USABILITY OF LEARNING MANAGEMENT SYSTEMS IN BUSINESS & MANAGEMENT HIGHER EDUCATION INSTITUTES IN SRI LANKA

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DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Signature of the supervisor: Date: 25th May 2020

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Signature of the supervisor: Date: 25th May 2020

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ABSTRACT

This study explores some ideas drawn from product design and quality management literature to develop a framework to assess the amount of intervention of e-learning on the current teaching and learning processes of the undergraduates in business and management faculties in Sri Lanka. This will provide an intuitive understanding of such assessment measures to the educationalists involve in e-learning.

Literature surveys and expert interviews provide available teaching and learning tools in commonly used learning management systems (LMS) in higher education institutes in Sri Lanka. Our stakeholder structured and semi-structured interviews record the customer requirements of e-learning delivery. We deploy Analytic Hierarchy Process (AHP) to screen the above customer/stakeholder requirements in terms of relative importance. Quality Function Deployment (QFD) maps the tools against the requirements.

Keywords: Analytic Hierarchy Process, E-learning, Learning Management System, Quality Function Deployment

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	Description
AHP	Analytic Hierarchy Process
CAI	Computer-assisted instruction
E-LEARNING / EL	Electronic Learning
EPLMS	Effectiveness Percentage of the LMS
HOQ	House of Quality
ICT	Information and Communication Technology
ILTC	Impact Level of a Technical Capability
LMS	Learning Management Systems
MCDA	Multi-Criteria Decision Analysis
MOODLE	Modular Object-Oriented Dynamic Learning Environment
QFD	Quality Functional Deployment
RSCR	Relationship Strength between Capability and the Requirement
VOC	Voice of Customers

LIST OF APPENDICES

1. INTRODUCTION

1.1 ICT enabled teaching & learning practices

Contemporary changes in the global economic order call for pervasive and innovative ways of delivering education. This has made educators look for adaptable and flexible learning technologies, changes in existing organizational structures. As a result, e-learning systems can be both theoretically and fundamentally engaging tools which, can be taken as a way to create learning and teaching resources to improve delivery quality and ultimately increase the efficiency and effectiveness of students learning.

Different forms of e-learning approaches are available to support the learning community to deal with teaching and learning activities such as active participation, feedback, reflective practices, and prior preparation. Already a large amount of educational data is available as a result of the recent use of e-learning systems to offer on-line courses.

1.2 Background of study

It is almost impossible to think of teaching and learning processes without any involvement and intervention of ICT. ICT enabled teaching and learning or sometimes popularly known as e-learning is gaining its momentum and as a result it has made a paradigm shift in contemporary education. Then the mixed/blended learning, which associates online components with the conventional face-to-face components, has emerged as a substitute for teaching and learning mode (Watson, 2008). Today the delivery of e-learning mostly performs via both commercial and free-and-open-source Learning Management Systems (LMS) such as Computer Aided Learning (CAL), Modular Object-Oriented Dynamic Learning Environment (Moodle) and Blackboard.

These systems provide attractive alternatives to the education institutions with limited space to create a cost-effective virtual teaching and learning environment (Werbach, 2000). This is without compromising some essential features such as student-teacher interaction, provide feedback, frequent conversation and peer networking available in conventional class-rooms (Benta, Bologa, Dzitac, & Dzitac, 2015).

Sometimes e-learning can be thought of as a conveyance instrument of course content over many sorts of web-based and online media (Wang, 2003). Today, e-learning models and approaches are available in real time (synchronous) mode, anytime and anywhere (asynchronous) mode, or in hybrid mode.

To harness the maximum potential of e-learning, the system configurations and implementations should be geared to satisfy the requirements of all stakeholders in the teaching and learning process. Despite the continuous growth of market for e-learning or sometimes known as online learning and the amount of benefits, educators have raised their concerns over the relatively high rate of discontinuations of e-learning courses (Dutton, Dutton, & Perry, 2002).

The resource redundancy is another common issue with these systems. That is, configured tools in the LMS may not be fully utilized due to issues such as the lack of awareness about the tools and capabilities among teachers and students, no proper assessment of customer requirements versus system capabilities, system configuration not supporting some learning outcomes and wrong choice of the type of LMS at the procurement stages (Estacio & Raga Jr, 2017). Currently, several universities in Sri Lanka use e-learning platforms. However, these systems are largely operating in asynchronous mode. So, the current surveys show relatively low utilization of available resources and low student participation. Still, some institutions have not taken adequate measures to use electronic learning methods (Kanaganayagam & Fernando, 2013).

1.3 Research issue

How does online teaching and learning strategies have improved student learning experience and their performance?

1.4 Research Objectives

This study aims to establish the following objectives:

- To assess the perceived stakeholder requirement of learning management systems to accomplish teaching and learning activities
- To identify the tools and/or functions available in learning management systems to perform teaching and learning activities
- To develop a stakeholder requirement – technical capability matrix for learning management systems to support tactical and operational decision making.

1.5 Scope

This research focuses on developing a design framework for different functions in LMS based on consumer preference in business and management studies in Sri Lanka higher education sector.

The first part of this study identifies the stakeholder requirements of the existing LMS framework related to management areas. Then as the next step of this study technical capabilities that would enable the features of LMS framework and customer requirements are also examined. As all the requirements might not have been possible to be implemented, the study screened only the most suitable factors from the identified requirements to get the customer requirements. Then the study evaluated the technical capabilities against the customer requirements. Finally, a decision matrix is developed to support tactical and operational decision making.

1.6 Significance

This study would help the authorities firstly in preparing specifications of LMS during procurement process and secondly configuring new or existing LMS to suite consumer expectations in the area of business and management studies. This will prevent making and LMS unnecessarily complex, and also it will maximize the utility of majority of available functions in an LMS. There is no solid evidence on stakeholder requirement analysis conducted during pre-procurement stages of LMS and stakeholder expectation surveys conducted at post-implementation stages of LMS in higher education institutes in Sri Lanka. Even though, majority of higher education institutes already have invested significant amount of money to acquire or/and develop learning management systems, their financial reports fail to unveil important performance measures such as usage levels, return on investment, and quality of delivery (Thuseethan, Achchuthan, & Kuhanesan, 2014).

1.7 Organization of Chapters

Chapter 2 reviews relevant literature that relates to the study. First introduce the e-learning concept as well as related other concepts with definitions. Then identify the research gap. Finally identify research methods/approaches; mainly the AHP and QFD process described.

Chapter 3 explains the research methodology that was used in carrying out the research. Research strategy and research methods used in this study and other assumptions used were discussed with justifications.

Chapter 4 presents data analysis. The first part provides descriptive analysis. This study deploys multi-criteria decision analysis techniques for detail data analysis and then it shows how to map outcomes using the Quality Functional Deployment (QFD) model. Finally, a decision matrix is

constructed to support tactical and operational decision making in the business and management discipline.

Chapter 5 provides conclusions, recommendations and further research directions.

2. LITRATURE REVIEW

2.1 Introduction

This chapter reviews the existing literature pertaining to stakeholder side issues on the learning management systems. Section 2.2 introduces e-learning concepts and it identifies different platforms of the usage of e-learning. Section 2.3 explains stakeholder expectations on e-learning and highlights some literature that studies the ways to assess stakeholder expectations. Finally, Section 2.4 highlights the summary of the literature findings.

2.2 E-Learning

2.2.1 What is e-learning?

Technology enabled teaching and learning processes such e-learning has had significant effects on education over last few decades. Today it has become a mainstream component in delivery modes of teaching and learning to different audiences.

The advancement of internet and its availability for common people have certainly fueled the developments of e-learning pedagogy and techniques. “Learner-oriented design” of present e-learning platforms, provides the student greater control over the appearance of the virtual elements and the learning process (Downes, 2005).

According to Hancer (2010), learning behavior has changed mainly due to the developing social media, developing technology and “y” generation. The necessity for distance education is increasing day by day due to these progressions. And according to Sen & Zhi-liang (2010) the e-learning concept emerged to facilitate distance learning. This emergence of distance learning is increasing every day due to several reasons. Some of them are, to distribute education to a larger crowd, to minimize the barriers in traditional education by providing a learning opportunity to students with different learning methods, to deliver equality of opportunity in education and especially to meet the educational need of students who cannot continue their higher education due to different reasons and etc.

Early literature reports some degree of conceptual misalignments among e-learning, online learning and distance learning (Moore & Kearsley, 2011). However, Nichols (2003) recognizes e-learning as an internet-friendly online learning, available via web-based and web-capable technical resources where Garrison (2011) mentioned e-learning as online learning enabled by network

technology. That aforementioned definition further expanded by mentioning to it as the use of IT and web in teaching and learning (education) to make it simpler, more expansive and more effective (Pham & Huynh, 2017). In spite of that, a prolonged definition of e-learning that involves offline ways for transmitting learning material using different types of media like CDs, audio and video, satellite broadcasting and even interactive television has been proposed by Ellis (2004) (Benson, Lawler , & Whitworth, 2002; Clark, 2002). Later, Fallon and Brown (2016) concluded e-learning with another broader perspective and they considered e-learning as any usage of eminent and established learning related computer technologies.

Even though the basic definition of e-learning is learning online, different scholars have identified this e-learning concept in different ways, following table highlights definitions given by different research articles.

Table 1 : E-Learning definition by different scholars

Source	Definition
Arkorful & Abaidoo, (2014)	Characterize of e-learning as a mode to manage to teach and getting the hang of, addressing all or part of the instructive model applied, that relies upon the usage of electronic media and devices as gadgets for improving contact to learning, correspondence, and joint effort and that empowers the gathering of better methodologies for comprehension and making learning.
Kentnor, H., (2015)	Portrays online learning method to get, the use of the Internet to get to learning materials; to interface with the teacher, and various students; and to get aid during the learning method, in order to make sure about data, to assemble singular significance, and to create from the learning experience.
Vackova & Kovacova, (2015)	There are numerous definitions in the literature depicting e-learning that incorporates web-based learning, PC based, IT ICT based learning. These are e-learning strategies definitions for advanced education programs that are regularly utilized. Broadly, e-learning alludes to the utilization of different electronic innovations to help to learn and instructing.
Christensson, (2020)	E-learning is a collective term that portrays learning and teaching utilizing electronic gadgets and computerized media. It involves everything from traditional classrooms that join essential technology to online colleges.

Mayadas, Miller, & Sener, (2015)	One meaning of web-based learning is that it is a strategy for introducing teaching and learning material to a learner by method for a PC program. This program gives a chance to an individual association.
Bezhovski & Poorani, (2016)	Describes e-learning as "the utilization of ICT as interchanges and conveyance instrument among people and groups, to help learners and improve the administration of learning.
Sun & Chen, (2016)	Characterizes e-learning as a blend of learning and knowledge management. Preparing is the manner by which the guidance is transmitted so as to shape the learning procedure, though the information the board alludes to the utilization of extra information and execution bolster apparatuses that help the learners to learn and improve their work.

Source: (Ramzani & Suleiman, 2019)

2.2.2 **E – Learning in Higher Education Sector**

The education landscape has had some major overhauling as a result of the advancement of information and communication technology (ICT). Generally, however e-learning presumes internet learning because computers and the internet have become norms in our day-to-day lives (Baytak, 2010). Technology enabled education can provide learning at all levels (nursery, primary, secondary and tertiary) with new perspectives (Steeples, Jones, & Goodyear, 2002). But this is not without challenges, though.

Even though, the above levels or stages are different from each other (e.g., age of the learners, learning content, learning context, and learning purpose), e-learning appears to successfully adaptable (Hunt & Ivergard, 2005). The following Table 2 indicates the potential of e-learning versus the level/stage of education.

Table 2: Types of Learning and eLearning Potentials

Education Stage	**Type of Learning**	**E-learning Potentials**
Nursery	Play	Utilizing technology to investigate prospects. Getting comfortable with the essential controls of the technology. Having the option to follow learning and to utilize this as a benchmark for additional advancement with the technology. E-learning focuses on technology. Recognizable substance from regular sights and sounds.

Primary	Socialization	Distribution of technology to other people. Collective learning with technology as a medium. Viable components as a method for specific ability improvement. E-learning technology as a self-coordinated apparatus for learning. Socialization components through carrying the external world into the video display unit (VDU).
Secondary	Discipline	Customizing the technology towards yields of learning (for example study/education). Innovation for learning substance and connections between content. The technology utilized for the person's precise purposes.
Tertiary	Specialization	Technology as a learning apparatus both to convey explicit substance and to help the client in distinguishing extra (related) content. E-learning Technology as both procedure and outcome creation.

Source: (Hunt & Ivergard, 2005)

Today e-learning has received one of the growing attentions from both national and international education levels (McIsaac & Gunawardena, 2001). As per the researcher, Collis and Van der Wende (2005) e-learning will be a significant component in the current framework as well as in future education and training frameworks also. In this manner, in the higher education division, e-learning has become a prevailing marvel that requires all colleges to think about accepting just as receiving it (Neal, 2007).

2.2.2.1 **E-Learning for Management Educations**

So, the implementation of the changes discussed in the previous section will affect immensely in the field of higher educational sectors. There also not only the high-tech sectors but the business and management education discipline now tend to influence a lot from this e-learning adoption.

2.2.2.2 **Approaches, Tools & Techniques**

Both the emergence and advancement of interactive media and data technologies advances and the utilization of the internet is influencing the way or the style of teaching. Then it caused thorough variations in the approaches related to traditional teaching (Wang, Wang, & Shee , 2007). Yang & Arjomand (1999) mentioned that this advancement of IT has created a further revolution for the

present education. To have an operative and effective e-learning system, the e-learning process can be reserved as the most significant factor. Therefore, considerable attention should be given to the e-learning process. Mainly there are four elementary components of an e-learning procedure. They are identified as technological infrastructure, e-learning platform, content of e-learning and users or stakeholders.

Another important aspect that draws attention is the views of e-learning. According to Devedzic (2006) the fundamental perspectives/aspects of e-Learning can be named in two forms. They are technological and pedagogical. The technology includes the infrastructure/structure and the platform that permits the progress, hosting and delivery of e-learning content for its stakeholders. The pedagogical aspect concerns the content of e-learning and its use for escalating the learner knowledge.

So, to achieve all of the aforesaid aspects of e-learning, tools and techniques related to e-learning is important. Therefore, the learning content in the e-learning environment is presented and also disseminated to the learner through e-learning tools/techniques or learning objects enabled by means of the Learning Management Systems (LMS).

2.2.2.2.1 **Learning Management Systems (LMS)**

E-learning, virtual learning and distance learning are confusing concepts which prevails in the IT industry. LMS is also a novel concept but it also often confused (Kritikou, 2008). Different scholars viewed and defined LMS in differently according to the features and tools operated associated with LMS. Alias & Zainuddin, 2005 characterized LMS as an online-based technology that helps the planning, delivery, and assessment of a particular learning procedure. LMS is described as an online methodology which permits customers to share and cooperate data online (Lonn , Teasley, & Krumm, 2011). According to Sallum (2019), LMS is a packed bundle and that is due to some high properties. Mainly that permits the distribution and management of content and properties to all students and employees. Software applications together with structural changes to the systems, have made learning contents easily available, reachable, and managed. Not only that, it also assists teachers and instructors to deliver their students with resources of learning and be able to do the registration of students. LMS typically offers a bundle of facilities, namely discussion forums, file sharing, administration of assignments, lesson plans, syllabus, chat, etc. But all LMS are not comparable, and they can be used in different types of scenarios. However, according to professionals, LMS is a combined system where e-learning is systematized and

accomplished in that system. All learning activities and resources in a course also are systematized and achieved through that LMS.

Cavus & Momani (2009) also defined LMS as an application of software that practices the internet as an intermediate to assist and uplift the education and the learning procedure. Particularly, in order to manage the education process, educational institutes can apply this LMS system effectively. Because LMS is a beyond process from the delivering course and training materials electronically.

Sridhar (2005) also sees LMS as similar to e-laerning which can be used as a tool or a methodology to enhance the learning process inside a classroom. Thus, in this paper, the focus lies on LMS that is embedded in an educational institution like universities. There the final intent is to adopt the procedure of learning within the classrooms. So, LMS links heavily with the virtual learning perception and the objective is to assist learning inside classrooms through well managed techniques, technologies and tools (Albirini, 2006).

All educational institutes, specially universities all over the world are adapting as well as practicing e-learning specially LMS. Main aim of the usage is to support and expand learning within their institution. Therefore, universities have made a significant investment in the use of LMSs to facilitate their teaching learning procedures; however, these systems are not used by the all end users to their fullest capabilities.

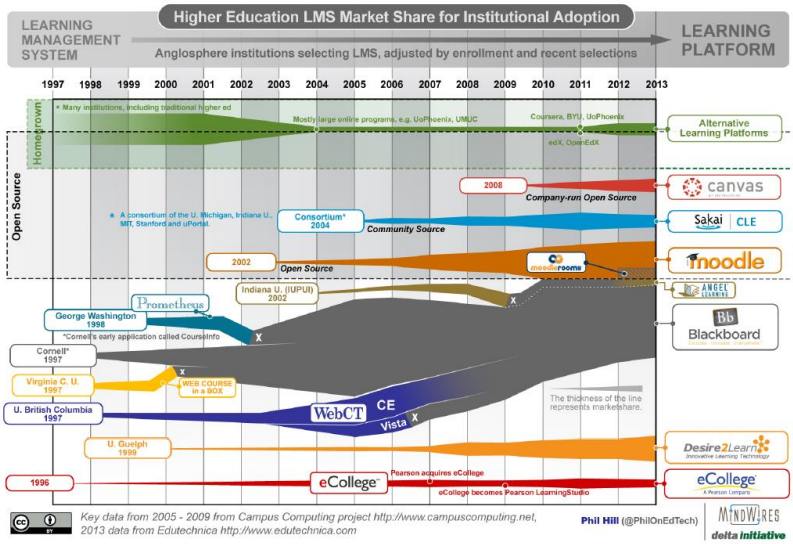

Figure 1: LMS Eco System of the Higher Education System

2.2.2.3 **Blended Learning**

As referenced above e-learning originates from various structures. Mainly there are three sorts. Those sorts are web-supported, blended, or mixed-mode and totally online e-learning group. The 'blended or mixed learning' approach has been grasped by practically all the advanced education foundations. Because universities are directly using information and exchange advances of ICT (for instance, the Internet). In this way, the essential point of embracing mixed or blended learning is to pick up pace in universities around the globe and to convey course content (Wade 2012).

