repositories and other digital technologies that facilitate sharing of relevant content.

While this study paid attention to reusability of learning content in universities, specifically on application and integration characteristics of learning management systems, such ideas are also beneficial to enable the higher education sector to increase the rate of newer technology-based (Serdyukov, 2017). Integrated information systems about technology used in teaching and learning are significant for lecturers as well as content authors. Their views, described in this study, would create a foundation knowledge for innovations that are done at a larger scale as well as related researches.

The practical value for lecturers is the reduced time in authoring content and uploading the same on a learning management system. One learning management system has been used broadly in Zimbabwe universities. This technology has been designed, not to reduce lecturers' burdens but to help them integrate technology in teaching. Therefore, this study contributes towards enhanced higher education teaching and learning.

The key findings of this study are beneficial for policy making. Digital technology thinking would provide policy makers with an understanding of who should be involved in the design processes, what other learning management systems features are required to support teaching and learning, and how the varied technological components relate to each other. It is worthwhile to note how the concept of integration fits into e-learning management systems, which have become a part of life for digital natives.

From an administrative point of view, the design model brings together lecturers, students as actors in teaching and learning process. When such entities relate to learning management systems and massive open online courses, this has implications for improving access to relevant content in real-time and more efficiently.

From a content point of view, the study identified massive open online courses content that can be shared through the target repository. This includes content generated from discussion forums, notes and videos. As lecturers upload learning content, the automation process will forward the content to the target repository as per the submitted query. Target repository features serve both print content and online content to be accessed from light weight devices.

Repository facilitates communication between devices, lecturers and students to basically connect them. There is further contribution from use of existing e-learning platforms, learning management systems, and massive open online courses. The design model developed is different in terms of its features. By leveraging massive open online courses platforms, the design model appears to be more flexible, intuitive, responsive and user friendly. Thus, it is practical for the use in the real-world application to meet user needs and expectation.

Data analysis for the preliminary survey reveals that the major stakeholders in university require an improvement in the learning content access. In most courses, students may not obtain relevant learning content timeously. Therefore, the automation on the side of the lecturer would facilitate the provision of the content needs of the stakeholders. Most of the lecturers wish for a learning management system that runs on light weight devices, which improves student engagement as they interact with relevant content anytime and at anyplace.

7.3 Further applications of the model

The use of learning management systems at university level has been growing in Zimbabwe (Mbengo, 2014). The model could be implemented in other areas where digital resources can be shared in terms of content as well as infrastructure. In this study, the researcher felt that universities were already imagining what the new generation learning management system would be like.

The future of learning management systems should overcome the current limitations of the present technology; for example, the deletion or closure of a course at the end of a semester (Kipp, 2018). It is important to consider the applications that are used outside the education environment where users have their content for as long as they want. Policy makers could consider investing in the infrastructure that other external systems are using. Whilst plans and strategies are underway, lecturers can benefit from the automation process to bring some potential of learning management systems and massive open online courses.

7.4 Potential improvement of the model

The recent wave of smart learning environments (Çinici & Altun, 2018), which is shaping the future learning environments, provide a foundation for the possible extension of this study. Considering increased enrolments in Zimbabwe universities, there is need to build big-data-capable platform (Caviglione & Coccoli, 2018). The recent years have seen the creation of novel standardization efforts in the e-learning areas. Robson (2018) submits that the initiative for standards originates from the challenge of the portability of learning management systems.

The findings from software experts show the need to consider the new agents in the learning environment; for example, integrating learning management systems, massive open online courses, and technology hubs. The government has established innovation hubs which aim to address the gap between theory and practical skills required in the workplace. Universities in Zimbabwe should consider switching from monolithic systems (Luo & Lin, 2013) to more flexible service-oriented applications. Scholars in other circles argue that learning management systems are monolithic in nature and constrain innovation. It is against that premise that the research saw the potential of the integrated designs growing in the direction of micro services-based platforms.

The emphasis of integration was to gather and obtain information from numerous systems for a target system that required the information (Jakimoski, 2016). To purse that end, newer technologies such as blockchains, which are still maturing, could be explored. In educational technology, it is imperative that the stakeholders embrace the technologies and be willing to adopt in the foreseeable future.

One important point put forward in this thesis is that lecturers and students can benefit from an improved digital learning infrastructure. The literature review presented in Chapter 2 shows that learning management systems on their own would not reach their full functionality but when integrated with other systems, institutions can achieve more. The design science research approach followed in this study, resulted in use of quasi-experimental method for design evaluation. Although this work was limited to learning content in a digital environment, choosing software engineering principles for obtaining requirements, added value to the study. In addition, working with software engineering experts had significant impact on the findings for this study. There is enough room left for further research to be done.

7.5 Conclusion

This concluding chapter began with a brief overview of the research; provided answers to the research questions and the conclusions about the hybrid evaluation model. In this thesis, the researcher proposed the concept of providing generic design views for integrated platforms and established the usefulness of integrated platforms in teaching and learning. The concept of automated learning tools is potentially beneficial to university stakeholders.

The processes followed in conducting the study was highlighted in the previous chapters. From a theoretical point of view, very few studies focused on integrating existing learning management systems with massive open online courses on available infrastructure. This study developed a proposed software design model with which to automate the proposed integration towards improved provision of study resources to students. It extends knowledge in computer science (software engineering), computer science education, and in policy making. The study presented the component functional units for integrating learning management systems, and massive open online courses on a digital learning platform.

Furthermore, the study revealed lecturers had issues with uploading content on learning management systems (Bhalalusesa, Lukwaro, & Clemence, 2013). Literature was also reviewed around integration challenges faced in other domains. The requirements elicitation exercise used in the context of design science research enabled the unearthing of challenges identified by software engineering experts. Using software engineering principles and the design science research framework (Peffers et al., 2006), the challenges were identified and statistically evaluated to provide an acceptable desired artefact.

Data about the software design model was collected using questionnaires. Based on the preliminary survey findings, it emerged that in most courses, students may not acquire pertinent learning content timeously. Therefore, automation on the side of the lecturer facilitates the provision of the needs of the stakeholders. Based on component functional unit design evaluation, experts confirmed completeness of the software design models. They, however, expressed the need for the designs to be extended towards accommodating more detailed artificial intelligence features. Also based on the design model evaluation findings, universities in Zimbabwe were likely to adopt the integrated software design model since they saw relevance in the proposed features to their tasks.

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Appendix A

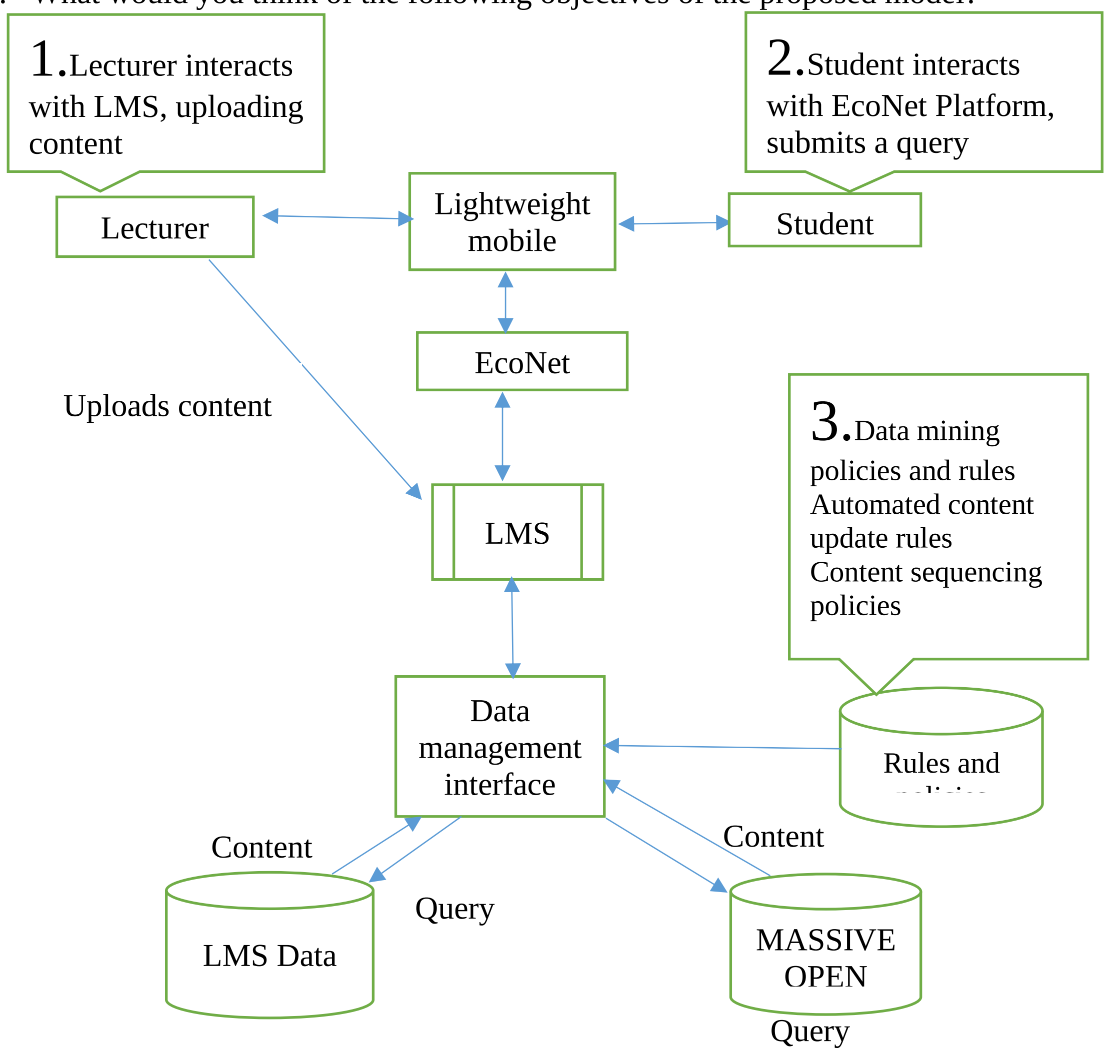
Questionnaire for software engineering experts

