International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-11 Issue-12, November 2022

A Sustainable Model for Deployment of M-Learning in Kenyan Universities

Stanley Mogaka, Jairus Odawa, Collins Odoyo

Abstract: ***Institutions of higher learning around the world are considering the use of technology as alternative methods of instruction. Mobile learning technologies and wireless networks are becoming increasingly popular tools of facilitating learning in higher education institutions. Mobile learning (or m-learning) has the ability to connect learners to information anytime and anywhere. While some studies have explored the challenges and the issues of implementing this technology, a majority have focused on acceptance alone. However, little research has been conducted to comprehend factors for sustainable deployment of m-learning in higher education. This study was conducted with the intention of identifying the factors that affect the deployment of m-learning, in order to propose and evaluate a sustainable model for mobile learning deployment in university education. Objective: The main objective of the study was to develop a deployment model for use of m-learning in HEI in Kenya. Another objective was to find out the factors that affect deployment of HEI. Methodology: The study adopted a mixed method of research design where both qualitative and quantitative approaches were used. The study was A survey was conducted with a total of 148 students and 28 lecturers. The findings of this study indicate that a conceptual framework and model clearly delineating pre and post-deployment processes can provide a roadmap for sustainable deployment of m-learning. Furthermore, Education Organization and schools can use the model for blending mobile learning with traditional learning using a planned approach to improve education and learning.***

Keywords: Mobile learning, M-learning, E-learning, Mobile technology, M-learning school, M-learning sustainability, M-learning deployment model.

I. INTRODUCTION

Learning is a process by which knowledge and skills are acquired through teaching and training. Today two methods of facilitating the transfer of knowledge are the conventional education and mobile learning. Owing to the rapid growth of education and the ever-changing needs traditional instruction methods are unable to meet the current learning needs. Fortunately, the proliferation of the internet and the ever-increasing mobile phone ownership present people with the opportunity to facilitate learning process.

Manuscript received on 29 October 2022 | Revised Manuscript received on 08 November 2022 | Manuscript Accepted on 15 November 2022 | Manuscript published on 30 November 2022.

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However, despite the obvious benefits that are associated with new mobile learning technologies. Kenyan universities are yet to realize the full potential of m-learning as a tool for enhancing learning and training [1]. Nevertheless m-learning is largely regarded as the next frontier of e-learning and distance learning all of which promote learning anytime and anywhere. To promote high engagement and learning experiences among students in higher education, the use of hand-held devices creates a flexible and convenient platform through which students and lecturers collaborate while in constant communication [2], [3] and collaboration among students leading to high engagement and learning experiences. To achieve this, there is therefore need for deployment of a sustainable model for m-learning in higher learning institutions. The deployment of mobile technology to support learning is gaining a lot of traction and acceptance worldwide due to affordability of mobile devices to learners like Self-study [4]; [5]. Resources such as course materials can easily be accessed by learners anywhere, anytime through the use of the mobile devices [6]. Affordability, convenience, scalability, ease of updating learning content and the ability to enable learners to personalize instruction are some of the overarching factors that have led to acceptance and adoption of m-learning [7],[8],[9]. Developed countries are increasingly deploying mobile devices such as laptops, smartphones, and tablets to support teaching and learning anywhere anytime [10] in a fast-changing world. The adoption and implementation of m-learning in HEIs has been necessitated by prolonged closure of educational institutions. In their study, [10] show that m-learning has been widely and successfully deployed in many developed countries. According to [11] majority of African Universities lack adequate physical facilities like lecture rooms for provision of a better learning and teaching environment. Additionally, universities adopt a face-to-face lecture method of instruction. Although this method has been used for many years, it continues to face numerous challenges in the delivery of curriculum in higher education institutions. According to International Telecommunications Union [12], mobile phone subscription and ownership is estimated at 7 billion globally. Of this, approximately 1.1 billion people in Africa, 80%, own a cellular phone [13]. According to the 2018/2019 Quarter 1(Q1) sector statistics report by the Communications Authority of Kenya (CA) on mobile phone ownership, mobile phone penetration in Kenya stands at 91% of Kenya's population while annual growth rate is estimated at 20%. Majority of students in HEI possess a mobile phone [14] making it the closest technology students can access.