Blended learning has been used to imply the participation that consolidates traditional classroom studies with e-learning with individual learning (Kovaleski, 2004). However, Friesen (2012) characterized it as the methodology with an amalgamation of at least two educating techniques. That can be between electronic innovations, educational methodologies, instructional advancements, and occupation assignments. Once in a while, that mix could be between any type of instructional technology (e.g., tape, CDs, Computer-assisted instruction (CAI), online-based learning with classroom education.

The mixed learning system utilizes the distinctive instructing medium to make an instructional course for students. As indicated by the requirements of the course, the modern teaching like web-based teaching strategy, and traditional teaching technique team up with one another. In any case, the target of mixed learning is stayed unaltered and that is to make preparing media into a joint unit to make an unending effect (Bersin, 2004). Following figure 2 delineates the segments of blended or mixed learning.

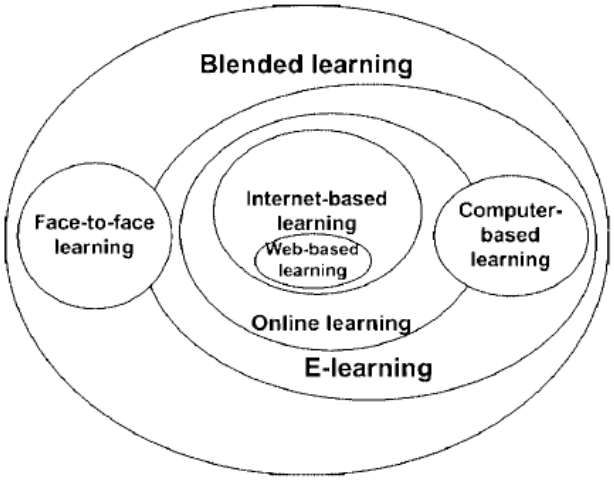

Figure 2 : Components of blended learning
Source: Hadjerrouit, 2008, p.5

Algahtani (2011), conducted a research in Saudi Arabia to assess e-learning effectiveness and experiences. There he discovered three different replicas that can be used e-learning in education. They are "adjunct, blended e-Learning and online". As demonstrated by Algahtani (2011) the adjunct e-learning, aide in the traditional classroom by providing different types of assistance. In mixed/blended e-learning, Algahtani (2011) and Zeitoun (2008) clarified that the conveyance obviously materials and clarifications are shared between conventional learning strategies and it wins as an e-learning approach in the classroom setting. online which is the third model, is completely away from conventional learning or classroom participation. In this type of use, e-learning is absolute so that there is the most extreme distinction to the students or learners (Algahtani, 2011; Zeitoun, 2008). Zeitoun (2008) has gone further to clarify that the online model is separated into individual and collaborative learning. There, the collaborative learning includes two techniques, in particular, synchronous and asynchronous learning (Zeitoun, 2008).

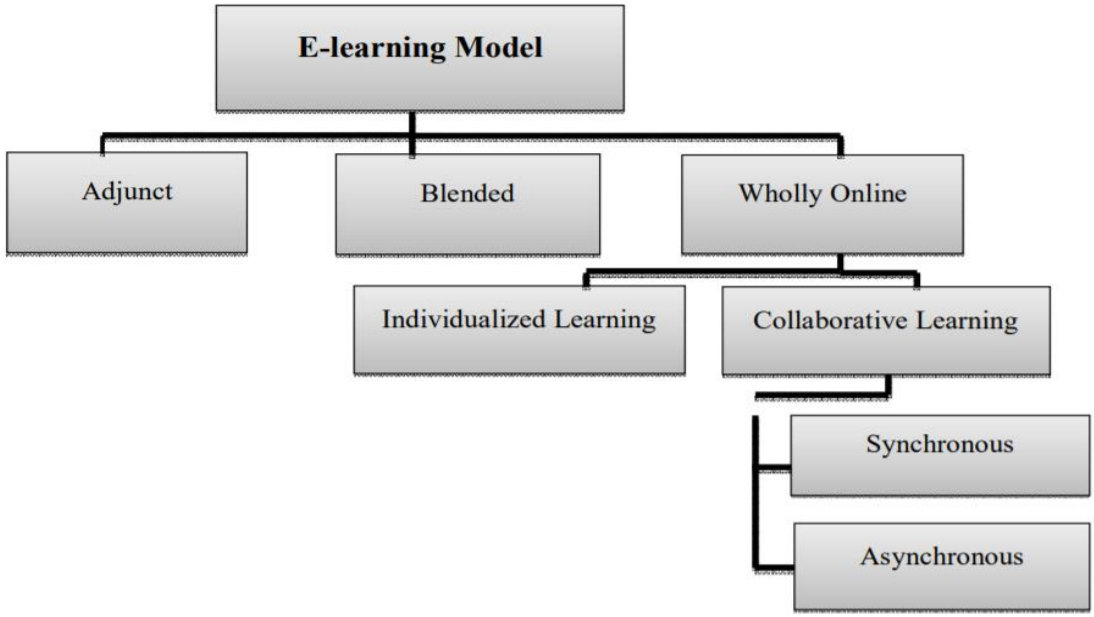

Figure 3: An Approach for Using E-learning in Education
Source: Adapted from Algahtani (2011)

2.2.3 **Issues and Future Developments of E-Learning**

As mentioned above e-learning is available in both society and commercial world. Global, growth rate of e-learning market is 35.6% (Sun *et* al., 2008). It might seem like a simple procedure of distributing materials related to learning and exploration of expertise and/or knowledge by digital

means. But the e-learning expansion as well as flexibility mainly depend on IT. Therefore, we can consider that these types of approaches and implementation of new methods are still evolving.

As technology progresses step by step, those affirmed certain components and instruments are embraced and broadly used by numerous institutions and organizations. Subsequently, it intensely influences the e-learning industry also. Additionally, the current globalization of the economies fundamentally altered the clients/customers association with the product or service providers. Presently the customer selects what he/she needs. This pattern can be found in the e-learning industry also.

Since the e-learning market is part of an all-around competitive market, to endure and to maintain their offers, e-learning suppliers have proposed to present their own new item/administration advancement and redesigning instruments. It will ensure the quality of their e-learning items and administrations.

2.2.4 **Current Status of E-Learning in Higher Education Sector in Sri Lanka**

The effect of e-learning has extraordinarily affected every developed nation and now most of developing nations are additionally trying to appreciate the advantages of e-learning in spite of troubles and uncertainties.

Even though Sri Lanka is a medium human development country, it has a high literacy rate due to a well-established education policy (91.90% - Central Bank Report, 2019). The demand for lifelong learning in Sri Lanka increasing day by day. That is due to the rapid social changes taking place in the country such as Social, political, educational, economical, technological and marketing transformations are occurring in the country (Little, 2014). Many are interested to go for higher education to improve knowledge and skills through higher education.

There is a speedy advancement of ICT frameworks in Sri Lanka. Each one of those inspires each instructive establishment to utilize the web as a mode of correspondence among students of educational institutions. The compelling and productive way of approach to materials related to learning accomplished by the ideas and systems of technology-based learning. In this way, expanding the utilization of e-learning materials turns into a critical asset for organizations. In Sri Lanka there are three main types of universities: state universities; fully independent private universities, often with international affiliations; and one Open University (government funded, mainly catering for adult and distance learners) (Ministry of Education, 2005). Further, under the system of the Ministry of Higher Education, state funded, also known as government funded,

technical colleges deliver diploma and advanced diploma courses in various disciplines (UGC, 2006). It is clear that in Sri Lanka, e-learning is generally used in each and every higher education institutes and universities highly adopt this technology without any hesitation. Most of the time, all most all the Sri Lankan state universities use e-learning and, Moodle open source platform is used as LMS. The most prominent motivation to use by universities is that the web has gotten one of the most significant manners by which students and instructors can convey and get or share data (Arkorful & Abaidoo, 2015); it is utilized to create learning resources, to instruct, and to manage courses in the college. From the following figure also, you can comprehend that Sri Lanka is one of the most elevating nations in terms of e-learning.

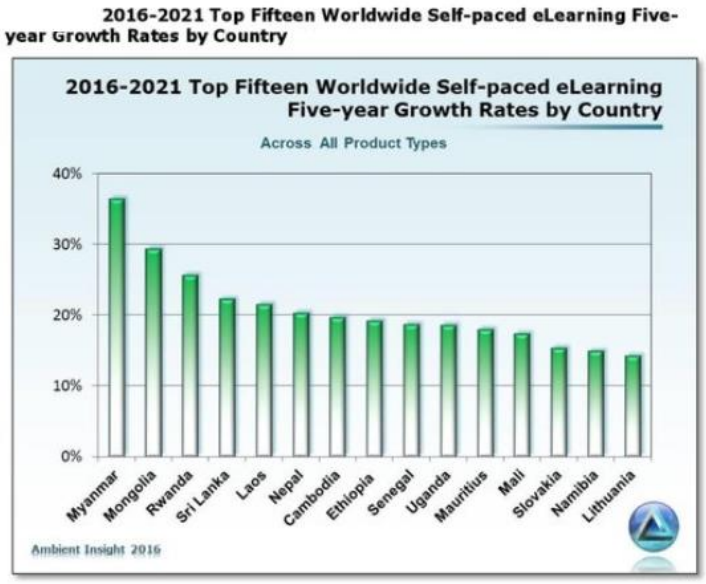

Figure 4 : E-learning growth

By considering above facts, it is obvious that e-learning is important for Sri Lankas' young population's modern reconstruction. According to Gökdaş & Kayri (2005) this kind of restoration means providing education for individuals and governments every time at everywhere. In fact, it approaches acceptance in traditional education and training to have a revolutionary influence on educational institutions in the future (Campbell & Rozsnyai, 2002).

As per the examination by Thuseethan, Achchuthan, & Kuhanesan (2014), the universities in Sri Lanka are expecting in any event the accompanying functionalities from efficient Moodle learning management systems. They are, the enlistment of instructors and students in the instructive entry, arranging and planning the course and the method for organizing it, give the method for

conveyance or make available the course open for enrolled clients, trace the students' advancement, produce programmed reports of students' presentation, discussing students with one another through gatherings, messages, document sharing, and teacher and student assessment.

2.2.4.1 **Use of E-Learning in Management/Business Faculties/Schools**

Colleges and universities have perceived e-learning as a possibility to change individuals, knowledge, aptitudes, and execution (Henry, 2001). With reference to Love & Fry (2006), colleges, universities, and different organizations of higher learning race to progress online course capacity in a rapidly creating digital industry of education. Through that we can understand that the e-learning has come to be increasingly more significant in foundations of advanced education. The presentation and extension of a scope of e-learning apparatuses have been starting a few variations in advanced education foundations, especially with regards to their instructive conveyance and bolster forms (Dublin, 2003). There are distinct varieties of e-learning just as there are various methods for utilizing the technique in education. As comprehended from the above realities, it is extremely certain that the utilization of e-learning for educating and learning has developed quickly as of late and has been driven by the development of specialized help related with the presentation of e-learning courses in colleges and universities (Paechter & Maier, 2010). There additionally LMS has been generally utilized in advanced education because of different favorable circumstances including adaptable learning times and boundless distance education (Hamuy & Galaz, 2010).

2.2.4.2 **Critical Issues**

While the advanced education e-learning future appears to be encouraging, just as regardless of the quick development in the e-learning field there still present a scope of issues confronting the stakeholders of e-learning frameworks.

Learning method customization can improve the utility of online course delivery. Thus, the objectives which minimize the competitive gain of such e-learning activities and the basic elements should be totally recognized and should direct appropriately. Literature also has recently highlighted the need to observe the issues or issues in e-learning and to create a conclusive strategy to defeat those barriers (Piccoli & Ives, 2005).

One of the key issues in estimating the achievement or the accomplishment of the e-learning framework. With regards to e-learning frameworks, this issue is viewed as progressively complex because there are various perspectives identified with the e-learning term. Cohen & Nycz (2006) express that e-learning can be hard to comprehend on the grounds that various creators utilize the term in an unexpected way. This absence of assessment of e-learning frameworks achievement is accepted to be a fundamental concern for the analysts, users and all the participants of these frameworks. As per Ardito, Costabile, De Marsico , & Lanz (2006), a compelling approach to assess the e-learning framework achievement, is yet inaccessible. Moreover, the issue of absence of a viable strategy to assess e-learning framework achievement is not, at this point constrained uniquely to the advanced education field. Wang et al. (2007) mentioned that only a few types of research have been developed to quantify the e-learning achievement or effectiveness from the industrial context. Since a lot of cash has been spent in the deliberate advancement of technology infrastructure (Georgina and Olson, 2008).

However, there is likewise a significant absence of knowledge and expertise in utilizing and making content among instructors and teaching personnel (Noam, 1995). They are frequently not educated about the novel advancements and the potential outcomes they offer on the web or in the tech world. According to Peter Cochrane, the current information age, is, like a college with children who can read or write where the same ability is not with teachers (Prensky, 2001).

Further exertion is fundamental to make content of e-learning for students. Teachers are not ready to invest additional effort web-based responding to questions students may have for them. To beat this issue, they ought to be instructed on an institutional level and become aware that students anticipate that them should discover the time. And furthermore, lack of groups in every single educational institution, which would help the faculty engaged with instructing to stay aware of the advanced instructive and mechanical achievements and practice (Bates & Poole, 2003).

Another basic issue confronting IT projects, is their high pace of disappointment. E-learning frameworks can be taken as IT projects and they likewise experience the issue of disappointment or failure. As indicated by Rovai & Downey (2010), some e-learning ventures had fizzled on the grounds that it didn't meet enrolling targets. In another model, the absence of assessment is accepted to be a noteworthy explanation behind disappointment on e-learning frameworks. As per McGorry (2003), numerous instructive organizations have not taken into consideration this

significant issue of assessing e-learning frameworks. In this manner, these frameworks should be surveyed consistently to ensure that the produces address users' issues.

In like manner, there are both pros and cons of utilizing the e-learning framework, particularly in the advanced education framework

2.3 Stakeholder Requirements & Expectations of E-Learning

Despite certain difficulties examined, the previously mentioned writing has tried to clarify the job of e-learning specifically and how e-learning has had a solid impact on educating and learning. As indicated by Thompson & Strickland (2001) thought about stakeholders as a body electorate of an association from the association setting. Similarly, we can consider e-learning stakeholders and the individuals who are influenced by it as the interested parties of e-learning. As specified by Wagner, Hassanein, & Head (2008), there are seven types of stakeholders and they are, students, instructors, institutions, content providers, technology providers, accreditation bodies and employers. There every partner group has a significant task to carry out while cooperating towards the shared objective of improving the general learning experience. To expand the potential utilization of e-learning, the executions should endeavor to fulfill the requirements and uncertainties of all partner groups however much as could be expected. Accordingly, all the partners and their desires are noteworthy to build up a powerful e-learning framework. And furthermore, in any stage, the attitudes of the users toward the framework are vital and ought to be respected altogether. To boost this potential, e-learning executions should attempt to fulfill the requirements and worries of all partner bunches however much as could be expected.

Especially, in the IT field, client fulfillment has gotten significant consideration from the researchers. This consideration included e-learning frameworks also. DeLone & McLean (2003) considered user fulfillment as an estimation to measure or calculate e-learning framework achievement. However, Sun *et al*., (2008) additionally characterized the basic elements which drive fruitful e-learning in six measurements which are learner (student), instructor (lecturer), course, technology, design, and environmental. However, e-learners are an extraordinary gathering of consumers, who hold a special view as for the fulfillment or satisfaction. (Wang, 2003).

The literature review indicates that different factors have been considered as stakeholder expectations. In this research, quality and benefits have been taken as the main two categories of

stakeholder expectation. Because we consider that both quality and benefits have a significant effect on the effectiveness of any e-learning platform.

The quality of well-designed e-learning programs is the point of the reference factor for students while considering e-learning. Quality is another significant factor affecting learning impacts and satisfaction or fulfillment in e-learning (Piccoli, Ahmad, & Ives, 2001). Under quality, the soundness of the system, the capacity to survey learning execution, quality of e-learning platform, extravagance and broadening of showing materials, and elements of recording learning and training history estimated.

When using as well as developing an e-learning system, all the stakeholders think of benefits that the system provides. Ease of use, user identification, time saving, ease of sharing data/information, and flexibility in choosing learning / teaching content has taken as the components of the benefits. So, in order to investigate the extent of the importance of those stakeholder expectations, we use the multi criteria decision analysis. Since there are different analyses, AHP used to rank measurement and analyze the criteria.

2.3.1 Multi-Criteria Decision Analysis (MCDA)/Multi-Criterial Decision Making (MCDM) techniques

The use of multi-criteria decision analysis (MCDA) techniques has developed and progressed significantly over ongoing decades. A procedure that is equipped for combining different alternatives, at the point when a few perspectives and needs are considered to deliver a common output, is considered as MCDA. Mostly, it is helpful during the formation of a decision support system (DSS) with complex issues. According to Belton & Stewart (2002), MCDA refers to a diversity of matrices and analytical approaches that combine both quantitative, and qualitative considerations. There, limited or conflicting information as well as stakeholder input and preferences taken into a decision-making process. Different industries use MCDA as a decision-making tool.

Literature discusses a number of MCDA techniques such as Multi-Attribute Utility Theory (MAUT), Analytic Hierarchy Process (AHP), Fuzzy Set Theory, Data Envelopment Analysis (DEA), and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) (Montibeller & Franco , 2010). We used the Analytic Hierarchy Process (AHP) as the preferred method of technique to screen the stakeholder desires. Because AHP is a one of the prominent approaches which was started to be developed by Saaty (1980). Normally it follows three distinct

phases followed by principles and they are, the principle of "constructing hierarchies"; the principle of "establishing priorities"; and the principle of "logical consistency" (see Saaty & Alexander, 1989).

AHP is capable of using both subjective and objective data for proper decision-making. This capability makes AHP important for construction-related decision-making, as subjective judgments from different experts form a crucial part of construction decision-making. As referenced previously, the AHP parts a complex multifactor issue into a system with a chain of importance. The AHP joins both subjective and objective decisions in an incorporated structure dependent on ratio scales. That is done with the help of basic and simple pairwise comparisons.