Requirements elicitation

This questionnaire is aimed at finding and gaining an understanding of the key issues in learning management systems, massive open online courses and digital learning platforms. The findings will direct the development of requirements to enhance the infrastructure of digital technologies in universities.

Achievable goals and objectives of the proposed model

1. What would you think of the following objectives of the proposed model?



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Set objectives	**Comment**
To facilitate the automation of content selection, uploading, updating and removing	
To automate file sequencing, importing and exporting	
To access relevant content from global massive open online courses	

2. What are the best data mining techniques for content filtering and selection?
…………………………………………………………………………………………
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3. What information extraction approaches are available?

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Design Model for the proposed model

4. Are the proposed methods Joint Application Development (JAD), Boehm Spiral Model (BSM) and Agile principles suited for dealing with the project?

	Not suitable	Suitable
JAD		
BSM		
Agile		

Units and subsystems of the proposed model

5. What are the best approaches for integrating learning management system and massive open online courses on a digital learning platform?

.

6. Which standards are needed for integration?
   ………………………………………………………………………………………………
7. What impact do the standards have on the design process and the proposed model?
   ………………………………………………………………………………………………
8. What methods and tools are well suited for the integration? Please check all forms of integration that apply?

   Visual integration
   Data integration
   System Integration

Risks and challenges of system integration

9. What are the risks associated with learning management systems integration?

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Appendix B

Questionnaire for lecturers

* Required

Introduction *

Dear Colleague

The aim and purpose of this research is to embrace MOOCs' introduction into teaching and learning as alternative learning resources with up to date content relevant in different learning areas and investigate ways in which to automate communication between the learning management system and MOOCs. The proposed software model infers an improved teaching and learning space in Zimbabwean Universities.

The procedure involves filling an online survey that will take approximately 20 minutes. Your responses will be confidential and we do not collect identifying information such as your name, email address or IP address.

We will do our best to keep your information confidential. All data is stored in a password protected electronic format. To help protect your confidentiality, the surveys will not contain information that will personally identify you. The results of this study will be used for scholarly purposes only.

If you have any questions about the research study, please contact ttrugube@gmail.com or HSSREC@ukzn.ac.za.This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (approval number HSS/0461/071D).

ELECTRONIC CONSENT:

Clicking on the "agree" option below indicates that:

• you have read the above information
• you voluntarily agree to participate

If you do not wish to participate in the research study, please decline participation by clicking on the "disagree" option.

Mark only one oval.

◯ Agree

◯ Disagree *Skip to "Thank you for your time and attention."*

.

2.Learning Environment

2.1 Which of the following best represents your opinion of the following instructional approaches in Higher education?

Mark only one oval per row.

	Completely opposed	Generally opposed but willing to consider its place in higher education	Neutral	Generally supportive but somewhat skeptical about its place in higher education	Completely supportive	Don't Know
Online Degree Programs	⬭	⬭	⬭	⬭	⬭	⬭
Gamification	⬭	⬭	⬭	⬭	⬭	⬭
Open educational resources (OER)	⬭	⬭	⬭	⬭	⬭	⬭

2.2 In what type of learning environment do you prefer to teach? *Mark only one oval.*

- ⬭ One with no online components
- ⬭ One with some online components
- ⬭ About half online and half face-to-face
- ⬭ One that is mostly but not completely online
- ⬭ One that is completely online
- ⬭ No preference

2.3 Please indicate how you use the E-learning portal. Select all that apply. *Check all that apply.*

- ☐ To post a course outline

.

- ☐ To upload information, such as handouts
- ☐ To teach partially online courses
- ☐ To teach completely online courses
- ☐ Other: ______________________

2.4 Please indicate your satisfaction with the following aspects of the E-learning portal: *Mark only one oval per row.*

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied	N/A
Creating or posting Content (e.g. course outline, supplemental learning materials, e-texts)	⬭	⬭	⬭	⬭	⬭	⬭
Importing content from a previous offering of the same course	⬭	⬭	⬭	⬭	⬭	⬭
Integrating third-party Content (e.g. reusable learning objects, material from publishers	⬭	⬭	⬭	⬭	⬭	⬭

Section 3: Teaching and Learning

3.1 I could be a more effective instructor if I were better skilled at integrating this technology into my courses:

Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	N/A
E-portfolios	⬭	⬭	⬭	⬭	⬭	⬭
E-textbooks	⬭	⬭	⬭	⬭	⬭	⬭
Free, supplementary web-based content (MOOCs)	⬭	⬭	⬭	⬭	⬭	⬭
Lecture recordings						
Social media as a teaching	⬭	⬭	⬭	⬭	⬭	⬭

.

and learning						
Software to create videos or multimedia resources as a learning tool in class or assignments	⬭	⬭	⬭	⬭	⬭	⬭

Section 4: Technology use

8. **4.1 How often, in a semester, do you upload content to the e-learning portal for the courses you teach?**
Mark only one oval.

⬭ Upload daily
⬭ Upload weekly
⬭ Upload 2 or 3 times a month
⬭ Never upload

4.2 Rate your satisfaction with the following: *Mark only one oval per row.*

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	NA
Uploading content for all courses you teach	⬭	⬭	⬭	⬭	⬭	⬭
Creating content for new allocated courses	⬭	⬭	⬭	⬭	⬭	⬭

4.3. How long does it take you to author course content for all courses you teach? *Mark only one oval.*

⬭ Less than a month
⬭ One month
⬭ More than one month

4.4 Do you feel the need for automating the process of uploading learning content? *Mark only one oval.*

⬭ Yes

.

- No
- Maybe
- Other: ____________________

4.5 Do you feel it beneficial if content would be outsourced or shareable? *Mark only one oval.*

- Yes
- Most of the time
- No

4.6 Please rate your experiences with the following technology enabled learning provided by your institution:

	Service not offered	Have used in the past year	poor	Fair	neutral	Good	Excellent
Online collaborative platform							
Access to learning resources from home							
Support for finding and using online content							

4.7 Do you have any other requirements?

Section 5: Demographic questions

5.1 Are you? *Mark only one oval*

Female ⬭

Male ⬭

5.2 Subject area

Check all that

apply.

- ☐ Humanities
- ☐ Creative Art and Design
- ☐ Business
- ☐ Engineering and Sciences

Thank you for your time and attention

Clicking the Submit button below completes your response to the invitation to participate in the study.

Have a great day!

Appendix C

Questionnaire for Students

* Required

.

Introduction *

Dear Colleague

The aim and purpose of this research is to embrace MOOCs' introduction into teaching and learning as alternative learning resources with up to date content relevant in different learning areas and investigate ways in which to automate communication between the learning management system and MOOCs. The proposed software model infers an improved teaching and learning space in Zimbabwean Universities.

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We will do our best to keep your information confidential. All data is stored in a password protected electronic format. To help protect your confidentiality, the surveys will not contain information that will personally identify you. The results of this study will be used for scholarly purposes only.

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ELECTRONIC CONSENT:

Clicking on the "agree" option below indicates that:

- you have read the above information
- you voluntarily agree to participate

If you do not wish to participate in the research study, please decline participation by clicking on the "disagree" option.

Mark only one oval.

- ◯ Agree
- ◯ Disagree *Skip to "Thank you for your time and attention."*

Demographic questions

2.1 Are you

Mark only one oval.

- ◯ Female?
- ◯ Male ?