This has given rise to challenges and opportunities to HEI's in terms of sustainable deployment [14] and adoption as a learning and teaching tool among learners and educators.

Use of mobile devices to facilitate learning in post-secondary institutions is in its infancy and therefore many key concerns should be addressed in order to avoid challenges that may affect successful and sustainable implementation and use of these emerging mobile technologies [15] . Although mobile learning in educational institutions is a concept that has been investigated widely by scholars, a majority of studies have largely been done in Asian and European countries [16]. [17]in their investigation of the use of mobile learning in higher learning institutions opine that a few researchers have conducted related reviews with focus on post-secondary institutions. Limited studies on mobile-centered learning have also holistically explored critical elements that may sustain it and designed models and implementation frameworks for its sustainability in learning [18].

Existing models and frameworks on use of mobile devices to extend learning are based on countries [19] thus insufficient in addressing the needs of learners and trainers in developing countries [19]. Sustainability of mobile mediated learning requires a scientific understanding of obstacles and a fair understanding of shared knowledge in order to meet the long-term goal of mobile learning sustainability in HEIs. Previously developed frameworks for adoption and use of mobile devices to facilitate learning can form a basis upon which to construct a sustainable deployment model for m-learning in developing countries.

1.1 Statement of the problem

There is limited research on the theoretical approach that can guide sustainable m-learning deployment in HEIs in Kenya. Factors that may foster sustainable implementation of m-learning in HEIs have not been well understood. While existing models provide a starting point, majority only focus on usage, acceptance and adoption but fail to address sustainable deployment of mobile technology to guarantee successful and continued use in Kenyan Universities. Further there is lack of accountability on sustainability elements that can ensure effective implementation, supervision and monitoring of m-learning technologies post-implementation in Kenyan HEIs. To realize mobile-centric learning in Kenyan HEIs, it is fundamental to develop and evaluate a model that outlines key elements for successful implementation and sustainability elements after implementation. While gains have been made towards implementation of mobile learning, successful deployment of sustainable mobile learning in higher educational institutions in Kenya is still a challenge. This has necessitated the continued use of conventional teaching and learning methods. However, some of these traditional approaches to teaching such as face-to-face learning have proven untenable considering the rapid change of societal needs. Research has established that these traditional methods offer low level engagement between lecturers and learners owing to their unidirectional communication that do not support deep learning. In addition, the ever-changing learning and social environments have demonstrated that there is the need to adopt m-learning technologies. However, limited research exists on theoretical approaches necessary for the development of a sustainable m-learning in higher education institutions (HEIs) in Kenya. Additionally, there is lack of a definitive account on sustainability factors to guarantee effective implementation, supervision and monitoring of m-learning technologies post-implementation in Kenyan HEIs. To realize mobile-centric learning in Kenyan HEIs, it is fundamental to develop and evaluate a model that outlines key elements for successful implementation and sustainability elements after implementation.

1.2 Research Background

Table; Review acceptance of mobile learning models

Table 1: Mobile learning models and frameworks (source: (Hsu & Ching, 2015))

Category (number of articles)	Year	Author	Article Title (hyperlinked)	Proposed Framework/Model
Pedagogies and Learning Environment Design (6)	2009	Koole	A model for framing mobile learning	The Framework for the Rational Analysis of Mobile Education (FRAME)
	2009	Peng, Su, Chou, & Tsai	Ubiquitous knowledge construction: Mobile learning re-defined and a conceptual framework	The Conceptual Framework of Ubiquitous Knowledge Construction
	2011	Park	A pedagogical framework for mobile learning: Categorizing educational applications of mobile technologies into four types	A Pedagogical Framework for Mobile Learning in Distance Education
	2012	Schmitz, Klemke, & Specht	Effects of mobile gaming patterns on learning outcomes: A literature review	A Framework of Analysis of Design Patterns for Mobile Learning Games
	2013	Abdullah, Hussin, Asra, &Zakaria	Mlearning scaffolding model for undergraduate English language learning: Bridging formal and informal learning	Mlearning Scaffolding Five-stage Model