2.3.1.1 **Screening of stakeholder requirements/expectations/attributes**

Further, literature highlights large number of applications of MCDA methods and Delphi methods for screening of decision-making criteria. MCDA techniques are popularly used as scoring models where the model assigns a score for each criterion. This can be used for screening or ranking processes of criteria. Delphi Method was also considered as one of the important methods which permits forecasting using experts' judgements. But according to Saffie, Shukor, & Rasmani (2016) Delphi method has many issues with fuzziness and influenced by few people.

As an alternative method, the fuzzy Delphi method which includes fuzziness in forecasting can be proposed. However, literature shows that fuzzy Delphi methods are not good in mainly four main criteria; iteration, anonymity, controlled feedback, and aggregation to be identified as a Delphi Method especially on the iteration and controlled feedback processes.

It appears that AHP based techniques provide more accurate and reasonable solutions for multi-criteria/attribute type problems (Radziwill & Benton, 2017).

2.3.2 **Product Design Concepts for E-Learning Tools**

The quality of a product is mainly depending on the product design. Because lot of vital decisions are made during the development stage of the product design. According to past literature it is stated that, poor design or structure is the foundation for 80% of the supposed product defects and faults where 60% of the failures happen in the products' guarantee time period (Pahl & Beitz, 1999).

In order to develop product design, there are some design theories and methodologies, such as quality function deployment (QFD), axiomatic design (AD), design for manufacture and assembly (DFMA), value engineering (VE) and failure mode and effects analysis (FMEA) (Gonc¸alves-

Coelho, Moura˜o , & Pereira, 2005). Out of those techniques, QFD is a group based multifunctional procedure intended to give an efficient method to expand product quality. Therefore, this article intends to use the QFD as the strategy to develop the product design to accomplish a superior concurrency.

2.3.2.1 **Quality Function Deployment (QFD)**

Quality function deployment (QFD) is one of the most emerging tools for quality monitoring of product and services. It can be used to convert voice of customers to voice of engineer at every stage of product and process development.

Chan & Wu (2005) stated the QFD as a framework to guarantee that stakeholder or customer drive product design and production approach. QFD was invented in Japan and later used by many manufacturing, health care and service organizations (Chan & López-Fresno, 2017). Basically, it is a customer-driven system for the design, manufacture and marketing of products. Because its prime objective is to match customer requirements to engineering capabilities in general. Some researchers name QFD as Matrix Product Planning, Decision Matrices and Customer Driven Engineering.

QFD contains both the users' "voice", identified by requests, and designers' "voice", identified by system technical characteristics. Therefore, it is an important benefit of QFD which it is capable of capturing, prioritizing and stabilizing customer requirements. In ISO 16355 guidance of novel or contemporary QFD strategies and devices can be identified (Mazur & Belt, 2016).

In short, the QFD permits to lessen the gap between "quality promised" and "quality supplied" (Eureka & Ryan , 1989). The basic steps of QFD which are definition of the customer, what the customer wants (needs) and how those needs are meant to be met can be summarized as follows:

2.3.2.2 **Application of QFD to an educational institute**

Many scholars and academicians have taken the advantages of applicability of QFD in different sector of product and service development and also applied it to education sector too. The application of QFD in the education sector has been begun in 1993 by Clayton. As indicated by Pitman, Motwani, Kumar, and Cheng (1996), the choice of prerequisites was essential since it would decide the 'subject' of progress. The accompanying Table 3 shows the literature review identified with the use of QFD. As needs are, past researchers also show that customers of an educational institute can be either or all of these students, staff, businesses. In this way, the voice of each of the three requires consideration both from the part of substantial (physical asset) and

impalpable (culture, address conveyance) parameters. Every one of these prerequisites is not of a similar degree of significance from the customer perspective. Henceforth significance rating, from the viewpoint of clients should be required to indicate.

Table 3 : Literature review of application of QFD.

Author	**Views**
Jaraiedi & Ritz (1994)	Conducted QFD to two procedures, 'prompting' and 'instructing'. Used to the department of engineering. primary concern related to the learners. Learner's necessities were considered and contrasted and some 'structure' prerequisites created for each procedure. Based on determining significance evaluations and target esteems for the structure prerequisites, ends were made on the manners in which that quality could be improved.
Pitman, Motwani , Kumar , & Cheng (1996)	Applied QFD in assessing an MBA program at a university. The necessities of three gatherings, for example, learners/students, managers, and academic staff were considered. Their outcomes, however not point by point, uncovered the qualities of their current program just as territories that necessary more consideration.
Ermer (1995)	In his investigation of the mechanical engineering division, prerequisites of clients' learners, scholastic staff, and industry-were broke down independently. On account of learners, their prerequisites in regards to educational plan and training forms were contrasted and quantifiable determinations of the program. The QFD grid for staff, notwithstanding, was very extraordinary since their own necessities corresponded with the duties of the department management.
Lam & Zhao (1998)	The paper addressed the issue of improving the quality of educating with the utilization of QFD and AHP.
Owlia & Apinwall (1998)	Used QFD for the improvement of value in an engineering division.

Fiorenzo *et* al., (1998)	Analyzed QFD to mechanical instructional classes and distinguished the two significant contrasts between the use of QFD for item advancement and for learning purpose.
Bouchereau & Rowlands (2000)	The article investigates the coordinated utilization of systems like fuzzy logic, artificial neural systems, and the Taguchi strategy with QFD to determine a portion of its downsides, and proposes cooperative energy among QFD and these three procedures.
Hwarng & Teo (2001)	In this article, they showed how a foundation in secondary and tertiary education can practice the three-staged, administration founded QFD approach at the operational level to interpret the voices of clients (VOC) in stages into activity necessities.
Chan & Ming-Lu (2002)	It is a review paper about QFD. It evaluates the chronicled improvement of QFD, methodological improvement of the system, applications under the grouping of various businesses, some QFD associations, and key characteristics on QFD.
Sahney et al. (2003)	The article reviews an investigation on learning institutions- industry association in the Indian point of view utilizing the QFD approach.
Sahney et al. (2004b)	A coordinated methodology of the SERVQUAL and QFD model is implemented to recognize the loopholes existing in quality education and customer necessities in the present education framework.
Thakkar & Deshmukh (2006)	The utilization of QFD which organizes specialized necessities and relates them with different clients'/customers' prerequisites for the current Indian setting is presented in the paper. It gives data about the significance of different specialized prerequisites of viable education as well.

Source: (Singh et al, 2008)

2.3.2.3 **Selection of QFD**

Match between significant user requirements and technical capabilities was evaluated using Quality Function Deployment (QFD) as recommended by Alshehri, Basheri, & Qureshi (2017) for Software Process Improvement (SPI). The Japanese verified that this tool was effective in planning the quality related aspects of products, services, software, and processes. So QFD incorporates the key features and essential elements of the various phases of a product's lifecycle (Singh, 2003). Therefore, can conclude that even for education this method is acceptable.

The house of quality (HOQ) is considered as the primary element of QFD. It is a matrix or a style chart that relates customer attributes called “WHATs” with technical characteristics called ``HOWs". Hauser & Clausing (1988) also categorized the HOQ to the category of conceptual map. There he provided the means for inter functional planning and communication. As in the following labeled QFD diagram (Figure 5 : Sample QFD), it usually has six sub matrices. Customer attributes, technical characteristics, a relationship matrix, a planning matrix, technical correlations, and a technical matrix are those sub matrices.

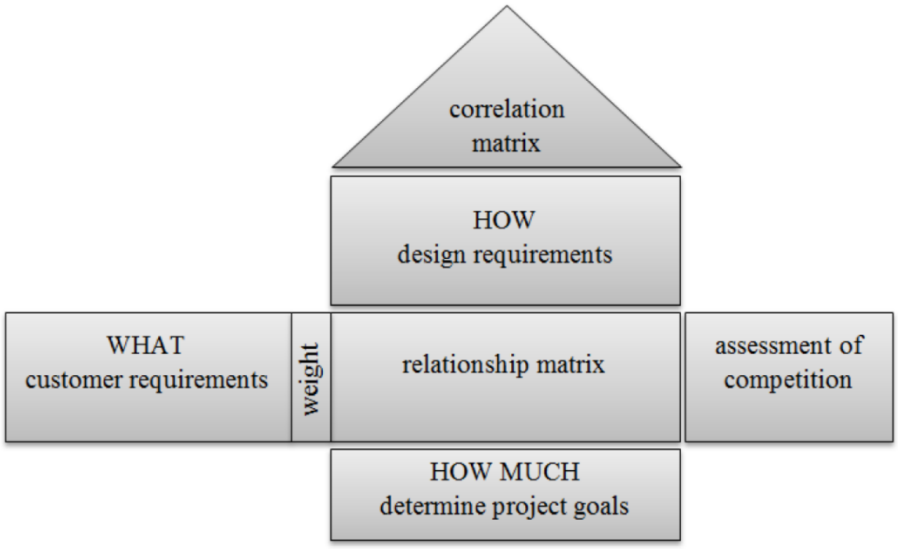

Figure 5 : Sample QFD
Source: (Baczkowicz & Gwiazda, 2015)

Martí Bigorra & Isaksson (2016) have described QFD as an instrument to calculate stakeholder satisfaction for the evaluation of systems of e-learning. According to them, the stakeholder requirements and the product development process can be matched by using a methodological approach like QFD. Cerit, Küçükyazıcı , & Kalem (2014) have described QFD as a technique that can be used for new product development according to the customer requirements. They further

describe QFD as a speedy way of adding user requirements in to the product development for lower time-to-market requirements. Therefore, this study has selected QFD for the framework development.

2.3.2.3.1 **Technical Capabilities**

Identification of technical capabilities is an important section in the HOQ matrix. It is also mentioned to functionalities, engineering features, or the Voice of the Company (Cmuk, Mutapcic, & Bilic, 2009). Producer defines his or her product in that term. Therefore, this information was produced and scrutinized by the design team of QFD. The designing team describe all the quantifiable product characteristics they need to create with the aim of meeting the particular stakeholder requirements.

Another fact is that, these requirements should be developed inline to the customer requirements. The study grouped the technical capabilities into the following groups: Functionality, Performance, and Novelties.

In our case, the most important issue was to create the exact priorities of the decision matrix so as to get the effectiveness and the expected quality. Therefore, the technical capabilities can be summarized as follows.

Table 4: Technical Capabilities Descriptions

Group	**Technical capabilities**	**Description**
Functionalities	Forum	A synchronous communication tools.
	Navigation	Activity of accurately ascertaining position
	Activity Tracking	Tracking of activity of the user, including experiments.
	Report	File submission support.
	Scheduling	Tool for term reservation.
Performance	Automated feedback	Check the users' achievement automatically.
	Adapted & Intuitive GUI	Experiment is adapted for the targeted device and transparent graphical user interface.
	Platform independent	Works on different platforms without special software installed.
Novelties	Mobile support	System is able to work on handheld devices.
	Content awareness	Awareness of the context of learning processes.

Source: (Cmuk, Mutapcic, & Bilic, 2009)

2.4 **Chapter Summary**

This chapter discusses about the literature that was reviewed on the study. It also explains how the literature content was applied into the research. Literature review on potential research methodologies and the reasoning behind the selection of methodologies are also explained in this section. Finally, the literature referred at selecting the technical capabilities are also explained in this section.

3. METHODOLOGY

3.1 Introduction

This chapter presents the methodological framework of the research on how the investigation was carried out. Section 3.2 describes the strategy of the research. Section 3.3 explains the design of the research with graphical explanations and in detail. Then the effective decision matrix development framework is explained in Section 3.4. Section 3.5 concludes with the chapter summary.

3.2 Research Design

We use quantitative (experiment based) applied research method. This study develops a multi-criteria decision analysis model using AHP to achieve the first objective. Then it uses QFD approach to develop the stakeholder requirement versus technical capabilities mapping matrix as in objective 02. We follow the research discussed process in Edirisooriya , Mahakalanda , & Yapa (2019).

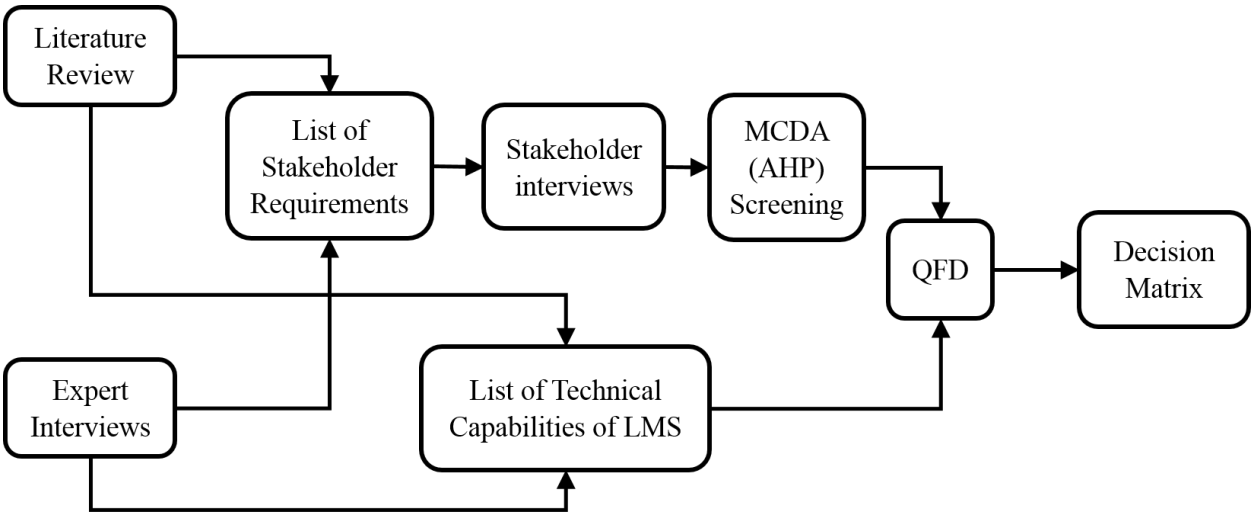

Figure 6 - Research Design

Following is the explanation of each of the processes given in *Figure 6*.

Table 5 : Research Design Descriptions

Component	Description
Literature Review	Searching for literature, examining and combining the results found from the literature survey

User/Expert Interview	Interviewing the end-users of existing LMS and the experts of the LMS usage to collect stakeholder requirements and technical capabilities (Using structured questionnaires and in-depth interviews).
MCDM (AHP Screening)	Analytic Hierarchy Process (AHP) (a widely used MCDA/MCDM technique) assigns weights for customer requirements in using LMS.
QFD	Quality Functional Deployment (QFD) is a popular product design technique. This can be used to plot screened stakeholder requirements against the technical capabilities of LMS systems.
Decision Matrix	The final output from QFD provides a tactical and operational decision matrix.

Source: Author Defined Based on Literature Review

3.3 Details of Research Design Processes

At the most general level, research design means all the issues involved in planning and implementing a research project from recognizing the research issue through to report (Punch, 2013). Punch (2013) further mentioned that the research design is the intermediate connector between research question and data. According to Nadeeshani (2006) research should consist of a design or a structure prior to starting the data collection or analysis. A research design is not just a work plan, but a task that aims to avoid situations in which the evidence does not address the initial research questions. Even according to Philliber, Schwab, & Sloss (1980) cited in (Yin, 2003) explained that research design is as a blueprint of the research. Design phase of this research can be explained under different steps in relation with the to the study.

Step 1: Stakeholders (end-users) identified and User Interviews and Expert Interviews

The stakeholders are classified into 2 groups: Lecturers, and the undergraduates. All of them are the internal end-users of the LMS system in a university.

These users of the existing LMS were physically interviewed with a structured questionnaire for extracting the ideas, opinions, issues and requirements about the existing LMS and for potential improvements. Experts of the using LMS were interviewed from four universities, namely; University of Moratuwa, University of Kelaniya, University of Colombo and University of Sri

Jayewardenepura, to collect this information. There are lot of literature related to these interviews but Warwick Manufacturing Group (2017), recommends and proposes the usage of such interviews for obtaining customer requirements for the QFD. More objective and insightful questions were asked from experts regarding the existing and expected systems as suggested by Warwick Manufacturing Group (2017).

Instrumentation

The instrument of this study was a comprehensive questionnaire. We developed this questionnaire after a thorough review of the literature. Two structured questionnaires were designed for experts in the business and management discipline at universities. The panel of experts includes lecturers and undergraduates who could make useful contributions to the design, development, and execution of the decision matrix. The questionnaire consists of four sections. They are,

Section One – mainly demographic factors included and those questions are about personal information of the respondents such as gender, academic qualifications, and the status of the lecturers/students, etc. (Questionnaires were included the Appendix 1 and 2).

Section Two – questions about the performance of LMS systems in the university such as system quality, system use, user satisfaction, etc.

Section Three – questions about the quality and benefit and the important analysis.

Section Four – contained questions related to relationship matrix of what's and how's.

Due to the limitation of resources, we have decided to limit the number of customer requirements to 10.

Step 2: Voice of Customer (VOC) collected

In the QFD process, the voice of customers (VOC) is the most crucial factor that need to be considered. Because it is the input to the whole QFD process. In the beginning users of QFD cannot get a precise representation of customer desires. To lessen this limitation, it is vital to carry out the process of QFD. According to Shillito (1994), VOC comprises from two aspects. They are aspects of qualitative and quantitative. Usually what customers require can be taken as the qualitative VOC while how they rank their requirement is identified as quantitative VOC. By listening to the VOC this can be composed. There are different types of techniques available to be used in QFD to collect the VOC. Some of them are including surveys, focus groups, interviews, customer complaints, and direct observations (Shillito, 1994; Cohen, 1995).

Accordingly, the first step in this research is also to recognize the voice of stakeholders who are primary customers of the LMS service facilitated by the university. And then to obtain this information, comprehensive questionnaire was distributed with 16 expert end-users.

There, we have conducted the survey to the director of the E-learning center, webmasters and some expert in usage of LMS to identify the strategic requirement of the LMS design from the teaching perspective.