2.2 Study Discipline

.

Mark only one oval.

- Business
- Humanities
- Engineering and
- Sciences Creative
- Art and Design

Device use and ownership

3.1 Do you own any of these devices?	No, and I don't plan to purchase one within the next 12 months	No, but I plan to purchase one within the next 12 months	Yes, I currently own one (or more)
Mark only one oval per row.			
Desktop			
Laptop			
Tablet			

3.2 What type of Smartphone do you have?

Mark only one oval.

- iPhone
- Android
- Phone
- Windows
- Phone
- Don't Know
- Other: ______________________

Section 3: Technology and University experience

.

Mark only one oval per row.

3.1 In the past year, to what extent have you used each device for your academic work?	Did not use at all	Used for at least one course	Used for about half of my courses	Used for all my courses
Desktop				
Laptop Tablet				
Smartphone				

3.2 Please rate institution's support of the following activities you have performed or experienced on a handheld mobile device (e.g. smartphone or tablet)

Mark only one oval per row.

	Service not offered/does not function on my mobile device	Haven't used service in the past year	Poor	Fair	Neutral	Good	Excellent
Accessing course content							
Using the e-learning portal							
Looking up course-related information while in class							

Learning Environments

4.1 Which resources/tools do you wish your	Don't know (Less)	1	2	3	4	(More) 5

.

instructors used
less...or more?

Mark only one oval per row.

E-learning Portal
Online collaboration tools
E-books or e-textbooks
Supplementary web-based content
Simulations

4.2 Please indicate your satisfaction with using your institution's e-learning system to perform the following activities:

Mark only one oval per row.

	Not offered	Don't use this feature at all	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Accessing course content							
Collaborating on projects							
Study groups with other students							

.

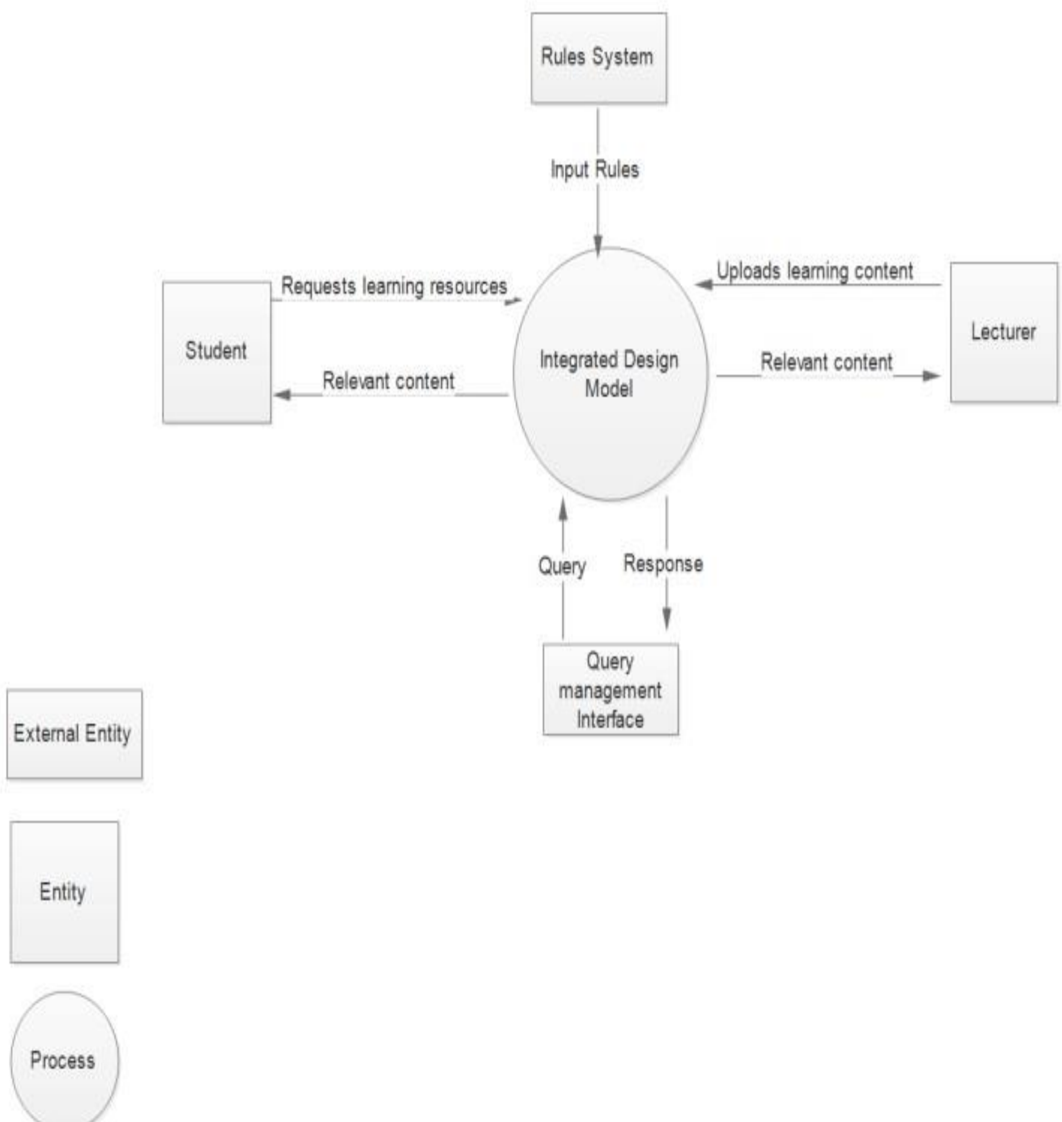
4.3 Do you have other requirements?

Appendix D

Questionnaire for software engineering experts – logical designs evaluation
Introduction
Dear Participant

Thank you for your participation in this study. The goal of this experiment is to show the practical usefulness of the designs for stakeholders in universities. The researcher aims to evaluate the design model with experiment. This experiment aims to test the completeness of data flow diagrams and entity relationship diagram.

Context diagram



.

Description of the integrated system

The aim and purpose of this research is to embrace massive open online courses' introduction into teaching and learning as alternative learning resources with up to date content relevant in different learning areas and investigate ways in which to automate communication between the learning management system and Massive open online courses. Proposed designs infer an improved teaching and learning space in Zimbabwe universities.

This experiment will take approximately 15 minutes of your time

* Required

Experiment worksheet

This section contains designs of the model of integrated learning management systems designed by the researcher. The model is partially shown here for the first iteration.

Mark only one oval.

- Lacks all features
- Lacks most features
- Has some features
- Has most features
- Has all features
- Don't know
- Other

Q2. Comment

Q3. Express your level of agreement to each of the following statements by checking one box: *Mark only one oval per row.*

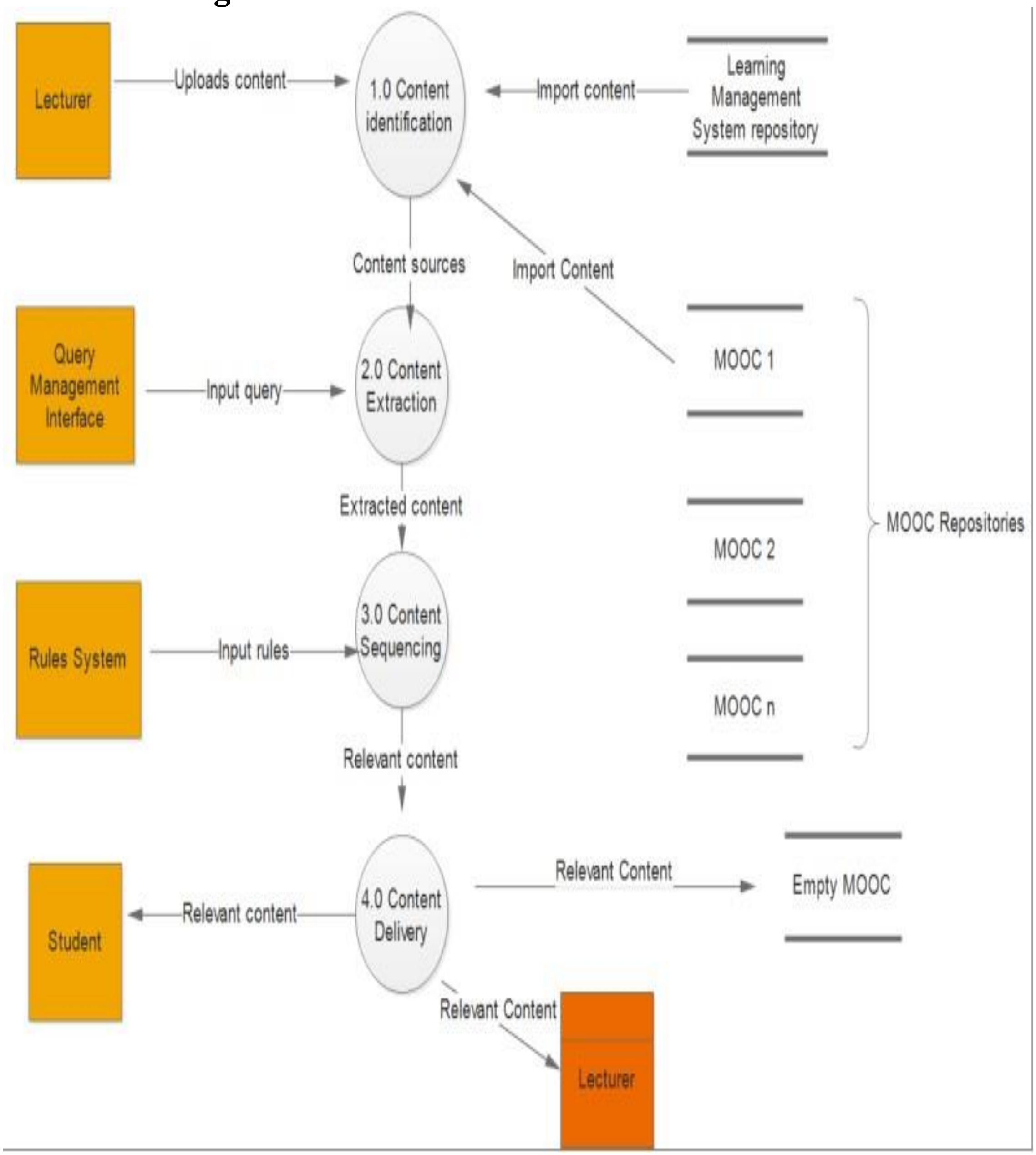
	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
The various functions in this context diagram was well integrated.					
The context diagram is unnecessarily complex					
There was too much inconsistency in the designs					