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	2013	Ng & Nicholas	A framework for sustainable mobile learning in schools	A Person-centered Sustainable Model for Mobile Learning
Platform/System Design (5)	2006	Taylor, Sharples, O'Malley, Vavoula, &Waycott	Towards a task model for mobile learning: A dialectical approach	Task Model for Mobile Learning
	2007	Motiwalla	Mobile learning: A framework and evaluation	An M-Learning Framework (for designing applications for collaborative learning)
	2007	Parsons, Ryu, &Cranshaw	A design requirements framework for mobile learning environments	A Framework for M-Learning Design Requirements
	2007	Uden	Activity theory for designing mobile learning	Using Activity Theory as a Framework for Designing Mobile Learning
	2007	Zurita& Nussbaum	A conceptual framework based on activity theory for mobile CSCL	The MCSCL Framework (based on Engestrom's Expanded Activity Theory Model)

A review of the previously developed models identifies key elements useful for the development of an initial model for sustainable m-learning in universities, including device aspect, device usability, learner aspect, social aspect [20]. Others include leadership and management, stake holder requirements, expert and stakeholder support, efficiency, implementation cost, rules and policies, good infrastructure, training, trust and confidence, collaborative learning, assessment of achievement, quality of service, attitude change [15], coordination, communication, device manufacturers, system designers, communication infrastructure and support staff [21]. Clearly, one needs to explore numerous models and frameworks when designing a sustainable model for easy acceptance and deployment of m-learning in higher institutions of learning. The table below summarizes the difference between models previously development and the frameworks in order to develop a model based on key success factors.

Table 2: mobile learning models

Model	Main focus	Gap
FRAME model	Pedagogy, mobile device, learners	Theoretical gap, lack of deployment and sustainability factors
A Person-Centred framework for sustainable mobile learning in schools	Pedagogy and leadership	Lack of sustainability elements. Focused on the human element
A sustainable model for deployment of mobile learning in schools.	Deployment of mobile learning	Theoretical gap, Small sample size used to develop the model, participants did not use m-learning before the research, Lack of e-waste management and ethical use of mobile devices, security of mobile devices and digital data and interoperability with other learning management systems
Proposed theoretical model for m-learning in developing countries.	Mobile learning environment, critical success factors, adoption	Lack of deployment and sustainability factors.

Source: research data (2022)

In their research, [19] note that the existing models on m-learning have focused on acceptance. However, no models are available to guide the effective deployment of m-learning. According to [21], no clear research is available to ensure a successful deployment of m-learning. Therefore, it is important to establish a model and evaluate it in order to investigate its potential success prior to its deployment. [22] postulates ten elements that can sustain technology in education: management, funds, skill development, technical support, assessment, technology adoption, electronic content development and management, uniform access to technology, connectivity and communication. With the rapid spread of e-learning systems, studies on its sustainability have been conducted worldwide [22]. However, few studies have been conducted on mobile-mediated learning sustainability. Studies on mobile learning post that some requirements are necessary for HEIs in order to sustain its use [22] like change of institutional culture, desire to adopt new technology, changeover period determination, budget for infrastructure, student needs, change of pedagogy, preparation of learning environment, motivating learners to participate in mobile learning and communication techniques. [22] observe that critical success factors for technology adoption should be well understood for sustainability of mobile mediated learning. Research studies on adoption have identified factors like interactivity, ease-of-use, motivation and collaboration, social influence, performance expectancy, self-efficacy and perceived enjoyment [22]. A study by [23] on critical success factors for developing applications for mobile learning identified elements such as characteristics of mobile devices like usability, reliability, efficiency, maintenance needs, and functionality features and student needs. To ensure sustainability, it is fundamental to understand limitations and challenges that can affect mobile educational environments [22].