In order to identify the requirements on behalf of the customer / user's point of view, 06 users (undergraduates) of the existing LMS were also interviewed. Because effective learning experience and technology cannot be separated in the 21st century, since any LMS worth its salt uses technology to achieve its aims. Beyond content, beyond strategy, beyond processes, and beyond technology, the effectiveness of any learning program is ultimately only as good as the learner experience. When evaluating an existing LMS or scout out a new LMS, most probably there are many checkboxes on the criteria list, and one of those should be the learner experience. Even if learners are provided best-in-class tools and learning programs, if the actual learner experience does not facilitate a smooth, tailored learning journey, then the ship has sunk before it has even left the harbor. Other than the inputs from the interviewees the researcher have used his own knowledge for requirement analysis as she is also a specialist in the domain of LMS or e-learning.

Generally, small sample size can antagonistically influence a few parts of any exploration including research, as well as including the information analysis and clarification of outcomes. But, the significant preferred feature of AHP over other MCDM strategies is that it doesn't require a statistically noteworthy (big) sample size to accomplish sound and measurably powerful outcomes (Doloi 2008). A few analysts contend that AHP is a subjective technique for look into concentrating on a particular issue, subsequently, it isn't important to utilize a large sample (Lam and Zhao 1998). Others contend that in light of the fact that AHP depends on professionals or experts' decisions, decisions from even a solitary qualified expert are normally archetypal (Tavares et al. 2008). Additionally, it might be unhelpful to utilize AHP in an investigation with a huge size of sample since 'cold-called' specialists/experts are probably going to give discretionary answers, which could essentially influence the consistency of the decisions (Cheng and Li 2002). A significant part of the prevalence of AHP in the management could be credited to its capacity to deal with small sample sizes.

The existent literature on AHP applications in development of the management demonstrates that there is no exacting necessity on the base sample size for AHP investigation. A small number of investigations utilized sample sizes going from four to nine (Lam et al. 2008; Dalal et al. 2010; Pan et al. 2012; Akadiri et al. 2013; Chou et al. 2013). Just a very few studies utilized sample sizes more than 30 (El-Sayegh 2009). These discoveries propose that AHP can be performed with a small sample size to accomplish valuable choice outcomes and models, which frequently makes it a more favored strategy in the management look into than other MCDM strategies.

In summary the sample of interviewees consists of 09 lecturers and 06 undergraduates. The main criteria for the selections were based on their experiences and volunteers. An affinity diagram (Figure 7) and a comprehensive questionnaire are used to collect and analyze the information. After that two questionnaires were developed to both parties. The questionnaire contains four main categories as mentioned above.

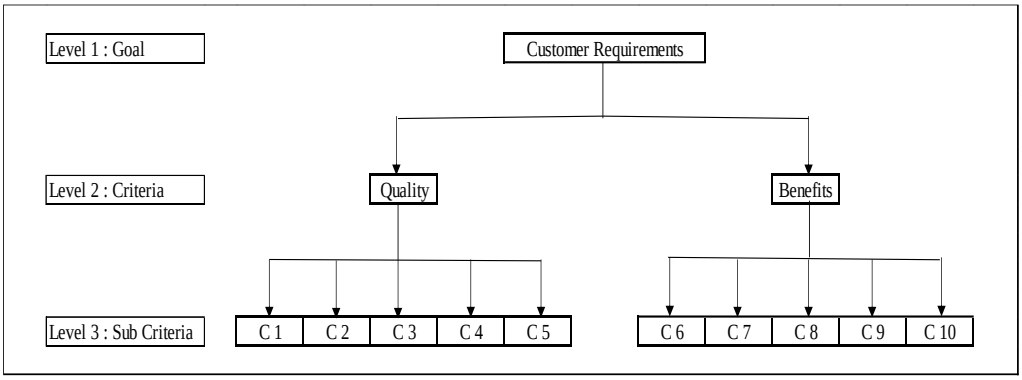

Figure 7: Affinity Diagram
Source: Author Developed Based on Research

Table 6 : The hierarchical structure of the quality attributes for the proposed evaluation

LEVEL 1 Goal	LEVEL 2 Criteria	LEVEL 3 Sub criteria
Customer Requirements	Quality	C1: Stability of network
		C2: Ability to assess learning performance
		C3: Quality of e-learning platform
		C4: Richness and diversification of teaching materials
		C5: Functions of recording learning and teaching history
	Benefits	C6: Ease of use
		C7: User identification

		C8: Time saving
		C9: Ease of sharing data/information
		C10: Flexibility in choosing learning / teaching content

Step 3: Technical Capabilities

Literature review was carried out to identify the technical capabilities to implement the user requirements identified in the interview process. Due to the limitation of resources, we have decided to limit the number of technical capabilities to 10. Findings of the literature review process was described in detail in Chapter 2.

Technical Capabilities	Forum
	Navigation
	Activity Tracking
	Report
	Scheduling
	Automated feedback
	Adapted & Intuitive GUI
	Platform independent
	Mobile support
	Content awareness

Step 4: Stakeholder requirements ranked

To prioritize customer needs, AHP is applied. Professor Saaty around 1980, developed the concept of AHP. It is mainly applicable to determine the prioritize the determinations, resource planning, distribution of resources, and investment portfolios (Chin & Leung, 2004). In 1980 Saaty proposed a complete procedure. There were main motives to build this kind of methodology, some of them are to methodically simplify complex questions, to decompose a hierarchical structure for decomposing units, and to assess them broadly after determining the thread through quantitative judgment. According to Arunraj & Maiti (2010), these are done to provide information for decision-makers to select appropriate systems and to minimize the risk of making erroneous decisions.

So, accordingly, results were extracted from the questionnaires. Then through the matrix of AHP, each representative's priorities are articulated. The AHP matrices are joint within each customer group by measuring the geometric mean of the stakeholder's importance weights (Saaty, 1980).

There is an expected limit of inputs to the QFD. Since there are various requirements and capabilities, to prioritize and to limit that number, the AHP method is used. Microsoft Excel spreadsheets are used for the AHP process. The number of user requirements are reduced from 10 to 08 using AHP. Also, the number of technical capabilities were not reduced since it has only 10. When prioritizing the user requirements, the level of usability was considered as the criteria for pairwise comparison. When prioritizing the technical capabilities, the technical feasibility was used as the criteria for pairwise comparison.

Step 5: House of quality of effective LMS design / Quality Functioning Deployment Process

A House of Quality (HOQ) matrix is mainly created to examine the association between customers' requirements (What's) and technical capabilities (How's). Figure 05 shows the HOQ structure (Cohen , 1995). The quality council or the group of experts determines the relationship values among customer requirements and technical capabilities.

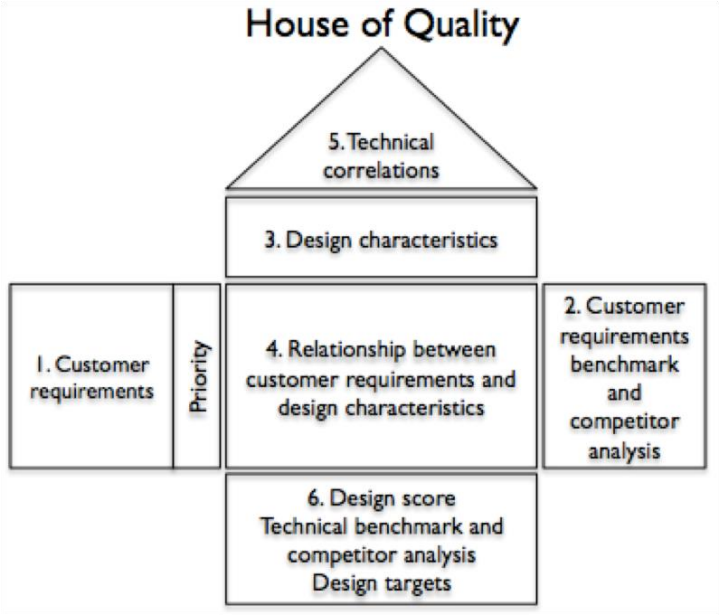

Figure 8 : HOQ

This study intends to conduct the research on the areas of 1,2,3,4 and 5 from the above HOQ construction.

Chen and Chen (2002) introduce tasks to build the house of quality. In accordance with that we identify tasks as follows.

Task 1: Identification of stakeholder requirements

The first task is to identify stakeholder requirements. Those were recognized via a survey and interviews with numerous stakeholders. The most mentioned items were listed as the Customer Requirements (What's).

Quality
-Stability of network (e.g. less interruptions)
-Ability to assess learning performance
-Quality of e-learning platform (LMS)
-Richness and diversification of teaching materials
-Access to archived teaching and learning materials
Benefits
-Ease of use
-Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)
-Time saving
-Ease of sharing or uploading data/information
-Flexibility in choosing learning/teaching content

Task 2: Evaluating Technical Capabilities of an effective LMS design

Using the quantitative information provided by the QFD, the technical capabilities that has the highest impact on user requirements can be selected for evaluation.

Task 3: User Requirement Importance Level (URIL)

User Requirement Importance Level (URIL) is the respective *Importance as a Percentage* value in for each *Significant User Requirement*. This parameter indicates the percentage of total requirements that are achieved by the respective User Requirement. This value is found from the AHP evaluation performed in the Excel spreadsheet.

Task 4: The values of Customer requirements

The values of customer requirements importance weights were allotted by the stakeholder survey. They were multiplied by the customer requirement, value which is ranked by a group of experts.

Table 7 : User Requirement Importance Level

Intensity of importance	**Definition**	**Explanation**

1	Equal importance	Two criteria are correspondingly significant or important
3	Moderate importance	One of the criteria is slightly more significant than the other
5	Strong importance	One of the criteria is strongly/sturdily vital than the other
7	Very strong importance	One of the criteria is very strongly preferred than the other and its dominance verified in practice
9	Extreme importance	The indication of importance of one of criterion over another is of the highest possible order of confirmation which cannot being comparable

Task 5: Classification

The important LMS decision matrix features, technical capabilities (How's), are classified into three groups: Functionality, Performance and Novelties.

Functionality:	Forum
	Navigation
	Activity Tracking
	Report
	Scheduling
Performance:	Automated feedback
	Adapted & Intuitive GUI
	Platform independent
Novelties:	Mobile support
	Content awareness

Task 6: The relationship between the customer requirements and technical capabilities

The expert group determine the association or the relationship between the customer requirements and technical capabilities. It provides a listing of how the technical capabilities represent each end user's needs on a scale of 1, 3,5, 7 and 9. In this relationship scale, 1 signifies a weak or possible relationship, 3 denotes a moderate relationship, and 5 denotes a strong relationship, 7 denotes a very strong relationship and 9 stands for an extreme relationship.

Task 7: The absolute weight

By multiplying the cell numbers by the corresponding importance values, the absolute weight is calculated for each decision matrix feature.

Task 8: The relationship between What's. and How's

The relationship/association between What's. and How's is represented by different signs and using those signs HOQ Matrix is presented. As the number of interviewees were not sufficient for a statistical conclusion, a qualitative analysis is also performed by the input given by each expert interviewee. Once the qualitative outcome is aligned with the quantitative result, the results of QFD can be used for further analysis. Otherwise, the expert interviewee has to be done again till the quantitative and qualitative results align with each other.

Task 9: Relationship Strength between Capability and the Requirement (RSCR)

Relationship Strength between Capability and the Requirement (RSCR) is the percentage of requirements that could be fulfilled by each technical capability for each user requirement.

$$1 \leq RSCR \leq 0$$

RSCR is directly obtained from the final score given to each relationship between stakeholder/user requirement and technical capability in QFD by the expert panel as in Table 05.

Table 8 : RSCR Calculation

Final Score given in QFD	Calculation	RSCR
0	0 / 9	0
1	1 / 9	0.1111
3	3 / 9	0.3333
5	5 / 9	0.5555
7	7 / 9	0.7777
9	9 / 9	1

Source: Author Defined Based on Analysis

Task 10: Impact Level of a Technical Capability (ILTC)

Impact Level of a Technical Capability (ILTC) evaluates the level of impact achievable per each technical capability (Edirisooriya *et al*, 2019). Impact Level of a Technical Capability can be calculated as follows.

$$\text{Impact Level of a Technical Capability} = \sum \begin{pmatrix} \text{User Requirement} \\ \text{Importance Level} \end{pmatrix} . \begin{pmatrix} \text{Relationship Strength between} \\ \text{Capability and the Requirement} \end{pmatrix}$$

Task 11: High Impacted Percentage

Sum of *Impact Level of a Technical Capability (ILTC)* for all selected technical capabilities provides the *High Impacted Percentage* (see Edirisooriya *et al*, 2019)). This value provides an indication of the level to which the LMS can be used to match the stakeholder requirements.

$$\text{High Impacted Percentage} = \sum(\text{Impact Level of a Technical Capability})/100$$

Task 12: Effectiveness Percentage of the LMS (EPLMS)

According to Edirisooriya *et al*, (2019), sum of Impact Level of a Technical Capability (ILTC) for all designated technical capabilities is the Effectiveness Percentage of the LMS (EPLMS). This value provides an indication of the level to which the LMS can be used to practice the stakeholder requirements.

$$\text{Effectiveness Percentage of the LMS (EPLMS)} = \sum(\text{Impact Level of a Technical Capability})\ \%$$

3.4 Effective LMS Development Framework

This study proposes the following procedure to develop QFD based decision matrix to map stakeholder requirements and technical capabilities of an LMS:

1. Define LMS user from stakeholders **S∈A,** expected stakeholder requirements **R,** and technical capabilities **T**
2. Recognize the **S** Stakeholders to be satisfied from **A**
3. **WHILE** Expected stakeholder Requirements **R** are not Saturated:
4. Interview & gather requirements **R** for each of **S**
5. **WHILE** Technical Capabilities **T** are not Saturated:
6. Analyze Literature and interview experts for Technical Capabilities **T** that fulfill **R**
7. Execute AHP to shortlist **R** to **SR** with at maximum to minimum criteria weights
8. Select **T** to **ST** with at maximum to minimum criteria weights
9. Map **SR** to **ST** with QFD
10. **IF** number of evaluators are not adequate for QFD:
11. Assess **SR** to **ST** qualitatively
12. Assess **QFD** quantitatively
13. Assess **EPLMS**

3.5 Chapter Summary

This chapter discusses about the research strategy, strategy selection, methodology and conceptual design. Mix method were used, giving justifications. Survey method and interviews has been identified to collate the data. Two questionnaires are planned to distribute among the experts in the e-learning platform to identify the parameters and ranks of the model. AHP computes the weights of customer requirements. Next chapter explains the data analysis and discussion of the research.

4. ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter is about data analysis and presentation of results and findings of the study. Section 4.2 provides descriptive statistics and visualizations of data collected from the interviews and surveys. Section 4.3.2 describes the Outcomes/Results of Structured Questionnaire Surveys and 4.4 describes the Application of Analytic Hierarchy Process (AHP) to screen user requirements. Section 4.5 presents the maximum eigenvalue (λ max) and consistency. Section of 4.6 shows how to Apply Quality Function Deployment (QFD) to map user requirements against technical capabilities of LMS tools/functions. Finally, section 4.8 discusses the summary.

4.2 Descriptive Analysis

4.2.1 Demographic information

Demographics information is quantifiable characteristics of a population such as gender, age, educational level, profession, and experience level. According to the questionnaire survey there are two demographic categories affects targeted population of this study. Because the study group consisted of end-users of the LMS and mainly have taken undergraduates and the lecturers. Of 15 end-users selected to participate in a questionnaire survey, all the 15 responded (response rate of 100%). Among the respondents were 9 (60%) lecturers, and (40%) undergraduates. Therefore, both lecturer's details as well as details of undergraduates has been identified as the demographic information of the responded.

4.2.1.1 Composition of the sample by Gender

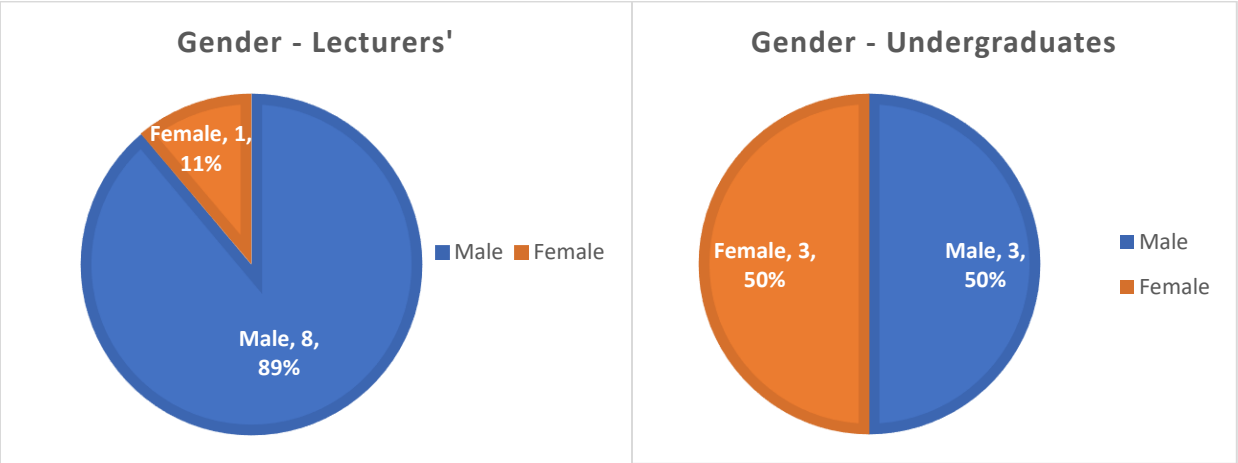

Figure 9: Gender of Lecturers' and undergraduates'

According to the figure 9 the sample of the lecturers consists of 89% of male and 11% of female lecturers. But according to the figure of undergraduate's shows that the depiction of male and female students is approximately equal.