.

Q4. If scalability is of concern, please provide the scaling factors to be measured

Q5. Can you think of ways that the design context diagram could be improved? What are they?

Data Flow Diagram Level 1



.

Q6. How would you rate the data flow diagram's completeness of features in describing the integrated design model to be developed? * *Mark only one oval.*

- Lack all features
- Lack most features
- Has some features
- Has most features
- Has all features
- Don't know

Q7. Express your level of agreement to each of the following statements by checking one box: *Mark only one oval per row.*

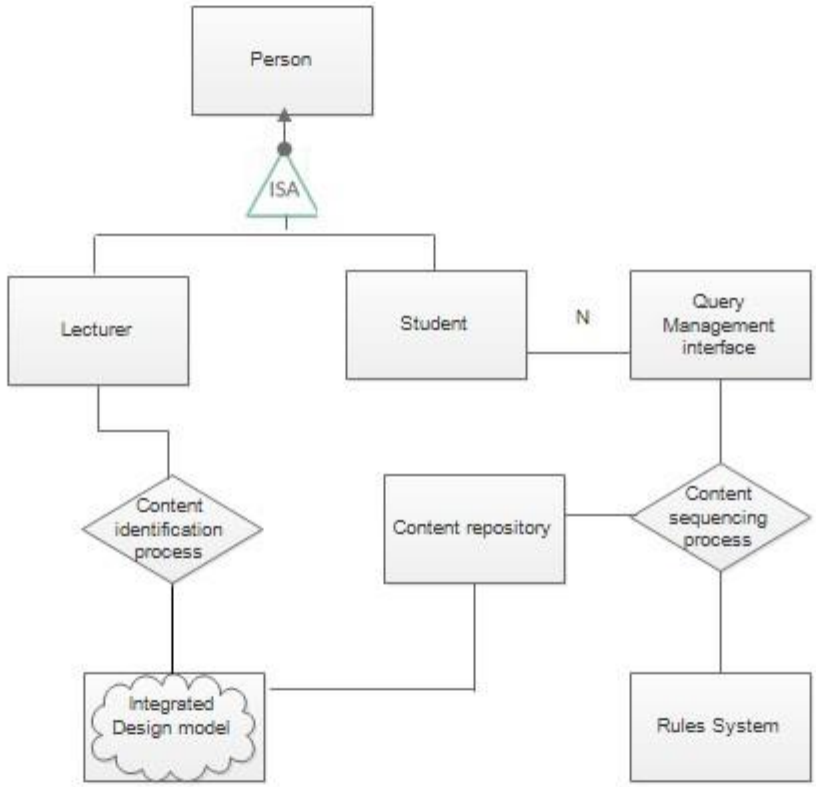
	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
The various functions in this context diagram are well integrated.					
The data flow diagram is unnecessarily complex					
There was too much inconsistency in the designs					

Q8. If scalability is of concern, please provide the scaling factors to be measured

Q9. Can you think of ways that the design of data flow diagram level 1 could be improved? What are they?

.

Entity Relationship Diagram



10 **Q10. How would you rate the data flow diagram's completeness of features in describing the integrated design model to be developed?** *Mark only one oval.*

- Lack all features
- Lack most features
- Has some features
- Has most features
- Has all features
- Don't know

11. **Q11. Comment**

.

12. **Q12. Express your level of agreement to each of the following statements by checking one box:**

Mark only one oval per row.

	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
The various functions in this entity relationship diagram are well integrated.	⬭	⬭	⬭	⬭	⬭
The entity relationship diagram is unnecessarily complex	⬭	⬭	⬭	⬭	⬭
There was too much inconsistency in the designs	⬭	⬭	⬭	⬭	⬭

13. Q13. If scalability is of concern, please provide the scaling factors to be measured

14. Can you think of ways that the design of the entity relationship diagram could be improved? What are they?

15 In the Entity Relationship Diagram, what else do you think would be useful to depict in addition to data attributes and relationships?

.

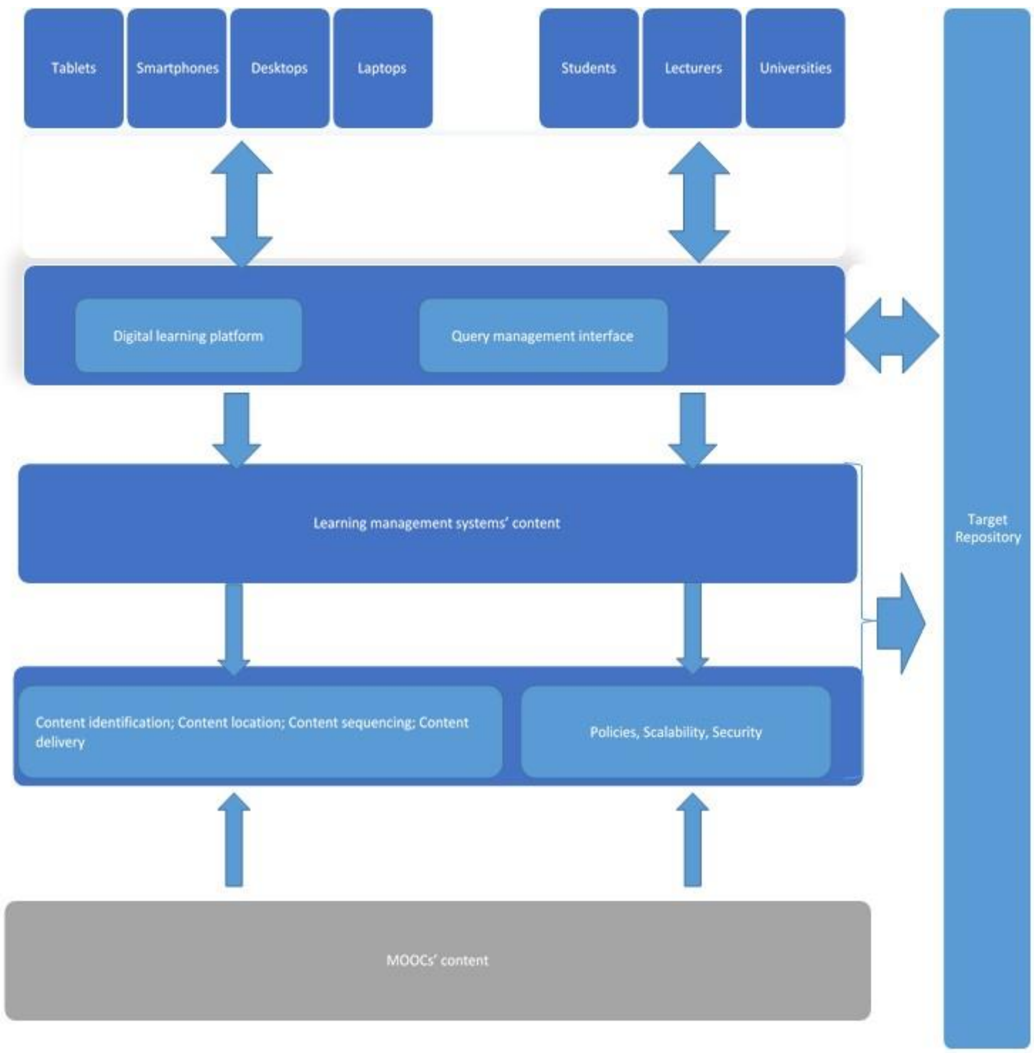
Appendix E

Technology Adoption Evaluation Form

Dear Colleague

The aim of this survey is to test the combined Technology Acceptance Model and Task Technology Fit on the adoption of the design model for integrating learning management systems and massive open online courses. Technology acceptance model and Task Technology Fit are used as strategies to evaluate the model and certify the designs according to the requirements specification. The researcher tests the level of acceptance of the design model and to ascertain if the functions of the technology corresponds with the tasks to be performed.