[24] identified limitations for mobile devices like software portability, hardware compatibility and network limitations that need to be addressed as shown in table 3.

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Table 3: classification of limitations based on four mobile device types (Papanikolaou & Mavromoustakos, 2006)

Mobile device constraints	Mobile phone	PDA	Palm	Laptop
Small screen	H	M	L	L
Small malfunctioning keypads	H	M/H	M	L
Limited computational power	H	M	L	L
Limited memory	H	M	L	L
Limited battery life	H	H	H	H
Non-volatile capacity	H	H	M/H	L
Low display resolution	H	H	L	L
Unfriendly user interface	H	M/H	L	L
Graphical limitations	H	M	L	L
Complicated text input mechanisms	H	M/H	L	L
Limited security	H	H	M	M
Limited bandwidth	H	H	H	H
Low connection stability	H	H	H	H

KEY: H-High, M-medium, L-Low

There is limited understanding on the quality of service constraints like usability, functionality, reliability, efficiency, maintainability and portability in relation to various mobile devices like mobile phones, tablets, palm tops and laptops. Relative comparison is important in selecting devices that can sustain mobile learning in educational environments. Comparable studies on mobile device limitations need to be done in order to produce knowledge that can enable device developers make mobile devices that can sustain mobile learning. [22] created a developmental sustainability framework that identified 18 factors under seven themes as shown in figure 1 below.