4.2.1.2 **Composition of the sample by Age**

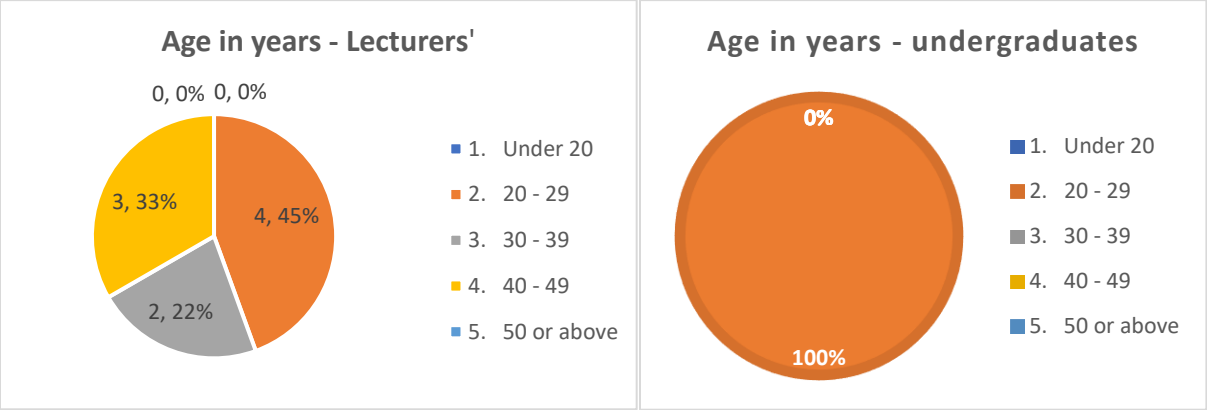

Figure 10: Age categories of Lecturers' and undergraduates'

As mentioned in the Methodology chapter, all the lecturers who were taken to the sample are expert in the field of LMS usage. Therefore, their age goes from 20 years to 49 years range. According to the figure given above, the highest representation of 45% was from 20-29 years category where only 22% of the sample was represented by 30-39 years range. But in the undergraduate's category all are in the age of 20-29 years category (100%). The reason behind this is the average age of an undergraduate lies on that category.

4.2.1.3 **Lecturers job related details**

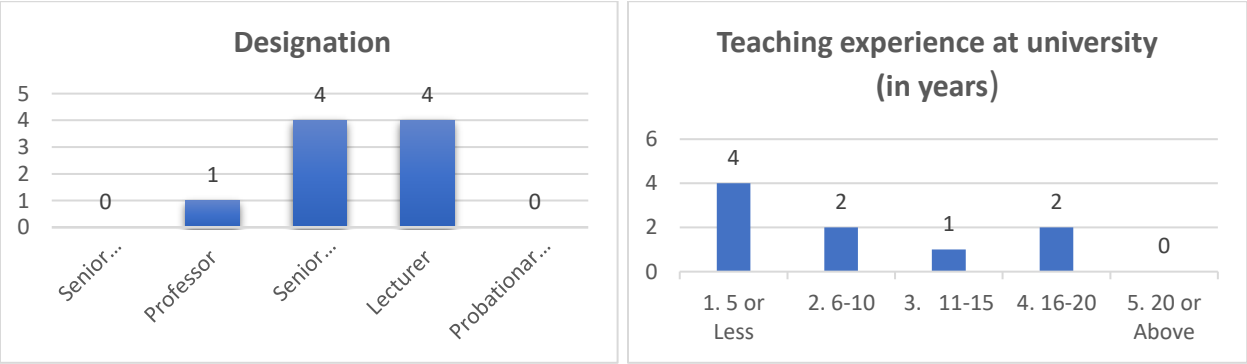

Figure 11: Designation and Teaching experience by years of Lecturers'

As seen in the figure 11 majority are working under the designation of lecturer and senior lecturer. Teaching experience also goes to a range of 1.5 years to 16 -20 years range.

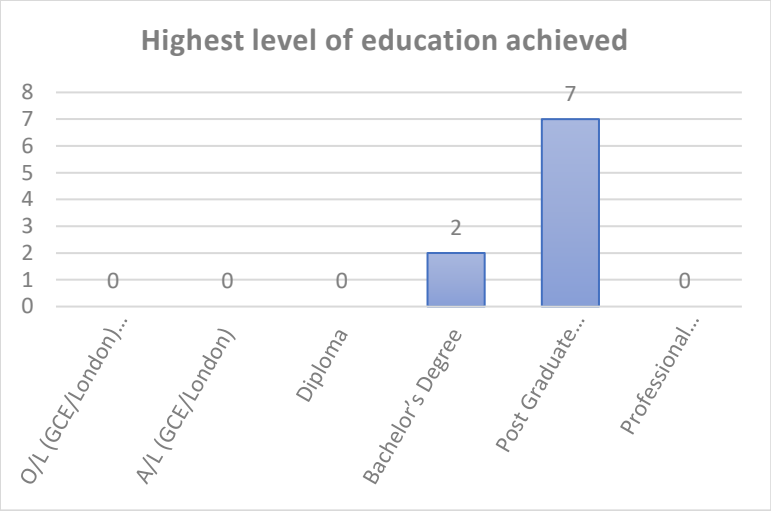

Figure 12: Lecturers' highest level of education

Figure 12 shows that the level of education of the lecturers and majority of them are having a post graduate degree as their education level. Only two from the sample are having a bachelor's degree as the highest education level.

4.2.1.4 Composition of the sample on received training with respect to effective use of LMS Practice

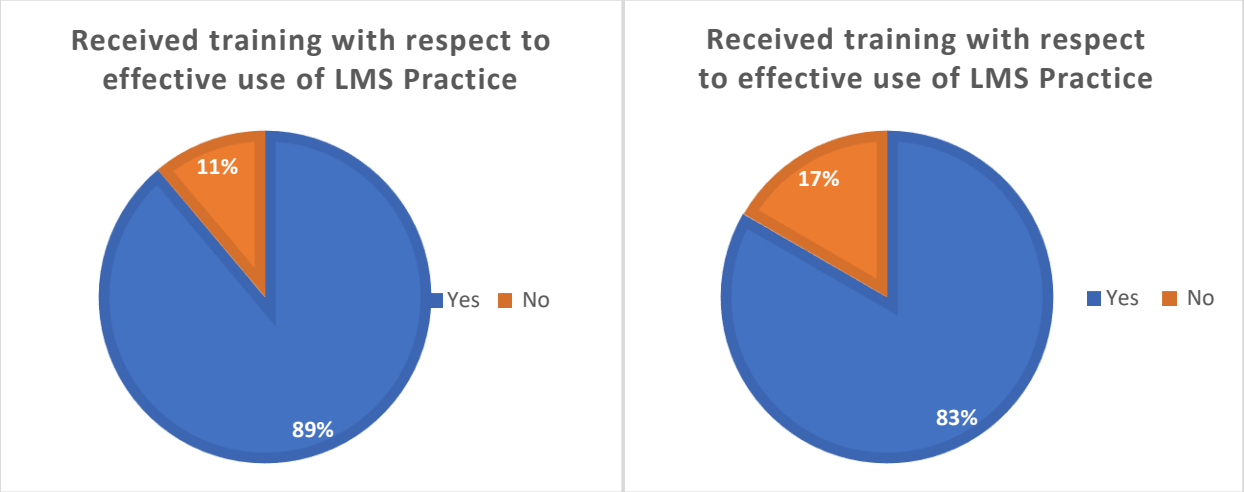

Figure 13: Training with regard to LMS practice

As seen in the above figure 13 almost more than 80% from both lecturers as well as from the undergraduates have received training with respect to effective use of LMS practice.

4.2.1.5 **Composition of the sample by experience with LMS in years**

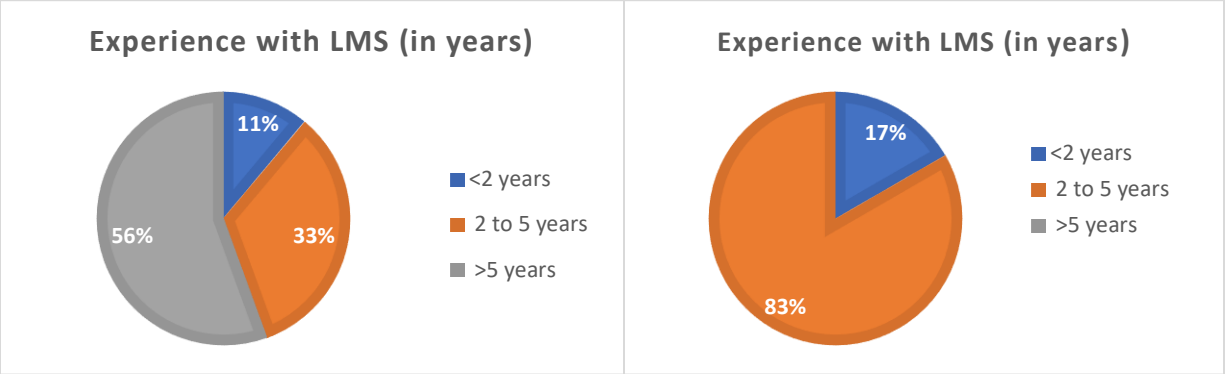

Figure 14: Experience with LMS in years

Here mainly, contributors were approached to demonstrate whether they had past involvement utilizing computers and e-learning framework gateways mainly LMS. Majority of the sample of the lecturer's category has experience with LMS more than 5 years and the percentage is 56%. Only 11% of the sample from the same category has experience of less than two years. But that is also a very less number when it compared with the majority.

But in the undergraduate's category three fourth of the sample is having a 2 to 5 years of experience with LMS. As a percentage it is 83% and only 17% is having less than two years of experience with LMS.

4.2.1.6 **Composition of the sample by experience with ICT in years**

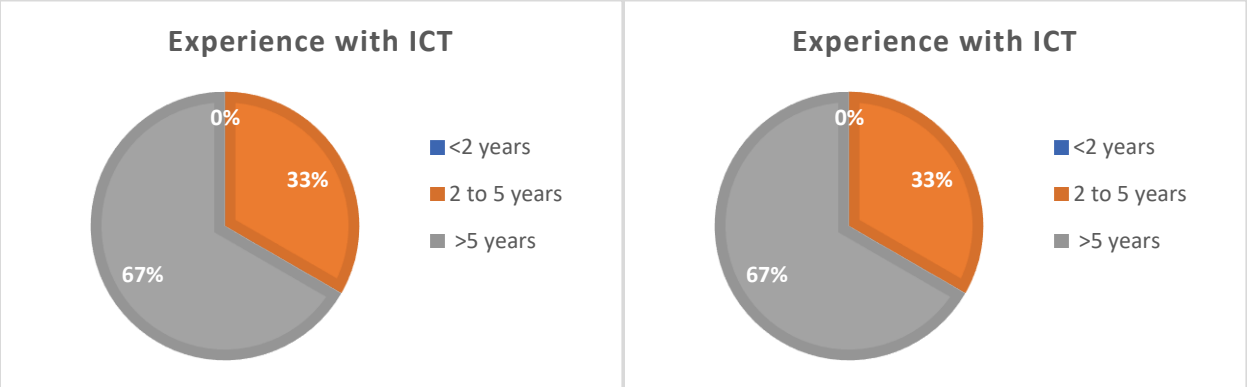

Figure 15: Experience with ICT in years

According to the figure 15 it is shown that almost both categories responded an equal response related to the experience with Information and Communication Technology (ICT). There also majority having a 67% is have more than 5 years of experience equally. Only 33% is having an experience of 2 to 5 years and no one is having less than 2 years of experience with relate to ICT.

4.2.1.7 **Composition of the sample by frequency of LMS usage**

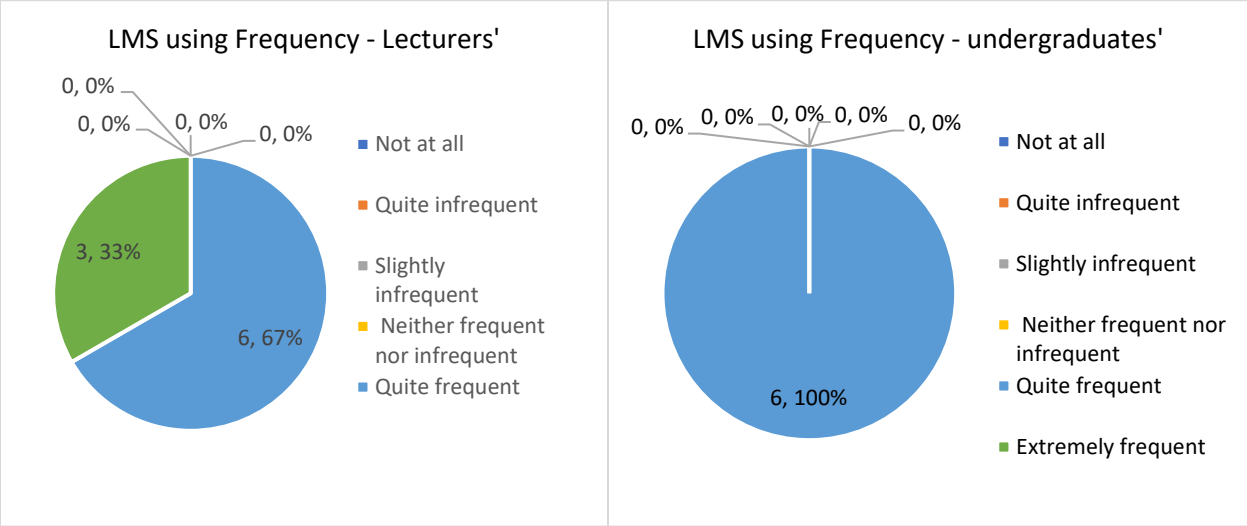

Figure 16: Frequency of LMS usage

According to the above figure, it is clear that majority of the lecturers as well as 100 % of undergraduates use LMS quite frequently where only 33% of lecturers use them extreme frequently. Based on this, it can be said that since they are experts in the field of eLearning, they are using the LMS frequently.

4.2.1.8 **Composition of the sample by LMS usage in times**

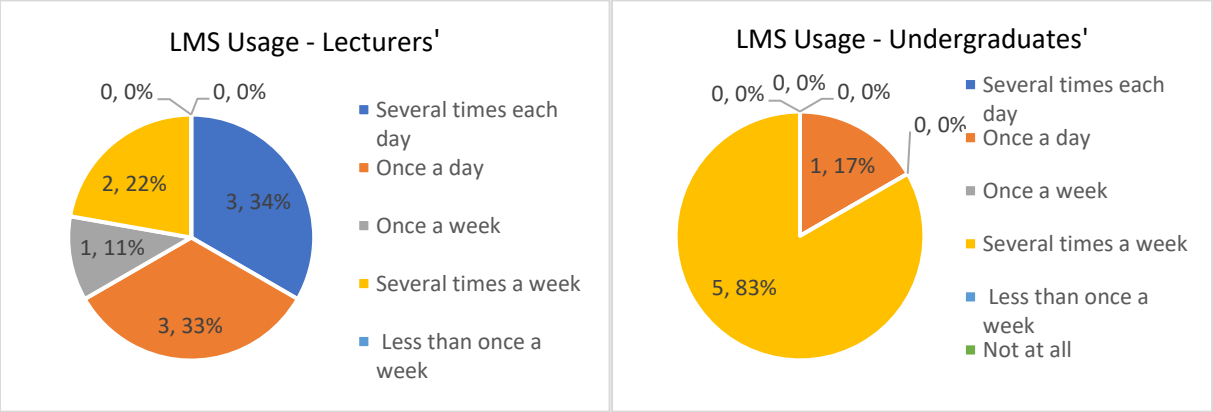

Figure 17 :Time of LMS usage

Based on the above figure, it is clear that 34% of lecturers use LMS several times each day where 33% (almost close to that amount) use once a day. 22% of lecturers use LMS several times a week but only 11% use LMS rarely and that is once a week. But in the undergraduates' section majority that is 83% use LMS several times a week where only 17% use it once a day. This indicates that lecturers consider LMS as a very useful major source of eLearning platform when conducting their

teaching activities. Furthermore, undergraduates also use that system as an important tool for learning. In both parties there is no one using LMS less than once a week.

4.2.1.9 **Composition of the sample by hours of LMS usage**

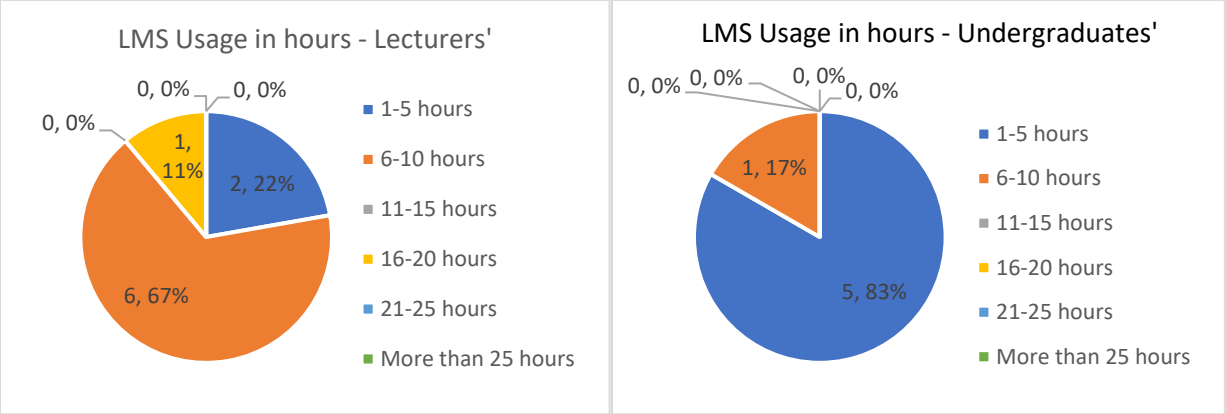

Figure 18: Hours of LMS usage

As in the figure 18 it is clearly visible that more than 80 % of undergraduates use LMS 1-5 hours per week. And 17% use 6-10 hours per week. But according to the lecturers' portion majority that is 67% use LMS for 6-10 hours per week. And there is some extreme end as well because some experts in the lecturer's category use LMS for 16-20 hours per week indicating a 11%.

The above-mentioned figures can be summarized as follows.