Proposed model



.

Task Characteristics

In this study, tasks refer to the content uploading processes and the related activities. The following statements help us understand how you view the tasks for the integrated designs.

1. **Please justify your level of agreement based on the statements below.** *Mark only one oval per row.*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Lecturers can be partially relieved from uploading content					
Student can access content anytime, anywhere					

Technology characteristics

The following statements will help us understand how you perceive tools that can be used for accessing learning content activities. In this study, technologies are the "tools used by individuals in carrying out their tasks". The attributes of these technologies can affect usage and user's perception of the technology.

2. **Please justify your level of agreement based on the statements below.**

Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Communication not sufficient at all					
Automation very inappropriate					
Resource sharing very inadequate					
Digital learning Platform not helpful at all					

Perceived usefulness

Perceived usefulness reflects the users' subjective assessment of whether using a particular system would enhance job performance. The degree to which a person believes that the integrated design model would enhance lecturers' job performance.

.

3. **Please justify your level of agreement based on the statements below.**

Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Using this integrated design can enable the students to interact more with content	⬭	⬭	⬭	⬭	⬭
Generally, the system is practical and useful	⬭	⬭	⬭	⬭	⬭
I think the integrated model can facilitate learning	⬭	⬭	⬭	⬭	⬭
I think the integrated designs can reduce lecturer workload	⬭	⬭	⬭	⬭	⬭

Perceived ease of use

This section of the questionnaire will help us to understand how you perceive the extent to which the designs ease of use.

4. **Please indicate the extent to which you perceive the ...to be useful** *Mark only one oval per row.*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I think it does not need a lot of effort and time to search for info on nth platform	⬭	⬭	⬭	⬭	⬭
I think the functions in the model are easy to understand	⬭	⬭	⬭	⬭	⬭
Generally, the model is practical and useful	⬭	⬭	⬭	⬭	⬭

.

Appendix F

Table: Cross-loadings of original path model

This table shows cross-loadings of original path model variables.

		Task_char	Tech_char	Task_tech_fit	Perc_usef	Perc_eas
Task_char						
1	TAC	0.34807	0.3408	0.22112	0.1661	0.22445
1	TAC2	0.60343	0.0645	0.28036	0.2252	0.26573
1	TAC3	0.63835	0.2015	0.29376	0.4145	0.28030
1	TAC4	0.77691	0.2110	0.38591	0.2487	0.25312
1	TAC5	0.54343	0.1193	0.23906	0.2814	0.29256
Tech_char						
2	TEC1	0.11476	0.3060	0.02957	0.0349	0.22721
2	TEC2	0.14275	0.4618	0.12548	0.1242	-0.03510
2	TEC3	0.12396	0.3423	0.05064	-0.0489	0.05208
2	TEC4	0.19861	0.2373	0.18395	0.0733	0.23791
2	TEC5	0.01685	0.4317	0.12863	0.0370	0.18011
2	TEC6	0.23733	0.7431	0.38286	0.3014	0.12090
2	TEC7	0.12511	0.6003	0.25798	0.2075	0.06815
Task_tech_fit						
3	TTF1	0.29024	0.3168	0.72406	0.4005	0.29094
3	TTF2	0.29111	0.2990	0.81895	0.5207	0.36302
3	TTF3	0.30668	0.2528	0.65504	0.3845	0.29392
3	TTF4	0.36370	0.4644	0.78656	0.4903	0.37740
3	TTF6	0.35398	0.3432	0.76179	0.4010	0.41370
3	TTF7	0.54017	0.3382	0.74612	0.4269	0.44143
Perc_usef						
4	PU1	0.37252	0.2441	0.42497	0.7056	0.40821
4	PU2	0.11862	0.2333	0.08562	0.1651	0.30788
4	PU3	0.41668	0.2377	0.46427	0.8014	0.37733
4	PU4	0.28160	0.1617	0.07914	0.3338	0.37674
4	PU5	0.14588	0.3735	0.33687	0.3462	0.28922
4	PU6	-0.01334	-0.1698	0.00865	0.1058	0.00588
4	PU7	0.14717	0.2266	0.43626	0.6796	0.27825
4	PU8	0.31700	0.1627	0.42921	0.7841	0.39035
Perc_eas						
5	PE1	0.38294	0.1757	0.38315	0.3553	0.73129
5	PE2	0.30013	0.1402	0.33590	0.4294	0.78451
5	PE3	0.11863	0.1499	0.20651	0.1964	0.55633
5	PE4	0.31016	0.1463	0.37485	0.4131	0.66643

.

Int_adop_mod

6	IA1	0.26897	0.0696	0.22619	0.1759	0.06825
6	IA2	-0.02760	0.1319	0.13208	0.1068	-0.02981
6	IA3	-0.01572	0.1453	-0.06534	-0.0226	0.04227
6	IA4a	0.00289	-0.0909	0.02942	0.1184	0.07978
6	IA5	0.07876	-0.0182	0.05705	0.2057	-0.00357

Appendix G

Table G-1 Partial Least Squares Path Modeling without traitor variables

This table presents round 3 without traitor variables

```
----------------------------------------------------------
MODEL SPECIFICATION
1    Number of Cases                      117
2    Latent Variables                     6
3    Manifest Variables                   29
4    Scale of Data                        Standardized Data
5    Non-Metric PLS                       FALSE
6    Weighting Scheme                     centroid
7    Tolerance Crit                       1e-06
8    Max Num Iters                        100
9    Convergence Iters                    5
10   Bootstrapping                        FALSE
11   Bootstrap samples                    NULL

----------------------------------------------------------
BLOCKS DEFINITION
            Block            Type        Size        Mode
1       Task_char            Exogenous      5         A
2       Tech_char            Exogenous      6         A
3   Task_tech_fit            Endogenous     6         A
4       Perc_usef            Endogenous     4         A
5        Perc_eas            Endogenous     4         A
6     Int_adop_mod           Endogenous     4         A

----------------------------------------------------------
OUTER MODEL
               weight  loading  communality  redundancy
Task_char
  1 TAC1       0.2552    0.347       0.1206     0.00000
  1 TAC2       0.3246    0.603       0.3641     0.00000
```

.

1	TAC3	0.3417	0.639	0.4088	0.00000
1	TAC4	0.4460	0.776	0.6028	0.00000
1	TAC5	0.2773	0.544	0.2957	0.00000
Tech_char					
2	TEC1	0.0486	0.223	0.0497	0.00000
2	TEC2	0.2049	0.366	0.1340	0.00000
2	TEC3	0.0855	0.356	0.1269	0.00000
2	TEC5	0.2128	0.461	0.2124	0.00000
2	TEC6	0.6305	0.786	0.6182	0.00000
2	TEC7	0.4266	0.679	0.4617	0.00000
Task_tech_fit					
3	TTF1	0.1965	0.726	0.5267	0.17075
3	TTF2	0.2240	0.822	0.6763	0.21925
3	TTF3	0.1755	0.649	0.4216	0.13668
3	TTF4	0.2446	0.783	0.6124	0.19851
3	TTF6	0.2290	0.766	0.5862	0.19002
3	TTF7	0.2579	0.746	0.5571	0.18060
Perc_usef					
4	PU1	0.3189	0.704	0.4962	0.16703
4	PU3	0.3603	0.808	0.6528	0.21974
4	PU7	0.2804	0.690	0.4756	0.16008
4	PU8	0.3613	0.805	0.6482	0.21818
Perc_eas					
5	PE1a	0.4126	0.732	0.5358	0.12925
5	PE2	0.3967	0.786	0.6185	0.14920
5	PE3	0.1672	0.553	0.3056	0.07372
5	PE4	0.4411	0.665	0.4427	0.10680
Int_adop_mod					
6	IA1	0.6185	0.574	0.3291	0.03587
6	IA2	0.2465	0.291	0.0846	0.00923
6	IA4a	0.5132	0.507	0.2566	0.02797
6	IA5	0.5161	0.607	0.3689	0.04022