Table 9 : Summary Table of the demographic factors

		Lecturer's		**Undergraduates**	
		Frequency	**%**	**Frequency**	**%**
Gender	Male	8	89%	3	50%
	Female	1	11%	3	50%
Age	1. Under 20	0	0	0	0
	2. 20 - 29	4	44%	6	100%
	3. 30 - 39	2	22%	0	0
	4. 40 - 49	3	34%	0	0
	5. 50 or above	0	0	0	0
Highest Education Level	1. O/L (GCE/London) or below	0	0	0	0
	2. A/L (GCE/London)	0	0	0	0
	3. Diploma	0	0	0	0
	4. Bachelor's Degree	2	22%	0	0
	5. Post Graduate Qualification	7	78%	6	100%

	6. Professional Qualification	0	0	0	0
Received Training on LMS	Yes	8	89%	5	83%
	No	1	11%	1	17%
experience with LMS (in years)	<2 years	1	11%	1	17%
	2 to 5 years	3	33%	5	83%
	>5 years	5	56%	0	0
experience with ICT (in years)	<2 years	0	0	0	0
	2 to 5 years	3	33%	2	33%
	>5 years	6	67%	4	67%
How frequently do you use LMS?	Not at all	0	0	0	0
	Quite infrequent	0	0	0	0
	Slightly infrequent	0	0	0	0
	Neither frequent nor infrequent	0	0	0	0
	Quite frequent	6	67%	6	100%
	Extremely frequent	3	33%	0	0
How many times (approximately) do you use LMS during a week?	Several times each day	3	33%	0	0
	Once a day	3	33%	1	17%
	Once a week	1	12%	0	0
	Several times a week	2	22%	5	83%
	Less than once a week	0	0	0	0
	Not at all	0	0	0	0
How many hours (approximately) do you use LMS every week?	1. 1-5 hours	2	22%	5	83%
	2. 6-10 hours	6	67%	1	17%
	3. 11-15 hours	0	0	0	0
	4. 16-20 hours	1	11%	0	0
	5. 21-25 hours	0	0	0	0
	6. More than 25 hours	0	0	0	0

4.3 Outcomes/Results of Structured Questionnaire Surveys

Table 9 describes the summary of the content collected from the interviewees in the interview process and literature.

4.3.1 Expected requirements/functionalities of LMS users

Table 10 : Development Requirements

Requirement	Description	Interested Stakeholders
Quality	C1: Stability of network (e.g. less interruptions)	Users
	C2: Ability to assess learning performance	Users
	C3: Quality of e-learning platform (LMS)	Users
	C4: Richness and diversification of teaching materials	Users
	C5: Access to archived teaching and learning materials	Users
Benefit	C6: Ease of use	Users
	C7: Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)	Users
	C8: Time saving	Users
	C9: Ease of sharing or uploading data/information	Users
	C10: Flexibility in choosing learning/teaching content	Users

Source: Author Defined Based on Interviews and literature

4.3.2 Technical capabilities of different functions/tools of LMS systems

After collecting the requirements of the users and the experts of the LMS the technical capabilities that would fulfill these requirements were searched in the literature. Table 11 summarizes the technical capabilities found from the literature survey. Detailed descriptions of each of the item were mentioned in the Chapter, *Literature Review*.

Table 11 : List of generally available technical capabilities of different tools/functions

Quality Characteristic	Description
Forum	A synchronous communication tools.
Navigation	Activity of accurately ascertaining position
Activity Tracking	Tracking of activity of the user, including experiments.
Report	File submission support.
Scheduling	Tool for term reservation.
Automated feedback	Check the users' achievement automatically.

Adapted & Intuitive GUI	Experiment is adapted for the targeted device and transparent graphical user interface.
Platform independent	Works on different platforms without special software installed.
Mobile support	System is able to work on handheld devices.
Content awareness	Awareness of the context of learning processes.

There are a number of technical capabilities are available but, in the study, only 10 was selected. They are highly important to develop the decision matrix.

4.4 **Application of Analytic Hierarchy Process (AHP) to screen user requirements**

There were 10 stakeholder/user requirements and 10 technical capabilities identified in the literature review and interview processes. The evaluation of all the identified requirements and capabilities in a QFD would require 10 x10 = 100 individual evaluations for the map between requirements and capabilities. Due to the lack of resources and due to the potential evaluator frustration, which would lead to poor evaluations, this numbers were to be reduced. As the number of requirements are too many to process further the Analytic Hierarchy Process (AHP) was used as follows. This reduce the user requirements to 80% of significance. The top 80% significant requirements are screened following the 80-20 principle, as described by Pereira and Xavier (2016). The filtered results are given in the following table. During the AHP, count of requirements and capabilities were reduced to 8 for each of them.

Table 12 : Significant User Requirements

Significant User Requirement	Importance as a Percentage
C4 Richness and diversification of teaching materials	11.7%
C2 Ability to assess learning performance	11.6%
C7 Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)	10.9%
C8 Time saving	10.7%
C3 Quality of e-learning platform (LMS)	10.2%
C5 Access to archived teaching and learning materials	9.8%
C10 Flexibility in choosing learning/teaching content	9.7%
C9 Ease of sharing or uploading data/information	9.4%
Total	**84%**

Source: Author Defined Based on Analysis

In light of the outcomes of weighting in table 12 above, it can be concluded that the criteria, Richness and diversification of teaching materials and Ability to assess learning performance have dominant role with a weight of 0.117 (11.7%). The second rank is the Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.) and Time saving criteria with the overall weight of 0.109 (10.9%) and the third rank is Quality of e-learning platform (LMS), Access to archived teaching and learning materials and Flexibility in choosing learning/teaching content with weight of 0.097 (9.7%).As the final criteria Ease of sharing or uploading data/information is taken with weight of 0.094 (9.4%).

Since, the number of technical capabilities is limited to 10 all the technical capabilities were taken to carry out the research.

After that, weights for the main parameters were calculated using AHP analysis and they are as follows.

Table 13 : Weights for Main Parameters

Main parameters	Quality	Benefits
Weights	50%	50%

The above-mentioned weights were summarized based on the following table.

Table 14 : Respondent's reaction on main parameters

No.	**Quality**	**Benefit**
Respondent 01	5	0
Respondent 02	0	3
Respondent 03	0	3
Respondent 04	0	5
Respondent 05	1	1
Respondent 06	0	5
Respondent 07	1	1
Respondent 07	1	1
Respondent 08	5	0
Respondent 09	5	0
Respondent 10	5	0
Respondent 11	5	0
Respondent 12	7	0
Respondent 13	0	7
Respondent 14	0	7
Respondent 15	0	7

4.4.1 **Assigning Weights for Sub Parameters**

Same group of experts have been considered for collect the data and AHP process, explained in the section 4.6.1, used to identify the weights for the Sub parameters in the decision model. Tables 15 and 16 explain the weights of sub parameters.

Table 15 : Weights of Sub Parameter According Quality

Main Parameter	Quality	**Weight**	50%		
Sub Parameters	C1: Stability of network (e.g. less interruptions)	C2: Ability to assess learning performance	C3: Quality of e-learning platform (LMS)	C4: Richness and diversification of teaching materials	C5: Access to archived teaching and learning materials
Weights	0.070	0.116	0.102	0.117	0.098

(Refer Appendix 03 – Detail AHP analysis of Quality Sub Parameter)

Table 16 : Weights of Sub Parameter According Benefit

Main Parameter	Benefit	**Weight**	50%		
Sub Parameters	C6: Ease of use	C7: Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)	C8: Time saving	C9: Ease of sharing or uploading data/information	C10: Flexibility in choosing learning/teaching content
Weights	0.090	0.109	0.107	0.094	0.097

(Refer Appendix 03 – Detail AHP analysis of Benefit Sub Parameter)

4.5 The consistency and the maximum eigenvalue (λ max)

The initial step of AHP is to quantify the consistency of the survey outcomes of each respondent through two indicators namely, Consistency Index (CI) and Consistency Ratio (CR). In order to calculate to above formulas first need to calculate the maximum eigenvalues (λ max).

The maximum eigenvalues (λ max) are calculated from the product amount of the number of fields with the main vector. The formula for the λ max can be described as follows.

maximum eigenvalues (λ max) = ( )+ ( )+...+ ( )

The consistency index (CI) is formulated using the λ max.

Consistency index (CI) = (λ max – n) /n.

Consistency Ratio (CR) is obtained by the formula CR = CI / IR, Where CR is Consistency Ratio and IR is Random Consistency Index. If the ratio consistency (the value of the consistent ratio - CI / IR) is less than or equal to 0.1 (CR ≤ 0.1. If CR> 0.1), the final result can be declared true.

If not, the matrix calculation ought to be halted and recalculated or it can be said that the respondent cannot be encompassed in the subsequent analysis. As mentioned in the previous chapters, the survey was distributed to 15 respondents. Each questionnaire is confirmed according to the consistency ratio.

Table 17 : Values of CI and CR

CR	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**
Lambda	14.167	14.174	14.274	15.055	15.264	14.726	15.188	14.785	14.65	15.38
Lambda max	15.3797									
CI	0.52959									
CR	0.35543									

Source: Author Defined Based on Analysis

According to the study Consistency Index (CI) is 0.52959 and Consistency Ratio (CR) is 0.35543. According to the past literature, the consistent ratio value/rate should be CR ≤ 0.1. But in our study, CR is 0.35. Therefore, we can assume that the value is due to the judgmental errors. And also, some past researchers propose that in development related decision making, AHP can aid guarantee an elevated level of consistency among the decisions acquired from various professionals who may have various discernments, encounters, and comprehension of the decision criteria.

4.6 Quality Function Deployment (QFD) Process

4.6.1 QFD Expert Team

Experts related to the LMS usage were difficult to find due to the novelty of the technology. This study found 15 experts in the fields related to LMS usage. They are as follows.

- Nine Lecturers (Director of the e-learning center of the University of Kelaniya, Web masters, Technical coordinators etc. and representatives from University of Kelaniya, University of Moratuwa, University of Colombo and University of Sri Jayewardenepura included.)
- Six undergraduates (All the undergraduates are from the 3rd and 4th years from above mentioned universities)

Researcher is also an expert in the field of LMS. Therefore, she acted as the moderator to review the results again with the set of experts when the evaluations were ambiguous. The rationale behind the collective opinion on the final result was discussed among the expert team and the summary for each of the decision is mentioned later in this chapter.

4.7 QFD Process/ Application of Quality Function Deployment (QFD) to map user requirements against technical capabilities of LMS tools/functions

In order to apply QFD to map the user requirements against technical capabilities of LMS tools/functions the relationship matrix is made. The relationship matrix lies in the middle of the HOQ. Due to the formulas of the study, it is vital to connect the WHATs and HOWs. Through this combination of WHATs and HOWs a matrix can be developed. According to Chan & Wu (2002), this matrix is an organized (systematic) arrangement. Mainly it recognizes the level of association between each WHAT and each HOW. Fisher & Schutta (2003) is also introduced a comparable statement regarding the relationship matrix. They also described this matrix as a combination of the customer WHATs versus the technical HOWs. The prime objective was to identify the degree of association among those two factors.

This matrix is presented through graphical signs. According to the American Supplier Institute (1994), usually there are six relationship levels, i.e., no relationship, weak relationship, moderate relationship, strong relationship, very strong relationship and extreme relationship. The scale of 0, 1, 3, 5, 7 and 9, respectively was used to interpret the above relationships.

According to the above facts and calculations following relationship matrix made but here we have used the numbers instead of visual symbols.

Table 18 : Quality Function Deployment

	Wieght	Activity Tracking	Report	Navigation	Mobile support	Adapted & Intuitive GUI	Scheduling	Automated feedback	Content awareness	Forum	Platform independent
C4	11.7%	5	5	3	3	3	5	3	5	3	3
C2	11.6%	5	3	3	3	3	3	5	3	3	3
C7	10.9%	7	5	5	5	3	3	5	3	3	3
C8	10.7%	5	5	7	5	7	5	5	3	5	5
C3	10.2%	5	9	5	5	5	5	5	5	5	3
C5	9.8%	5	3	5	5	5	5	3	5	3	3
C10	9.7%	5	3	5	5	5	3	3	3	5	3
C9	9.4%	5	5	5	5	5	5	3	5	5	5
Total	84%	42	38	38	36	36	34	32	32	32	28

Source: Author Defined Based on Analysis

4.7.1 **Qualitative Analysis between Requirements to Capability Relationship**

The summarized opinions of the expert team on the relationship between user requirements to technical capabilities given in Table are explained in this section. Reasoning behind the final score for each of the relationship is explained here. Quantitative results obtained above were verified with the qualitative information gathered during the interviews with the experts.

4.8 **Evaluating Technical features of a LMS decision matrix**

QFD was used to identify the Impact level of a technical capability (ILTC) of each of the technical capability screened from the AHP. As the number of evaluators were not statistically significant for the evaluation, a qualitative analysis was also done to verify the results of the QFD. Qualitative analysis was based on the qualitative analysis given by the interviewed experts. Once the QFD results were verified, the priority given for each of the technical capability / feature was observed. Impact level of a technical capability (ILTC) for each screened technical capability is calculated in Table 19.

Table 19: ILTC Calculation

Technical Capability	Calculation	ILTC
Forum	(3*11.7+3*11.6+3*10.9+5*10.7+5*10.2+3*9.8+5*9.7+5*9.4)/9	36.89
Navigation	(3*11.7+3*11.6+5*10.9+7*10.7+5*10.2+5*9.8+5*9.7+5*9.4)/9	43.87
Activity Tracking	(5*11.7+5*11.6+7*10.9+5*10.7+5*10.2+5*9.8+5*9.7+5*9.4)/9	49.09
Report	(5*11.7+3*11.6+5*10.9+5*10.7+9*10.2+3*9.8+3*9.7+5*9.4)/9	44.29
Scheduling	(5*11.7+3*11.6+3*10.9+5*10.7+5*10.2+5*9.8+3*9.7+5*9.4)/9	39.51

Automated feedback	(3*11.7+5*11.6+5*10.9+5*10.7+5*10.2+3*9.8+3*9.7+3*9.4)/9	37.64
Adapted & Intuitive GUI	(3*11.7+3*11.6+3*10.9+7*10.7+5*10.2+5*9.8+5*9.7+5*9.4)/9	41.44
Platform independent	(3*11.7+3*11.6+3*10.9+5*10.7+3*10.2+3*9.8+3*9.7+5*9.4)/9	32.47
Mobile support	(3*11.7+3*11.6+5*10.9+5*10.7+5*10.2+5*9.8+5*9.7+5*9.4)/9	41.49
Content Awareness	(5*11.7+3*11.6+3*10.9+3*10.7+5*10.2+5*9.8+3*9.7+5*9.4)/9	37.13
Total ILTC		**403.82**

Source: Author Defined Based on Analysis

From the total of ILTC, Effectiveness Percentage of the LMS (EPLMS) is calculated as follows.

EPLMS = Total ILTC / 100 % = 403.82 /100 % = 4.0382 %

Effectiveness Percentage of the LMS (EPLMS) was calculated for the features to be implemented in the decision matrix. It was found that only 4% of total requirements could be effectively using once it was built with the selected technical capabilities. Therefore, the new LMS decision matrix can use **4%** of requirements according to the calculation.

4.9 LMS Decision Matrix Development

Based on the results of quantitative and qualitative analysis, technical capabilities to be implemented can be given priorities as follows.

Activity Tracking > Report > Navigation > Mobile support > Adapted & Intuitive GUI > Scheduling > Automated feedback > Content Awareness > Forum > Platform independent

According to the final results, the aforesaid factors can be considered to develop the decision matrix of LMS for the business and management discipline, higher education sector in Sri Lanka and it can be rated as the best choice.

4.10 Summary

In order to test the framework discussed in the Chapter 3, we apply it to the development of decision matrix to use in the business and management discipline of the higher education sector. Analytic Hierarchy Process (AHP) identified the user requirements and screened and limit the number of customer requirement. Quality Function Deployment (QFD) uses to identify technical capabilities and mapped them with the user requirements.

The proposed framework, of decision matrix of LMS mainly developed specially for the business and management related universities of Sri Lanka. User requirements were mainly collected from various parties via interviews. The literature review provides technical capabilities. Both user requirements and technical capabilities were prioritized based on the significance level and applied in a QFD. QFD was filled with the collective decision of a team of experts. Relationship level between each of the selected significant user capability was evaluated against each significant technical capability. And also, the correlation level was evaluated by the expert team among each of the technical capability. Using both quantitative evaluations from the QFD and the qualitative opinion given by the team of experts the framework could identify the most important technical capabilities to be implemented in a decision matrix of LMS.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the conclusion of the research based on the findings detailed in the preceding chapters. Furthermore, the key findings are summarized under this chapter to build up conclusions and recommendations for the practitioners as well as further research directions for the academic researchers. Chapter summarizes the extent of work done in different phases of the study while highlighting the main outcomes derived from the research. Initially it provides overview of the study and then conclusions are given apropos to each objective.

5.2 Conclusion

Objective - 01 of this study is to assess the perceived stakeholder requirement of LMS to accomplish teaching and learning activities. From literature, we have identified, ten stakeholder requirements as the most appropriate requirements to develop the decision matrix. We applied AHP as a way to prioritize the identified user requirements and highest ranked eight user requirements were taken in to consideration.

Objective - 02 of this research is to identify the tools and/or functions available in learning management systems to perform teaching and learning activities. The literature review provides ten technical capabilities. According to the research findings analysis, all the main parameters were accepted to use in the decision matrix. We ranked those selected technical features through QFD.

Objective – 03 is to develop the stakeholder requirement – technical capability matrix for learning management systems to support tactical and operational decision making developed based on the above-identified parameters. This research identified the most significant parameters affecting to decision matrix through the expert surveys done in order to gather the data analyzing with AHP analysis and QFD. The decision matrix is in line with the MIRACLE - model which was introduced by the author Cmuk *et* al., (2009). But the priority/rankings of user requirements and technical capabilities are different from our model. The business and management discipline and higher education sector will get the advantage of this research findings and can be useful to all the users and professionals, in the business and management discipline for further developments and may assist with inferring new research pathways.

5.3 Findings of the Research

The research has found a framework to develop an LMS based on the existing stakeholder requirements and available technical capabilities. The research has also demonstrated the

mechanism to sort out the requirements and capabilities with lesser significant values to reduce the complexity of the analysis.

While applying a learning or teaching device or framework for learners/students, it is required to investigate both lecturers' and learners' attitudes toward that device or approach. Fundamentally, recognizing their experiences or understand their insights or perception toward learning or teaching background is a vital issue for increasing teaching performance and learning effects. The consequences of this investigation affirm that lecturers are eager to use e-learning environments to support their teaching activities. Learners also positively respond to environments of e-learning for completing their learning or teaching activities.

5.4 Policy Implications

This research introduces a formal methodology to identify stakeholder requirements, identify technical capabilities and applying them when an LMS is needed to be developed for the purpose of use it effectively in the management related higher education sector.

5.5 Limitations of the Study

This research always tries to imply a vigilant and systemic effort to integrate elements of LMS without any limitations. But there are several limitations that were identified during the process of research which would affect the performance of the newly introduced matrix. Some of them are,

There is no proper way to find the correct people to be interviewed for the stakeholder requirement gathering process. Some stakeholder requirements were conflicting with each other due to their role and the expertise knowledge with the involvement of the LMS or e-learning.

The level of literature review to be carried out is highly dependent on the nature of the framework developer.

Pairwise evaluation is highly dependent on the person who performs the AHP based evaluation. Evaluator's personal biases have a higher impact on the framework development as only a single person is involved. Another drawback with the process is that it's number of required evaluation steps grows quadratically with the number of features to be evaluated. This may make the evaluators frustrated and hence reduce the accuracy of the evaluations.

Sample size of the AHP analysis has been limited up to the 15 numbers of responses since it has to be used to calculate consistency ratio.

QFD has no way to deal with mutually exclusive features. When there are dependent features QFD has no way to map the dependencies inside the QFD.

5.6 Future Research Directions

Based on the limitations identified in the above section, following recommendations can to be given to resolve some of the identified issues.

A specification can be developed to restrict and guide the LMS developer to find the most suitable set of stakeholders to be interviewed during the interview process depending on the requirement. That would capture the strategically most relevant requirements for the LMS development.

Another specification can be developed to set priorities for each type of stakeholders. Then the requirements identified from each type of stakeholder can be weighted based on the type of the stakeholder. For example, when it comes to LMS framework development, for the technical support purpose, the customer requirement who use the system should be given higher priority over the requirements of the expert's requirements. This would add some quantitative evaluation into the qualitative interview process which would be used at prioritizing at AHP stage.

Bias introduced by the involvement of a single person in the AHP process can be reduced by improving the AHP so that the involvement of a team is possible. Combining the AHP with Fuzzy Delphi is another alternative if the shortcomings of Fuzzy Delphi can be eliminated with some modifications.

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APPENDICES

Appendix 1 – Questionnaire No 1 (Undergraduates')

Research Questionnaire

I'm K. Sachintha Sarathchandra, a post-graduate student who is currently reading for MBA in IT (Business Analytics) at University of Moratuwa, Sri Lanka. The questionnaire attached herewith intends to gather survey responses for my dissertation themed: ***Developing a framework for digital teaching & learning for the Management related higher education sector in Sri Lanka***. I would appreciate your valuable time and commitment extended to complete the following survey. It might take approximately 10 minutes of your time. Your responses will be confidential and used only for academic purpose. This questionnaire consists of four (04) sections. All questions are compulsory to answer and you are supposed to select the most appropriate answer for given questions.

Importantly, before you attempt the questions, please read the respective instructions and technical terms for clarity purposes.

Thank You,

K. Sachintha Sarathchandra
Email - sachinthas@kln.ac.lk
Mobile - 0779-261899

- **Section A - Demographic Profile**

5.6.1 **Section-A. Choose the most appropriate answer/option for the questions given.**
5.6.2 **Instructions: Tick in the appropriate answer box for questions ranging from A1 to A15 under**

Learning Management System (LMS) is defined as a web-based technology which assists in the planning, distribution, and evaluation of a specific learning process. (E.g.-: WebCT, Blackboard, Moodle, Computer Aided Learning (CAL), Lotus Notes and etc.)

- A1. Your gender: *

1. Male
2. Female

A2. Your age (in years): *

1. Under 20
2. 20 - 29
3. 30 - 39
4. 40 - 49
5. 50 or above

A3. What is the university that you attached to teach? *

1. University of Kelaniya
2. University of Moratuwa
3. University of Colombo
4. University of Sri Jayawardenapura

A4. Your Faculty and the Department: * _____

A5: Your highest level of education achieved/completed: *

1. O/L (GCE/London) or below
2. A/L (GCE/London)
3. Diploma
4. Bachelor's Degree
5. Post Graduate Qualification
6. Professional Qualification

A6: Your Designation: *

1. Senior Professor
2. Professor
3. Senior lecturer
4. lecturer
5. Probationary lecturer

A7: Your teaching experience at university (in years): *

1. 5 or Less
2. 6-10
3. 11-15
4. 16-20
5. 20 or Above

A8: Do you apply any Learning Management System (LMS) in your course(s) you teach? *

1. Yes
2. No

A9. Have you received training with respect to effective use of LMS Practice? *

1. Yes
2. No

A10. Your experience with LMS (in years) *

1. <2 years
2. 2 to 5 years
3. >5 years

A11. Your experience with Information and Communication Technology (ICT): *

1. <2 years
2. 2 to 5 years
3. >5 years

A12. LMS type you use: *_____

A13. How frequently do you use LMS? *

1. Not at all
2. Quite infrequent
3. Slightly infrequent
4. Neither frequent nor infrequent
5. Quite frequent
6. Extremely frequent

A14. How many times (approximately) do you use LMS during a week? *

1. Several times each day
2. Once a day
3. Once a week
4. Several times a week
5. Less than once a week
6. Not at all

A15. How many hours (approximately) do you use LMS every week? *

1. 1-5 hours
2. 6-10 hours
3. 11-15 hours
4. 16-20 hours
5. 21-25 hours
6. More than 25 hours

Section C.1 – Quality and Benefit

Table 01; Please respond the questionnaire with respect to the importance for select the service provider

No.	Description of the Parameter	Very Low	Low	Medium low	Medium	Medium High	High	Very High
1.	**Quality**							
1.1	Stability of network (e.g. less interruptions)							
1.2	Ability to assess learning performance							
1.3	Quality of e-learning platform (LMS)							
1.4	Richness and diversification of teaching materials							
1.5	Access to archived teaching and learning materials							
2.	**Benefits**							
2.1	Ease of use							
2.2	Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)							
2.3	Time saving							
2.4	Ease of sharing or uploading data/information							
2.5	Flexibility in choosing learning/teaching content							

Section C.2 – Important Analysis

Above mentioned sub criteria can be categorized under main five key criteria categories as shown in Table 1. Please indicate in Table 3 the relative importance of each of these key criteria categories in the selection. If one criterion is more important than another, please indicate the intensity (refer Table 2) of its importance over the other criterions.

Table 02: Scale for indicating intensity of importance

Intensity of importance	Definition	Explanation
1	Equal importance	Two criteria are equally important
3	Moderate importance	One of the criteria is slightly more important than the other
5	Strong importance	One of the criteria is strongly vital than the other
7	Very strong importance	One of the criteria is very strongly favored than the other and its dominance demonstrated in practice
9	Extreme importance	The evidence importance of one of criterion over another is of the highest possible order of affirmation which cannot being comparable

Table 03: Pair comparison

Comparison pair			**More important**		**Level of importance**				
A		B	A	B	1	3	5	7	9
Main parameters									
Quality	Vs	Benefit							

Comparison pair			**More important**		**Level of importance**				
A		B	A	B	1	3	5	7	9
Sub Parameters									
Stability of network (e.g. less interruptions)	Vs	Ability to assess learning performance							
	Vs	Quality of e-learning platform (LMS)							
	Vs	Richness and diversification of teaching materials							
	Vs	Access to archived teaching and learning materials							
	Vs	Ease of use							
	Vs	Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)							
	Vs	Time saving							
	Vs	Ease of sharing data/information							
	Vs	Flexibility in choosing learning/teaching content							
Ability to assess learning performance	Vs	Quality of e-learning platform (LMS)							
	Vs	Richness and diversification of teaching materials							
	Vs	Access to archived teaching and learning materials							
	Vs	Ease of use							

Comparison pair			More important		Level of importance				
A		B	A	B	1	3	5	7	9
Ability to assess learning performance	Vs	User identification							
	Vs	Time saving							
	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							
Quality of e-learning platform (LMS)	Vs	Richness and diversification of teaching materials							
	Vs	Access to archived teaching and learning materials							
	Vs	Ease of use							
	Vs	Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)							
	Vs	Time saving							
	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							

Comparison pair			More important		Level of importance				
A		B	A	B	1	3	5	7	9
Richness and diversification of teaching materials	Vs	Access to archived teaching and learning materials							
	Vs	Ease of use							
	Vs	Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)							
	Vs	Time saving							
	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							
Access to archived teaching and learning materials	Vs	Ease of use							
	Vs	Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)							
	Vs	Time saving							
	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							

Comparison pair			More important		Level of importance				
A		B	A	B	1	3	5	7	9
Ease of use	Vs	User identification							
	Vs	Time saving							
	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							
Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)	Vs	Time saving							
	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							
Time saving	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							
Ease of sharing or uploading data/information	Vs	Flexibility in choosing learning/teaching content							

Section D – Relationship matrix of WHATs vs. HOWs

Instructions: Please indicate the degree of strength between CRs (VOC) and TRs (VOE) using the following scale:

1 = "Weak relationship"
3 = "Moderate relationship"
5 = "Strong relationship"
7 = "Very strong relationship"
9 = "Extreme relationship"

7. How you rate the relationship of **Stability of network (e.g. less interruptions)** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

8. How you rate the relationship of **Ability to assess learning performance** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

9. How you rate the relationship of **Quality of e-learning platform (LMS)** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

1 = "Weak relationship"
3 = "Moderate relationship"
5 = "Strong relationship"
7 = "Very strong relationship"
9 = "Extreme relationship"

10. How you rate the relationship of **Richness and diversification of teaching materials** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

11. How you rate the relationship of **Access to archived teaching and learning materials** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

12. How you rate the relationship of **Ease of use** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

13. How you rate the relationship of **Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

1 = "Weak relationship"
3 = "Moderate relationship"
5 = "Strong relationship"
7 = "Very strong relationship"
9 = "Extreme relationship"

14. How you rate the relationship of **Time saving** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

15. How you rate the relationship of **Ease of sharing or uploading data/information** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

16. How you rate the relationship of **Flexibility in choosing learning/teaching content** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

Thank you for taking time to complete this survey.

Appendix 2 – Questionnaire No 2 (Lecturers)

Research Questionnaire

I'm K. Sachintha Sarathchandra, a post-graduate student who is currently reading for MBA in IT (Business Analytics) at University of Moratuwa, Sri Lanka. The questionnaire attached herewith intends to gather survey responses for my dissertation themed: ***Developing a framework for digital teaching & learning for the Management related higher education sector in Sri Lanka***. I would appreciate your valuable time and commitment extended to complete the following survey. It might take approximately 10 minutes of your time. Your responses will be confidential and used only for academic purpose. This questionnaire consists of three (03) sections. All questions are compulsory to answer and you are supposed to select the most appropriate answer for given questions.

Importantly, before you attempt the questions, please read the respective instructions and technical terms for clarity purposes.

Thank You,

K. Sachintha Sarathchandra
Email - sachinthas@kln.ac.lk
Mobile - 0779-261899

- **Section A - Demographic Profile**

Section-A. Choose the most appropriate answer/option for the questions given.

Instructions: Tick in the appropriate answer box for questions ranging from A1 to A13 under

Learning Management System (LMS)

Learning Management System (LMS) is defined as a web-based technology which assists in the planning, distribution, and evaluation of a specific learning process. (E.g.-: WebCT, Blackboard, Moodle, Computer Aided Learning (CAL), Lotus Notes and etc.)

- A1. Your gender: *

3. Male
4. Female

A2. Your age (in years): *

6. Under 20
7. 20 - 29
8. 30 - 39
9. 40 - 49
10. 50 or above

A3. What is the university that you attached to learn? *

5. University of Kelaniya
6. University of Moratuwa
7. University of Colombo
8. University of Sri Jayawardenapura

A4. Your Faculty and the Department: * _____

A5: Your highest level of education achieved/completed: *

1. O/L (GCE/London) or below
2. A/L (GCE/London)
3. Diploma
4. Bachelor's Degree
5. Post Graduate Qualification
6. Professional Qualification

A6: Do you use any Learning Management System (LMS) in your course(s) you study? *

3. Yes
4. No

A7. Have you received training with respect to effective use of LMS Practice? *

3. Yes
4. No

A8. Your experience with LMS (in years) *

4. <2 years
5. 2 to 5 years
6. >5 years

A9. Your experience with Computers: *

4. <2 years
5. 2 to 5 years
6. >5 years

A10. LMS type you use: *_____

A11. How frequently do you use LMS? *

7. Not at all
8. Quite infrequent
9. Slightly infrequent
10. Neither frequent nor infrequent
11. Quite frequent
12. Extremely frequent

A12. How many times (approximately) do you use LMS during a week? *

7. Several times each day
8. Once a day
9. Once a week
10. Several times a week
11. Less than once a week
12. Not at all

A13. How many hours (approximately) do you use LMS every week? *

7. 1-5 hours
8. 6-10 hours
9. 11-15 hours
10. 16-20 hours
11. 21-25 hours
12. More than 25 hours

Section C.1 – Quality and Benefit

Table 01; Please respond the questionnaire with respect to the importance for select the service provider

No.	Description of the Parameter	Very Low	Low	Medium low	Medium	Medium High	High	Very High
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1.3	Quality of e-learning platform (LMS)							
1.4	Richness and diversification of teaching materials							
1.5	Access to archived teaching and learning materials							
2.	**Benefits**							
2.1	Ease of use							
2.2	Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)							
2.3	Time saving							
2.4	Ease of sharing or uploading data/information							
2.5	Flexibility in choosing learning/teaching content							

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Above mentioned sub criteria can be categorized under main five key criteria categories as shown in Table 1. Please indicate in Table 3 the relative importance of each of these key criteria categories in the selection. If one criterion is more important than another, please indicate the intensity (refer Table 2) of its importance over the other criterions.

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	Vs	Ease of use							
	Vs	Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)							
	Vs	Time saving							
	Vs	Ease of sharing data/information							
	Vs	Flexibility in choosing learning/teaching content							
Ability to assess learning performance	Vs	Quality of e-learning platform (LMS)							
	Vs	Richness and diversification of teaching materials							
	Vs	Access to archived teaching and learning materials							
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	Vs	Flexibility in choosing learning/teaching content							
Quality of e-learning platform (LMS)	Vs	Richness and diversification of teaching materials							
	Vs	Access to archived teaching and learning materials							
	Vs	Ease of use							
	Vs	Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)							
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	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							

Comparison pair			More important		Level of importance				
A		B	A	B	1	3	5	7	9
Richness and diversification of teaching materials	Vs	Access to archived teaching and learning materials							
	Vs	Ease of use							
	Vs	Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)							
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	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							
Access to archived teaching and learning materials	Vs	Ease of use							
	Vs	Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)							
	Vs	Time saving							
	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							

Comparison pair			More important		Level of importance				
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	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							
Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)	Vs	Time saving							
	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							
Time saving	Vs	Ease of sharing or uploading data/information							
	Vs	Flexibility in choosing learning/teaching content							
Ease of sharing or uploading data/information	Vs	Flexibility in choosing learning/teaching content							

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9. How you rate the relationship of **Quality of e-learning platform (LMS)** with;

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10. How you rate the relationship of **Richness and diversification of teaching materials** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

11. How you rate the relationship of **Access to archived teaching and learning materials** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

12. How you rate the relationship of **Ease of use** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

13. How you rate the relationship of **Identification of LMS users separately (e.g. teachers, undergraduates, post graduates etc.)** with;

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9 = "Extreme relationship"

14. How you rate the relationship of **Time saving** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

15. How you rate the relationship of **Ease of sharing or uploading data/information** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

16. How you rate the relationship of **Flexibility in choosing learning/teaching content** with;

Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness

Thank you for taking time to complete this survey.