CROSSLOADINGS

	Task_char	Tech_char	Task_tech_fit	Perc_usef	Perc_eas	Int_adop_mod
Task_char						
1 TAC1	0.34721	0.3029	0.2200	0.144119	0.2252	0.037268
1 TAC2	0.60342	0.0467	0.2798	0.200308	0.2655	0.026748
1 TAC3	0.63938	0.1676	0.2945	0.416458	0.2807	0.151048

.

```
  1 TAC4          0.77640     0.1554          0.3844   0.238554    0.2533
0.128464
  1 TAC5          0.54378     0.1184          0.2390   0.268874    0.2931
0.269614
Tech_char
  2 TEC1          0.11470     0.2229          0.0295 -0.008795     0.2274
-0.000611
  2 TEC2          0.14264     0.3661          0.1243   0.120377   -0.0355
-0.111410
  2 TEC3          0.12381     0.3562          0.0519  -0.056761    0.0514
-0.005319
  2 TEC5          0.01682     0.4608          0.1291  -0.000788    0.1802
0.092801
  2 TEC6          0.23724     0.7863          0.3825   0.289813    0.1208
0.036984
  2 TEC7          0.12500     0.6795          0.2588   0.188932    0.0682
-0.015816
Task_tech_fit
  3 TTF1          0.29027     0.3145          0.7257   0.399523    0.2907
0.010452
  3 TTF2          0.29118     0.2969          0.8224   0.525250    0.3634
0.185245
  3 TTF3          0.30641     0.1792          0.6493   0.376981    0.2942
0.213357
  3 TTF4          0.36360     0.4049          0.7825   0.467025    0.3773
0.296277
  3 TTF6          0.35399     0.3290          0.7656   0.412890    0.4140
0.093307
  3 TTF7          0.54002     0.2956          0.7464   0.422915    0.4415
0.154524
Perc_usef
  4 PU1           0.37271     0.2132          0.4259   0.704435    0.4086
0.223576
  4 PU3           0.41697     0.2420          0.4644   0.807970    0.3773
0.269401
  4 PU7           0.14745     0.2547          0.4352   0.689628    0.2784
0.135765
  4 PU8           0.31723     0.1549          0.4290   0.805104    0.3911
0.306851
Perc_eas
  5 PE1a          0.38278     0.0647          0.3818   0.291404    0.7320
0.042247
  5 PE2           0.30016     0.0824          0.3362   0.390723    0.7865
0.071476
  5 PE3           0.11861     0.1065          0.2063   0.161048    0.5528
-0.034394
  5 PE4           0.31037     0.1689          0.3757   0.415831    0.6654
0.077679
Int_adop_mod
  6 IA1           0.26901     0.0526          0.2257   0.180513    0.0684
0.573667
  6 IA2          -0.02750     0.1669          0.1321   0.128810   -0.0296
0.290923
  6 IA4a          0.00299    -0.0957          0.0273   0.126345    0.0802
0.506510
  6 IA5           0.07887    -0.0224          0.0552   0.211280   -0.0036
0.607395

----------------------------------------------------------
INNER MODEL
$Task_tech_fit
            Estimate   Std. Error    t value   Pr(>|t|)
```

.

```
Intercept   5.76e-17       0.0770   7.49e-16   1.00e+00
Task_char   4.08e-01       0.0796   5.13e+00   1.22e-06
Tech_char   3.08e-01       0.0796   3.87e+00   1.84e-04

$Perc_usef
                Estimate   Std. Error    t value   Pr(>|t|)
Intercept       7.29e-18        0.076   9.59e-17   1.00e+00
Task_tech_fit   5.80e-01        0.076   7.64e+00   7.11e-12


$Perc_eas
                Estimate   Std. Error    t value   Pr(>|t|)
Intercept       4.88e-17       0.0812   6.01e-16   1.00e+00
Task_tech_fit   4.91e-01       0.0812   6.05e+00   1.88e-08


$Int_adop_mod
             Estimate   Std. Error     t value   Pr(>|t|)
Intercept    1.45e-16       0.0884    1.64e-15   1.000000
Perc_usef    3.68e-01       0.1011    3.64e+00   0.000413
Perc_eas    -1.04e-01       0.1011   -1.03e+00   0.304112


----------------------------------------------------------
CORRELATIONS BETWEEN LVs
               Task_char  Tech_char  Task_tech_fit  Perc_usef  Perc_eas
Int_adop_mod
Task_char          1.000      0.252          0.485      0.425    0.4338
0.2019
Tech_char          0.252      1.000          0.410      0.282    0.1517
0.0130
Task_tech_fit      0.485      0.410          1.000      0.580    0.4911
0.2147
Perc_usef          0.425      0.282          0.580      1.000    0.4856
0.3173
Perc_eas           0.434      0.152          0.491      0.486    1.0000
0.0743
Int_adop_mod       0.202      0.013          0.215      0.317    0.0743
1.0000


----------------------------------------------------------


TOTAL EFFECTS
                    relationships  direct  indirect    total
1          Task_char -> Tech_char   0.000    0.0000   0.0000
2      Task_char -> Task_tech_fit   0.408    0.0000   0.4078
3          Task_char -> Perc_usef   0.000    0.2366   0.2366
```

.

```
4            Task_char -> Perc_eas   0.000    0.2003   0.2003
5        Task_char -> Int_adop_mod   0.000    0.0662   0.0662
6       Tech_char -> Task_tech_fit   0.308    0.0000   0.3077
7           Tech_char -> Perc_usef   0.000    0.1785   0.1785
8            Tech_char -> Perc_eas   0.000    0.1511   0.1511
9        Tech_char -> Int_adop_mod   0.000    0.0499   0.0499
10      Task_tech_fit -> Perc_usef   0.580    0.0000   0.5802
11       Task_tech_fit -> Perc_eas   0.491    0.0000   0.4911
12   Task_tech_fit -> Int_adop_mod   0.000    0.1622   0.1622
13           Perc_usef -> Perc_eas   0.000    0.0000   0.0000
14       Perc_usef -> Int_adop_mod   0.368    0.0000   0.3680
15        Perc_eas -> Int_adop_mod  -0.104    0.0000  -0.1044

# plotting the loadings
>            plot(TAM_TTF_adop_pls_modA, what = "loadings")
>
```

Appendix H

Table H-1 Final Partial Least Squares – Path Modeling output for modified model

```
----------------------------------------------------------
MODEL SPECIFICATION
1   Number of Cases                     117
2   Latent Variables                    6
3   Manifest Variables                  29
4   Scale of Data                       Standardized Data
5   Non-Metric PLS                      FALSE
6   Weighting Scheme                    centroid
7   Tolerance Crit                      1e-06
8   Max Num Iters                       100
9   Convergence Iters                   5
10 Bootstrapping                        FALSE
11 Bootstrap samples                    NULL

----------------------------------------------------------
BLOCKS DEFINITION
            Block              Type           Size    Mode
1       Task_char              Exogenous      5       A
2       Tech_char              Exogenous      6       A
3   Task_tech_fit              Endogenous             6       A
```

.

4	Perc_usef	Endogenous	4	A
5	Perc_eas	Endogenous	4	A
6	Int_adop_mod	Endogenous	4	A

OUTER MODEL

	weight	loading	communality	redundancy
Task_char				
1 TAC1	0.2465	0.336	0.113	0.0000
1 TAC2	0.3087	0.592	0.350	0.0000
1 TAC3	0.4092	0.681	0.464	0.0000
1 TAC4	0.3628	0.724	0.524	0.0000
1 TAC5	0.3310	0.584	0.341	0.0000
Tech_char				
2 TEC1	0.1986	0.361	0.130	0.0000
2 TEC2	0.1663	0.329	0.108	0.0000
2 TEC3	0.0361	0.332	0.110	0.0000
2 TEC5	0.2397	0.494	0.244	0.0000
2 TEC6	0.6183	0.777	0.603	0.0000
2 TEC7	0.4016	0.655	0.429	0.0000
Task_tech_fit				
3 TTF1	0.1801	0.718	0.515	0.1609
3 TTF2	0.2255	0.821	0.675	0.2108
3 TTF3	0.1810	0.653	0.426	0.1331
3 TTF4	0.2611	0.791	0.626	0.1956
3 TTF6	0.2274	0.764	0.584	0.1824
3 TTF7	0.2516	0.743	0.553	0.1727
Perc_usef				
4 PU1	0.3487	0.729	0.531	0.2002
4 PU3	0.3830	0.822	0.676	0.2549
4 PU7	0.2613	0.668	0.447	0.1684
4 PU8	0.3275	0.783	0.614	0.2314
Perc_eas				
5 PE1a	0.4246	0.743	0.551	0.1626
5 PE2	0.3864	0.781	0.610	0.1798
5 PE3	0.1877	0.567	0.322	0.0948
5 PE4	0.4227	0.654	0.428	0.1262
Int_adop_mod				
6 IA1	0.7484	0.717	0.513	0.0635
6 IA2	0.3640	0.398	0.159	0.0196

.

```
  6 IA4a       0.3638    0.330        0.109          0.0135
  6 IA5        0.4038    0.492        0.242          0.0299

---------------------------------------------------------
CROSSLOADINGS
              Task_char  Tech_char  Task_tech_fit  Perc_usef  Perc_eas  I
nt_adop_mod
Task_char
  1 TAC1          0.3361     0.3206          0.2218   0.150735    0.2249
0.0379
  1 TAC2          0.5916     0.0375          0.2778   0.204241    0.2662
0.0387
  1 TAC3          0.6809     0.1735          0.2934   0.420093    0.2782
0.1506
  1 TAC4          0.7237     0.1446          0.3843   0.240624    0.2542
0.1492
  1 TAC5          0.5840     0.1230          0.2389   0.275693    0.2875
0.3031
Tech_char
  2 TEC1          0.1223     0.3608          0.0301  -0.007798    0.2326
0.0139
  2 TEC2          0.1433     0.3291          0.1250   0.124601   -0.0362
-0.1104
  2 TEC3          0.1235     0.3315          0.0488  -0.050924    0.0484
0.0214
  2 TEC5          0.0336     0.4942          0.1284  -0.000902    0.1801
0.0784
  2 TEC6          0.2291     0.7767          0.3837   0.289001    0.1211
0.0752
  2 TEC7          0.1308     0.6547          0.2589   0.190953    0.0657
0.0288
Task_tech_fit
  3 TTF1          0.2910     0.3003          0.7177   0.399379    0.2913
0.0445
  3 TTF2          0.2953     0.2820          0.8214   0.526329    0.3598
0.1974
  3 TTF3          0.2924     0.1601          0.6528   0.370541    0.2930
0.2171
  3 TTF4          0.3600     0.4084          0.7912   0.470334    0.3794
0.3053
```

.

```
  3 TTF6          0.3565     0.3234          0.7641   0.416882    0.4101
0.1684
  3 TTF7          0.5248     0.2930          0.7434   0.421321    0.4403
0.1742
Perc_usef
  4 PU1           0.3884     0.2095          0.4257   0.728566    0.4079
0.2489
  4 PU3           0.4353     0.2232          0.4661   0.822066    0.3742
0.2731
  4 PU7           0.1560     0.2366          0.4352   0.668263    0.2729
0.1257
  4 PU8           0.3291     0.1593          0.4293   0.783306    0.3855
0.2775
Perc_eas
  5 PE1a          0.3757     0.1252          0.3832   0.297364    0.7426
0.0387
  5 PE2           0.3129     0.1285          0.3367   0.390130    0.7810
0.0615
  5 PE3           0.1144     0.1215          0.2059   0.165564    0.5671
-0.0342
  5 PE4           0.3241     0.1437          0.3745   0.414037    0.6542
0.0759
Int_adop_mod
  6 IA1           0.2744     0.0552          0.2270   0.186210    0.0675
0.7165
  6 IA2          -0.0174     0.1660          0.1339   0.130599   -0.0307
0.3983
  6 IA4a          0.0141    -0.0915          0.0317   0.121875    0.0801
0.3302
  6 IA5           0.0822    -0.0158          0.0582   0.207657   -0.0065
0.4920

----------------------------------------------------------
INNER MODEL
$Task_tech_fit
            Estimate   Std. Error    t value   Pr(>|t|)
Intercept   5.90e-17       0.0777   7.60e-16   1.00e+00
Task_char   4.03e-01       0.0803   5.02e+00   1.93e-06
Tech_char   2.98e-01       0.0803   3.71e+00   3.25e-04

$Perc_usef
```

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-4.88e-17	0.0742	-6.58e-16	1.00e+00
Task_char	2.21e-01	0.0848	2.61e+00	1.04e-02
Tech_char	3.07e-02	0.0813	3.78e-01	7.06e-01
Task_tech_fit	4.63e-01	0.0895	5.17e+00	1.01e-06

$Perc_eas

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	-9.64e-17	0.0790	-1.22e-15	1.000000
Task_char	2.68e-01	0.0903	2.97e+00	0.003688
Tech_char	-3.17e-02	0.0865	-3.67e-01	0.714348
Task_tech_fit	3.74e-01	0.0953	3.93e+00	0.000148

$Int_adop_mod

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	2.07e-16	0.0881	2.35e-15	1.000
Task_tech_fit	1.55e-01	0.1132	1.37e+00	0.173
Perc_usef	3.00e-01	0.1127	2.66e+00	0.009
Perc_eas	-1.55e-01	0.1052	-1.47e+00	0.143

CORRELATIONS BETWEEN LVs

	Task_char	Tech_char	Task_tech_fit	Perc_usef	Perc_eas	Int_adop_mod
Task_char	1.000	0.2548	0.479	0.451	0.4389	0.2373
Tech_char	0.255	1.0000	0.401	0.273	0.1863	0.0621
Task_tech_fit	0.479	0.4005	1.000	0.581	0.4897	0.2537
Perc_usef	0.451	0.2725	0.581	1.000	0.4831	0.3151
Perc_eas	0.439	0.1863	0.490	0.483	1.0000	0.0658
Int_adop_mod	0.237	0.0621	0.254	0.315	0.0658	1.0000

TOTAL EFFECTS

.

	relationships	direct	indirect	total
1	Task_char -> Tech_char	0.0000	0.0000	0.0000
2	Task_char -> Task_tech_fit	0.4031	0.0000	0.4031
3	Task_char -> Perc_usef	0.2210	0.1867	0.4077
4	Task_char -> Perc_eas	0.2677	0.1509	0.4185
5	Task_char -> Int_adop_mod	0.0000	0.1199	0.1199
6	Tech_char -> Task_tech_fit	0.2978	0.0000	0.2978
7	Tech_char -> Perc_usef	0.0307	0.1379	0.1686
8	Tech_char -> Perc_eas	-0.0317	0.1114	0.0797
9	Tech_char -> Int_adop_mod	0.0000	0.0844	0.0844
10	Task_tech_fit -> Perc_usef	0.4631	0.0000	0.4631
11	Task_tech_fit -> Perc_eas	0.3742	0.0000	0.3742
12	Task_tech_fit -> Int_adop_mod	0.1554	0.0808	0.2361
13	Perc_usef -> Perc_eas	0.0000	0.0000	0.0000
14	Perc_usef -> Int_adop_mod	0.2996	0.0000	0.2996
15	Perc_eas -> Int_adop_mod	-0.1550	0.0000	-0.1550

Appendix I

Table I-1 Partial least squares path modeling with less negative relationships

```
----------------------------------------------------------
MODEL SPECIFICATION
1   Number of Cases      117
2   Latent Variables     6
3   Manifest Variables   29
4   Scale of Data        Standardized Data
5   Non-Metric PLS       FALSE
6   Weighting Scheme     centroid
7   Tolerance Crit       1e-06
8   Max Num Iters        100
9   Convergence Iters    5
10  Bootstrapping        FALSE
11  Bootstrap samples    NULL

----------------------------------------------------------
BLOCKS DEFINITION
            Block         Type   Size   Mode
1       Task_char    Exogenous      5      A
2       Tech_char    Exogenous      6      A
```

.