Appendix 3 – Detail AHP analysis of parameters

Appendix 3.1 – Customer Requirements Analysis

Teacher 01

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	3	0.333333	5	0.333333	0.333333	5	3	0.333333	3
C2	3	1	0.333333	5	0.2	0.333333	3	0.333333	1	5
C3	0.333333	0.333333	1	0.2	0.333333	0.333333	1	0.2	1	1
C4	5	5	0.2	1	3	3	5	5	3	3
C5	0.333333	0.2	0.333333	3	1	0.333333	0.333333	1	3	3
C6	0.333333	0.333333	0.333333	3	0.333333	1	5	3	3	5
C7	5	3	1	5	0.333333	5	1	3	3	1
C8	3	0.333333	0.2	5	1	3	3	1	5	3
C9	0.333333	1	1	3	3	3	3	5	1	3
C10	3	5	1	3	3	5	1	3	3	1

Teacher 02

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	0.2	0.333333	0.142857	0.142857	1	1	0.142857	5	1
C2	0.2	1	1	1	1	3	1	0.333333	1	3
C3	0.333333	1	1	1	1	3	1	5	3	0.333333
C4	0.142857	1	1	1	3	3	0.2	3	5	3
C5	0.142857	1	1	3	1	3	1	1	5	3
C6	1	3	3	3	3	1	0.333333	0.2	0.333333	1
C7	1	1	1	0.2	1	0.333333	1	5	1	1
C8	0.142857	0.333333	5	3	1	0.2	5	1	1	0.2
C9	5	1	3	5	5	0.333333	1	1	1	1
C10	1	3	0.333333	3	3	1	1	0.2	1	1

Teacher 03

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	0.2	1	0.333333	0.333333	0.333333	0.333333	1	1	3
C2	0.2	1	5	3	1	3	3	3	1	5
C3	1	5	1	3	1	3	1	3	3	1
C4	0.333333	3	3	1	5	3	3	1	0.2	0.333333
C5	0.333333	1	1	5	1	3	3	0.2	3	0.2
C6	0.333333	3	3	0.333333	3	1	3	1	0.333333	1
C7	0.333333	3	1	3	3	3	1	0.333333	1	0.333333
C8	1	3	3	0.333333	5	1	3	1	3	0.333333
C9	1	1	3	0.2	3	0.333333	1	3	1	0.333333
C10	3	5	1	0.333333	0.2	1	0.333333	0.333333	0.333333	1

Teacher 04

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	1	0.2	0.2	1	1	1	1	1	0.2
C2	1	1	1	0.2	5	5	5	5	1	5
C3	0.2	1	1	0.2	1	1	1	5	0.2	0.2
C4	0.2	0.2	0.2	1	0.2	1	1	5	1	1
C5	1	5	1	0.2	1	0.2	1	1	1	0.2
C6	1	5	1	1	0.2	1	1	1	0.2	0.2
C7	1	5	1	1	1	1	1	1	1	0.333333
C8	1	5	5	5	1	1	1	1	0.2	0.2
C9	1	1	0.2	1	1	0.2	1	0.2	1	0.333333
C10	0.2	5	0.2	1	0.2	0.2	0.333333	0.2	0.333333	1

Teacher 05

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	3	0.2	0.2	0.333333	1	1	1	0.2	0.333333
C2	3	1	0.142857	0.333333	1	0.333333	1	0.333333	0.142857	0.333333
C3	0.2	0.142857	1	1	7	1	3	1	1	1
C4	0.2	0.333333	1	1	5	1	3	1	1	1
C5	0.333333	1	7	5	1	0.2	0.333333	0.2	0.142857	0.2
C6	1	0.333333	1	1	0.2	1	5	1	1	1
C7	1	1	3	3	0.333333	5	1	0.2	0.142857	0.2
C8	1	0.333333	1	1	0.2	1	0.2	1	1	1
C9	0.2	0.142857	1	1	0.142857	1	0.142857	1	1	1
C10	0.333333	0.333333	1	1	0.2	1	0.2	1	1	1

Teacher 06

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
C2	0.2	1	1	1	1	1	1	1	1	1
C3	0.2	1	1	1	1	1	1	1	1	1
C4	0.2	1	1	1	5	5	5	5	5	5
C5	0.2	1	1	5	1	0.2	0.2	0.2	0.2	0.2
C6	0.2	1	1	5	0.2	1	1	1	1	1
C7	0.2	1	1	5	0.2	1	1	0.2	0.2	0.2
C8	0.2	1	1	5	0.2	1	0.2	1	5	5
C9	0.2	1	1	5	0.2	1	0.2	5		5
C10	0.2	1	1	5	0.2	1	0.2	5	5	1

Teacher 07

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	1	0.2	0.2	3	1	0.333333	1	1	0.333333
C2	1	1	1	3	1	3	1	0.333333	7	0.333333
C3	0.2	1	1	1	0.2	1	5	1	1	0.333333
C4	0.2	3	1	1	3	1	5	1	0.333333	0.333333
C5	3	1	0.2	3	1	1	3	5	3	3
C6	1	3	1	1	1	1	3	1	1	0.333333
C7	0.333333	1	5	5	3	3	1	3	1	0.333333
C8	1	3	1	1	5	1	3	1	1	1
C9	1	7	1	0.333333	3	1	1	1	1	1
C10	0.333333	0.333333	0.333333	0.333333	3	0.333333	0.333333	1	1	1

Teacher 08

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	0.20	7	0.142857	1	1	1	0.142857	0.20	0.142857
C2	0.20	1	0.111111	0.333333	1	1	1	1	3	5
C3	7	0.111111	1	0.333333	0.111111	3	0.2	1	1	1
C4	0.142857	0.333333	0.333333	1	1	1	1	1	1	1
C5	1	1	0.111111	1	1	0.142857	0.2	5	0.2	1
C6	1	1	3	1	0.142857	1	1	0.142857	0.142857	1
C7	1	1	0.2	1	0.2	1	1	1	1	1
C8	0.142857	1	1	1	5	0.142857	1	1	5	0.142857
C9	0.2	3	1	1	0.2	0.142857	1	5	1	0.333333
C10	0.142857	5	1	1	1	1	1	0.142857	0.333333	1

Teacher 09

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	1	3	1	1	1	1	3	0.2	1
C2	1	1	1	3	5	7	3	0.2	1	3
C3	3	1	1	1	0.333333	1	0.333333	1	1	1
C4	1	3	1	1	3	3	1	0.2	3	1
C5	1	5	0.333333	3	1	1	0.333333	5	3	3
C6	1	7	1	3	1	1	1	3	0.333333	0.2
C7	1	3	0.333333	1	0.333333	1	1	3	0.333333	3
C8	3	0.2	1	0.2	5	3	3	1	1	1
C9	0.2	1	1	3	3	0.333333	0.333333	1	1	1
C10	1	3	1	1	3	0.2	3	1	1	1

Student 01		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	C1	1	1	0.2	0.2	1	0.2	1	0.2	0.2	0.333333
	C2	1	1	0.333333	3	1	0.2	3	0.2	0.2	1
	C3	0.2	0.333333	1	3	3	0.2	1	0.2	5	5
	C4	0.2	3	3	1	1	0.333333	5	0.2	0.333333	3
	C5	1	1	3	1	1	0.2	3	0.333333	0.333333	1
	C6	0.2	0.2	0.2	0.333333	0.2	1	1	0.333333	3	3
	C7	1	3	1	5	3	1	1	0.333333	1	1
	C8	0.2	0.2	0.2	0.2	0.333333	0.333333	0.333333	1	3	3
	C9	0.2	0.2	5	0.333333	0.333333	3	1	3	1	1
	C10	0.333333	1	5	3	1	3	1	3	1	1

Student 02		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	C1	1	7	0.142857	0.2	0.111111	5	0.142857	5	3	0.142857
	C2	7	1	0.142857	0.142857	0.2	0.2	0.142857	0.2	0.333333	5
	C3	0.142857	0.142857	1	0.142857	3	3	5	0.2	0.333333	0.2
	C4	0.2	0.142857	0.142857	1	0.2	3	5	3	0.2	0.333333
	C5	0.111111	0.2	3	0.2	1	0.2	3	0.2	0.333333	0.333333
	C6	5	0.2	3	3	0.2	1	1	0.2	0.333333	0.333333
	C7	0.142857	0.142857	5	5	3	1	1	0.2	0.333333	1
	C8	5	0.2	0.2	3	0.2	0.2	0.2	1	1	1
	C9	3	0.333333	0.333333	0.2	0.333333	0.333333	0.333333	1	1	0.333333
	C10	0.142857	5	0.2	0.333333	0.333333	0.333333	1	1	0.333333	1

Student 03		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	C1	1	0.2	1	0.333333	0.333333	0.333333	0.333333	1	1	3
	C2	7	1	0.142857	0.142857	0.2	0.2	0.142857	0.2	0.333333	5
	C3	0.2	0.142857	1	0.142857	3	3	5	0.2	0.333333	0.2
	C4	0.142857	0.333333	0.333333	1	1	1	1	1	1	1
	C5	1	1	0.111111	1	1	0.142857	0.2	5	0.2	1
	C6	1	1	3	1	0.142857	1	1	0.142857	0.142857	1
	C7	1	1	0.2	1	0.2	1	1	1	1	1
	C8	1	5	5	5	1	1	1	1	0.2	0.2
	C9	1	1	0.2	1	1	0.2	1	0.2	1	0.333333
	C10	0.2	5	0.2	1	0.2	0.2	0.333333	0.2	0.333333	1

Student 04		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	C1	1	0.142857	3	0.111111	0.142857	5	0.142857	0.2	0.142857	0.2
	C2	0.142857	1	0.142857	5	5	0.2	5	5	0.142857	7
	C3	3	0.142857	1	3	3	0.333333	5	0.333333	5	5
	C4	0.111111	5	3	1	1	1	3	3	0.333333	1
	C5	0.142857	5	3	1	1	3	3	3	0.2	1
	C6	5	0.2	0.333333	1	3	1	0.333333	0.2	0.2	1
	C7	0.142857	5	5	3	3	0.333333	1	3	3	3
	C8	0.2	5	0.333333	3	3	0.2	3	1	0.333333	0.2
	C9	0.142857	0.142857	5	0.333333	0.2	0.2	3	0.333333	1	1
	C10	0.2	7	5	1	1	1	3	0.2	1	1

Student 05		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	C1	1	1	0.2	0.2	1	0.2	1	0.2	0.2	0.333333
	C2	1	1	1	1	1	0.2	3	0.2	0.2	1
	C3	0.2	1	1	1	3	0.2	1	0.2	3	3
	C4	0.2	1	1	1	1	0.333333	3	0.2	0.333333	3
	C5	1	1	3	1	1	0.2	3	0.333333	0.333333	1
	C6	0.2	0.2	0.2	0.333333	0.2	1	1	0.333333	3	3
	C7	1	3	1	3	3	1	1	0.333333	1	1
	C8	0.2	0.2	0.2	0.2	0.333333	0.333333	0.333333	1	3	3
	C9	0.2	0.2	3	0.333333	0.333333	3	1	3	1	1
	C10	0.333333	1	3	3	1	3	1	3	1	1

Student 06		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	C1	1	1	0.333333	0.2	1	0.2	1	0.2	0.2	0.333333
	C2	1	1	0.2	3	1	0.333333	3	0.2	0.2	1
	C3	0.333333	0.2	1	3	3	0.2	1	0.2	5	3
	C4	0.2	3	3	1	1	0.333333	5	0.2	0.333333	3
	C5	1	1	3	1	1	0.2	3	0.333333	0.333333	1
	C6	0.2	0.333333	0.2	0.333333	0.2	1	1	0.333333	3	3
	C7	1	3	1	5	3	1	1	0.333333	1	1
	C8	0.2	0.2	0.2	0.2	0.333333	0.333333	0.333333	1	1	1
	C9	0.2	0.2	5	0.333333	0.333333	3	1	1	1	1
	C10	0.333333	1	3	3	1	3	1	1	1	1

Appendix 3.2 – Average Table

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	1	1.342857	1.15619	0.577566	0.728677	1.186667	0.965714	1.152381	0.925079	0.903492
C2	1.79619	1	0.836614	1.943492	1.64	1.666667	2.219048	1.168889	1.170159	3.177778
C3	1.102857	0.836614	1	1.267937	1.998519	1.417778	2.102222	1.302222	2.057778	1.551111
C4	0.564868	1.95619	1.280635	1	2.226667	1.8	3.08	1.986667	1.471111	1.8
C5	0.773122	1.693333	1.805926	2.226667	1	0.867937	1.64	1.853333	1.351746	1.275556
C6	1.231111	1.72	1.417778	1.622222	0.867937	1	1.711111	0.859048	1.134603	1.471111
C7	1.010159	2.27619	1.782222	3.08	1.64	1.711111	1	1.462222	1.067302	1.026667
C8	1.152381	1.666667	1.622222	2.208889	1.906667	0.91619	1.64	1	2.048889	1.351746
C9	0.925079	1.214603	2.048889	1.471111	1.405079	1.138413	1.067302	2.048889	1	1.177778
C10	0.716825	3.177778	1.551111	1.8	1.222222	1.417778	0.982222	1.351746	1.177778	1
Sum	10.27259	16.88423	14.50159	17.19788	14.63577	13.12254	16.40762	14.1854	13.40444	14.73524

Appendix 3.3 – Normalization Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	Criteria Weight
C1	0.097346	0.079533	0.079729	0.033584	0.049787	0.09043	0.058858	0.081237	0.069013	0.061315	0.070
C2	0.174853	0.059227	0.057691	0.113008	0.112054	0.127008	0.135245	0.082401	0.087296	0.215658	0.116
C3	0.107359	0.04955	0.068958	0.073726	0.13655	0.108041	0.128125	0.0918	0.153515	0.105265	0.102
C4	0.054988	0.115859	0.08831	0.058147	0.152139	0.137169	0.187718	0.14005	0.109748	0.122156	0.117
C5	0.075261	0.100291	0.124533	0.129473	0.068326	0.066141	0.099954	0.130651	0.100843	0.086565	0.098
C6	0.119844	0.10187	0.097767	0.094327	0.059302	0.076205	0.104288	0.060559	0.084644	0.099836	0.090
C7	0.098335	0.134812	0.122898	0.179092	0.112054	0.130395	0.060947	0.103079	0.079623	0.069674	0.109
C8	0.11218	0.098711	0.111865	0.12844	0.130274	0.069818	0.099954	0.070495	0.152851	0.091736	0.107
C9	0.090053	0.071937	0.141287	0.08554	0.096003	0.086752	0.065049	0.144436	0.074602	0.079929	0.094
C10	0.06978	0.18821	0.106961	0.104664	0.083509	0.108041	0.059864	0.095291	0.087865	0.067865	0.097

Appendix 3.4 – Lamda Calculations

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	Lambda
C1	0.070083	0.156368	0.118266	0.067361	0.071559	0.106639	0.105351	0.122881	0.08655	0.087824	14.167
C2	0.125883	0.116444	0.085576	0.226666	0.161054	0.149774	0.242078	0.124641	0.109479	0.308896	14.174
C3	0.077292	0.097419	0.102289	0.147877	0.196262	0.127407	0.229334	0.138859	0.192524	0.150776	14.274
C4	0.039588	0.227787	0.130995	0.116628	0.218667	0.161756	0.336	0.211843	0.137636	0.174969	15.055
C5	0.054183	0.197179	0.184726	0.259692	0.098204	0.077996	0.178909	0.197625	0.126468	0.12399	15.264
C6	0.08628	0.200284	0.145023	0.189197	0.085235	0.089864	0.186667	0.091602	0.106152	0.142999	14.726
C7	0.070795	0.265049	0.182302	0.359215	0.161054	0.153768	0.109091	0.15592	0.099856	0.099797	15.188
C8	0.080762	0.194074	0.165936	0.257619	0.187242	0.082333	0.178909	0.106632	0.191692	0.131397	14.785
C9	0.064832	0.141433	0.209579	0.171573	0.137984	0.102303	0.116433	0.218478	0.093559	0.114486	14.650
C10	0.050237	0.370033	0.158662	0.209931	0.120027	0.127407	0.107152	0.14414	0.110192	0.097205	15.380

Appendix 3.5 – Lamda max and CI, CR Calculations

Lambda max	15.37971
CI	0.52959
CR	0.35543

QFD Process

Appendix 3.6 – Initial Table – Technical Capabilities

	Wieght	Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness	Sum of Average
C4	**11.7%**	3	3	4	4	4	2	3	2	3	4	**32**
C2	**11.6%**	3	3	4	3	3	4	3	3	3	3	**32**
C7	**10.9%**	3	5	6	4	3	4	3	3	5	2	**38**
C8	**10.7%**	4	6	5	4	5	5	7	5	5	2	**48**
C3	**10.2%**	5	5	5	8	4	5	4	3	4	4	**47**
C5	**9.8%**	3	4	5	3	4	2	4	3	4	4	**36**
C10	**9.7%**	5	5	5	3	3	3	4	3	5	3	**39**
C9	**9.4%**	4	4	4	4	5	3	5	4	5	4	**42**
Total	**84%**	**30**	**35**	**38**	**33**	**31**	**28**	**33**	**26**	**34**	**26**	

Appendix 3.7 –Technical Capabilities According to the priority

	Wieght	Activity Tracking	Navigation	Mobile support	Adapted & Intuitive GUI	Report	Scheduling	Forum	Automated feedback	Platform independent	Content awareness	Sum of Average
C4	**12%**	4	3	3	3	4	4	3	2	2	4	**32**
C2	**12%**	4	3	3	3	3	3	3	4	3	3	**32**
C7	**11%**	6	5	5	3	4	3	3	4	3	2	**38**
C8	**11%**	5	6	5	7	4	5	4	5	5	2	**48**
C3	**10%**	5	5	4	4	8	4	5	5	3	4	**47**
C5	**10%**	5	4	4	4	3	4	3	2	3	4	**36**
C10	**10%**	5	5	5	4	3	3	5	3	3	3	**39**
C9	**9%**	4	4	5	5	4	5	4	3	4	4	**42**
Total	**84%**	**38**	**35**	**34**	**33**	**33**	**31**	**30**	**28**	**26**	**26**	

Appendix 3. 8– Justifications Values

0	0
0.0-1.99	1
2-0-3.99	3
4.0-5.99	5
6.0-7.99	7
8.0-9.00	9

Appendix 3.9 –Justified Technical Capabilities Table

	Wieght	Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness	Sum of Average
C4	**11.7%**	3	3	5	5	5	3	3	3	3	5	**38**
C2	**11.6%**	3	3	5	3	3	5	3	3	3	3	**34**
C7	**10.9%**	3	5	7	5	3	5	3	3	5	3	**42**
C8	**10.7%**	5	7	5	5	5	5	7	5	5	3	**52**
C3	**10.2%**	5	5	5	9	5	5	5	3	5	5	**52**
C5	**9.8%**	3	5	5	3	5	3	5	3	5	5	**42**
C10	**9.7%**	5	5	5	3	3	3	5	3	5	3	**40**
C9	**9.4%**	5	5	5	5	5	3	5	5	5	5	**48**
Total	**84%**	**32**	**38**	**42**	**38**	**34**	**32**	**36**	**28**	**36**	**32**	

Appendix 3.10 –Technical Capabilities ILTC Calculations

	Wieght	Forum	Navigation	Activity Tracking	Report	Scheduling	Automated feedback	Adapted & Intuitive GUI	Platform independent	Mobile support	Content awareness
C4	**11.7%**	0.351	0.351	0.585	0.585	0.585	0.351	0.351	0.351	0.351	0.585
C2	**11.6%**	0.348	0.348	0.58	0.348	0.348	0.58	0.348	0.348	0.348	0.348
C7	**10.9%**	0.327	0.545	0.763	0.545	0.327	0.545	0.327	0.327	0.545	0.327
C8	**10.7%**	0.535	0.749	0.535	0.535	0.535	0.535	0.749	0.535	0.535	0.321
C3	**10.2%**	0.51	0.51	0.51	0.918	0.51	0.51	0.51	0.306	0.51	0.51
C5	**9.8%**	0.294	0.49	0.49	0.294	0.49	0.294	0.49	0.294	0.49	0.49
C10	**9.7%**	0.485	0.485	0.485	0.291	0.291	0.291	0.485	0.291	0.485	0.291
C9	**9.4%**	0.47	0.47	0.47	0.47	0.47	0.282	0.47	0.47	0.47	0.47
Total	**84%**	**3.32**	**3.948**	**4.418**	**3.986**	**3.556**	**3.388**	**3.73**	**2.922**	**3.734**	**3.342**
		0.37	0.44	0.49	0.44	0.40	0.38	0.41	0.32	0.41	0.37