3	Task_tech_fit	Endogenous	6	A
4	Perc_usef	Endogenous	4	A
5	Perc_eas2	Endogenous	4	A
6	Int_adop_mod2	Endogenous	4	A

OUTER MODEL

	weight	loading	communality	redundancy
Task_char				
1 TAC1	0.24713	0.337	0.1134	0.00000
1 TAC2	0.30918	0.592	0.3502	0.00000
1 TAC3	0.40876	0.681	0.4634	0.00000
1 TAC4	0.36357	0.724	0.5246	0.00000
1 TAC5	0.32974	0.583	0.3399	0.00000
Tech_char				
2 TEC1	0.02139	0.164	0.0269	0.00000
2 TEC2	0.24892	0.378	0.1425	0.00000
2 TEC3	-0.00227	0.248	0.0617	0.00000
2 TEC5	0.12706	0.347	0.1201	0.00000
2 TEC6	0.67280	0.838	0.7030	0.00000
2 TEC7	0.45011	0.655	0.4294	0.00000
Task_tech_fit				
3 TTF1	0.17954	0.717	0.5147	0.16775
3 TTF2	0.22450	0.821	0.6742	0.21973
3 TTF3	0.18285	0.654	0.4274	0.13927
3 TTF4	0.25971	0.791	0.6251	0.20372
3 TTF6	0.22944	0.765	0.5851	0.19068
3 TTF7	0.25093	0.743	0.5523	0.17999
Perc_usef				
4 PU1	0.34534	0.726	0.5276	0.20032
4 PU3	0.38557	0.823	0.6775	0.25726
4 PU7	0.26459	0.671	0.4497	0.17074
4 PU8	0.32504	0.783	0.6124	0.23255
Perc_eas2				
5 PE1a	0.44387	0.757	0.5727	0.16845
5 PE2	0.37992	0.782	0.6108	0.17966
5 PE3	0.18727	0.565	0.3195	0.09399
5 PE4	0.40850	0.640	0.4092	0.12037
Int_adop_mod2				
6 IA1	0.70121	0.680	0.4624	0.04921

```
  .


  6 IA2          0.45005     0.490        0.2404     0.02558
  6 IA4a         0.26128     0.237        0.0560     0.00596
  6 IA5          0.45008     0.535        0.2859     0.03043

---------------------------------------------------------
CROSSLOADINGS
               Task_char  Tech_char  Task_tech_fit  Perc_usef  Perc_eas2
Int_adop_mod2
Task_char
  1 TAC1          0.3367     0.2997         0.2218    0.14992     0.2272
0.0342
  1 TAC2          0.5917     0.0345         0.2778    0.20464     0.2669
0.0318
  1 TAC3          0.6807     0.1903         0.2932    0.41984     0.2776
0.1490
  1 TAC4          0.7243     0.1773         0.3843    0.24023     0.2566
0.1425
  1 TAC5          0.5830     0.0863         0.2390    0.27527     0.2849
0.2851
Tech_char
  2 TEC1          0.1223     0.1639         0.0299   -0.00845     0.2378(
trai          0.0288
  2 TEC2          0.1435     0.3775         0.1251    0.12395    -0.0379
-0.0905
  2 TEC3          0.1235     0.2483         0.0485   -0.05081     0.0429
0.0424
  2 TEC5          0.0333     0.3466         0.1281   -0.00104     0.1808
0.0763
  2 TEC6          0.2293     0.8384         0.3837    0.28931     0.1213
0.0816
  2 TEC7          0.1308     0.6553         0.2585    0.19181     0.0623
0.0534
Task_tech_fit
  3 TTF1          0.2911     0.3084         0.7174    0.39955     0.2913
0.0460
  3 TTF2          0.2953     0.3011         0.8211    0.52622     0.3581
0.1903
  3 TTF3          0.2926     0.2016         0.6537    0.37118     0.2937
0.2019
  3 TTF4          0.3601     0.4177         0.7906    0.47055     0.3816
0.3031
```

.

```
  3 TTF6          0.3565     0.3444          0.7649    0.41696     0.4081
0.1818
  3 TTF7          0.5250     0.2994          0.7432    0.42124     0.4403
0.1817
Perc_usef
  4 PU1           0.3884     0.2290          0.4256    0.72634     0.4088
0.2472
  4 PU3           0.4350     0.2616          0.4659    0.82311     0.3715
0.2780
  4 PU7           0.1560     0.2793          0.4354    0.67057     0.2682
0.1178
  4 PU8           0.3289     0.1778          0.4292    0.78259     0.3830
0.2785
Perc_eas2
  5 PE1a          0.3758     0.0536          0.3831    0.29652     0.7568
0.0153
  5 PE2           0.3129     0.0679          0.3367    0.38918     0.7815
0.0510
  5 PE3           0.1145     0.0913          0.2057    0.16566     0.5653
-0.0348
  5 PE4           0.3238     0.1505          0.3747    0.41468     0.6397
0.0753
Int_adop_mod2
  6 IA1           0.2742     0.0473          0.2271    0.18570     0.0675
0.6800
  6 IA2          -0.0176     0.1679          0.1342    0.13078    -0.0311
0.4903
  6 IA4a          0.0139    -0.0961          0.0317    0.12216     0.0820
0.2367
  6 IA5           0.0822    -0.0378          0.0578    0.20721    -0.0096
0.5347

----------------------------------------------------------
INNER MODEL
$Task_tech_fit
            Estimate   Std. Error    t value   Pr(>|t|)
Intercept   8.66e-17       0.0769   1.13e-15   1.00e+00
Task_char   3.97e-01       0.0795   4.99e+00   2.16e-06
Tech_char   3.21e-01       0.0795   4.04e+00   9.86e-05

$Perc_usef
```

.

```
                Estimate  Std. Error   t value   Pr(>|t|)
Intercept       5.80e-17      0.0741  7.83e-16   1.00e+00
Task_char       2.18e-01      0.0846  2.58e+00   1.12e-02
Tech_char       6.63e-02      0.0819  8.10e-01   4.20e-01
Task_tech_fit   4.49e-01      0.0902  4.97e+00   2.37e-06

$Perc_eas2
                Estimate  Std. Error   t value   Pr(>|t|)
Intercept       2.42e-17      0.0787  3.08e-16   1.00e+00
Task_char       2.66e-01      0.0896  2.97e+00   3.68e-03
Task_tech_fit   3.62e-01      0.0896  4.04e+00   9.73e-05

$Int_adop_mod2
                Estimate  Std. Error   t value   Pr(>|t|)
Intercept       1.76e-16      0.0885  1.99e-15     1.0000
Task_tech_fit   1.08e-01      0.1088  9.89e-01     0.3249
Perc_usef       2.52e-01      0.1088  2.31e+00     0.0225

----------------------------------------------------------
CORRELATIONS BETWEEN LVs
               Task_char  Tech_char  Task_tech_fit  Perc_usef  Perc_eas2
Int_adop_mod2
Task_char          1.000     0.2554          0.479      0.450     0.4394
0.2250
Tech_char          0.255     1.0000          0.422      0.312     0.1282
0.0666
Task_tech_fit      0.479     0.4225          1.000      0.581     0.4896
0.2539
Perc_usef          0.450     0.3116          0.581      1.000     0.4799
0.3143
Perc_eas2          0.439     0.1282          0.490      0.480     1.0000
0.0504
Int_adop_mod2      0.225     0.0666          0.254      0.314     0.0504
1.0000
----------------------------------------------------------
TOTAL EFFECTS
                  relationships  direct  indirect   total
1          Task_char -> Tech_char  0.0000    0.0000  0.0000
2      Task_char -> Task_tech_fit  0.3971    0.0000  0.3971
3          Task_char -> Perc_usef  0.2181    0.1782  0.3963
4          Task_char -> Perc_eas2  0.2659    0.1438  0.4097
```

.

5	Task_char -> Int_adop_mod2	0.0000	0.1425	0.1425
6	Tech_char -> Task_tech_fit	0.3210	0.0000	0.3210
7	Tech_char -> Perc_usef	0.0663	0.1441	0.2104
8	Tech_char -> Perc_eas2	0.0000	0.1163	0.1163
9	Tech_char -> Int_adop_mod2	0.0000	0.0875	0.0875
10	Task_tech_fit -> Perc_usef	0.4488	0.0000	0.4488
11	Task_tech_fit -> Perc_eas2	0.3622	0.0000	0.3622
12	Task_tech_fit -> Int_adop_mod2	0.1076	0.1130	0.2206
13	Perc_usef -> Perc_eas2	0.0000	0.0000	0.0000
14	Perc_usef -> Int_adop_mod2	0.2517	0.0000	0.2517
15	Perc_eas2 -> Int_adop_mod2	0.0000	0.0000	0.0000

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Appendix J

Ethical clearance letter

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

21 July 2017

Mrs TT Rugube 216076156
School of Education
Edgewood Campus

Dear Mrs Rugube

Protocol Reference Number: HSS/0461/017D
Project title: "A Design Model for Integrating Learning Management Systems and Massive Open Online Courses on Enhanced Communication Networks' Digital E-Learning Platform: Implications for policy and practice in Zimbabwean Universities".

Full Approval – Expedited Application

In response to your application received 4 May 2017, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....

Dr Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committee

/pm

cc Supervisor: Prof TC Dr C Chibaya
cc. Academic Leader Research: Dr SB Khoza
cc. School Administrator: Ms Tyzer Khumalo

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

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Appendix K

Turnitin Report

Turnitin Originality Report

Design Model for Integrating Learning Management Systems and Massive Open Online Courses on a Digital E-Learning Platform by Talent Rugube

From Draft Thesis (General)

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Design Model for Integrating

4**Learning Management Systems and Massive Open Online Courses**

on a Digital E-Learning Platform: Implications for Zimbabwean Universities A thesis submitted to the cluster