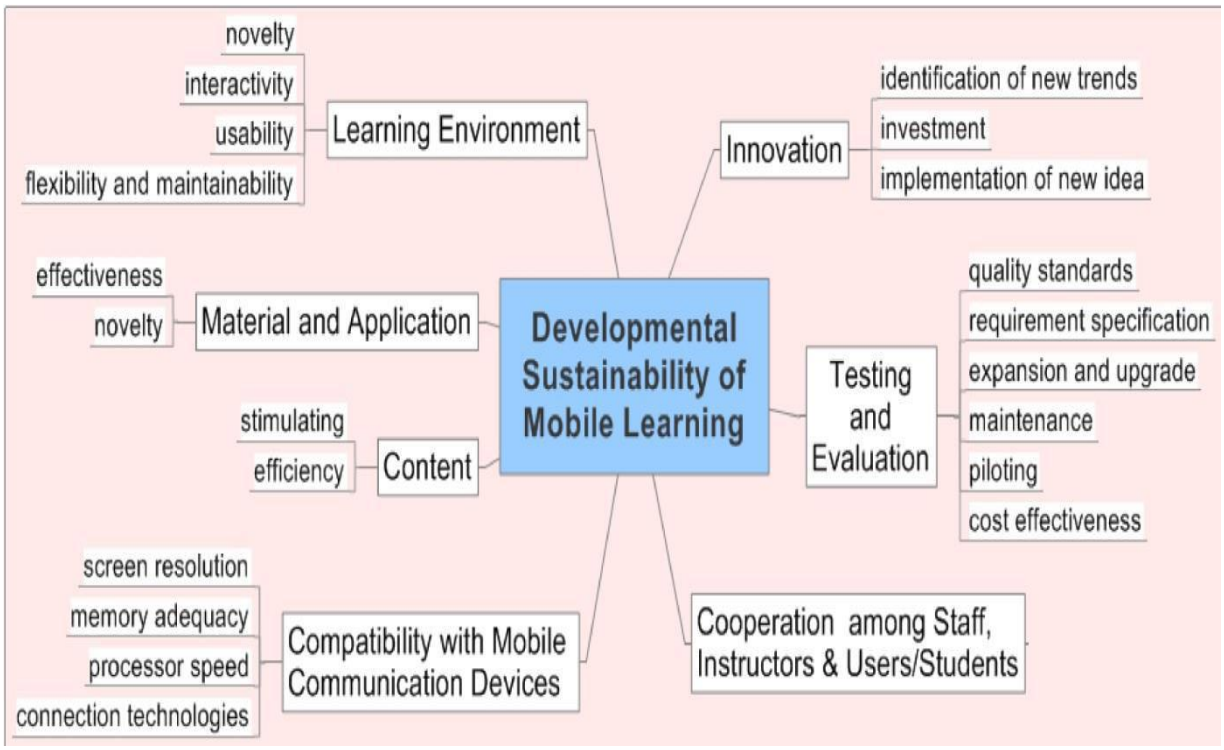

Figure 1: developmental sustainability of mobile learning (Setirek & Tanrikulu, 2015)

There is need to understand other dimensions of sustainability like technological dimension, environmental dimension, organizational dimension and psychological dimension. A study titled "readiness roles and responsibilities of stakeholders on mobile learning" [25] in Nigeria identified internal stakeholders to m-learning and elements that may sustain m-learning. Lecturers, government, learners, institutional administration and IT personnel were the key stakeholders that needed to play critical roles for sustainable implementation. Key activities for m-learning sustainability [25] include awareness, capacity building, pedagogical design, policy development, execution and commitment and review and regular checking.

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Table 4: Summary of mobile technology sustainability components

Component	Characteristics	References
Technological factors	Mobile device type, mobile device features, delivery options, transport options, good infrastructure	(Baker A. et al., 2005)
Economic factors	Financial constraints, implementation cost	(Alavi et al., 2018; Okai-Ugbaje et al., 2020)
Pedagogical factors	Collaboration, user and device interaction, communication	(Koole, 2009; Ng & Nicholas, 2013; Sophonhiranrak & Promsaka Na Sakonnakron, 2017)
Device limitations	Memory size, battery life, screen size, processing power, usability challenges	(Papanikolaou & Mavromoustakos, 2006; Sophonhiranrak & Promsaka Na Sakonnakron, 2017)
Security	Digital content protection, security of mobile devices, trust and confidence	(Alavi et al., 2018)
User readiness	Lecturer and learner readiness, Training, attitude, self-efficacy	(Al-Emran et al., 2016; Alavi et al., 2018; Sophonhiranrak & Promsaka Na Sakonnakron, 2017; Yorganci, 2017)
m-learning policies	Lecturer and learner training support, essential rules for m-learning	(Alavi et al., 2018; Ghasia et al., 2018; Okai-Ugbaje et al., 2020)
Leadership and management	Vision, delegating, consulting	(Ghasia et al., 2018; Ng & Nicholas, 2013; Okai-Ugbaje et al., 2020)

Source: research data (2022)

Therefore, it is necessary to explore available frameworks and models in order to design a stable and sustainable model for acceptance and deployment of m-learning in Universities in Kenya. The above table summarizes the differences between previous models of m-learning based in the approaches used to establish the model and the elements of the model as well as the assessment and validation of the model for sustainability.

1.3 Research purpose and importance

To a successful deployment of m-learning, it is necessary to construct and evaluate a sustainable model for effective deployment of m-learning and ensure its viability post-deployment. The primary purpose of this research is to construct a model for sustainable deployment of m-learning in Kenyan universities. The secondary aim is to review key success factors needed to enable implementation of m-learning. The proposed model will provide a framework for identifying the challenges and how they can be overcome to realize proper deployment and harnessing of benefits of m-learning in Kenyan universities.

II. RESEARCH METHODOLOGY

Quantitative and qualitative research methods will be used in this study. Quantitative research technique involves measurement of quantity. It is suitable for phenomenon that can be quantified [26]. Quantitative data will be processed using quantitative techniques. Qualitative technique is suitable for phenomenon that involves quality, attitude, perception or opinion [26]. Research objective two on challenges of mobile learning in universities and objective three on elements that may sustain mobile learning deployment will be analyzed using qualitative and quantitative techniques. This study therefore will employ a mixed methods approach. Mixed method encompasses more than one type of research method that may include a mix of quantitative and qualitative methods and this will help in triangulation of collected data or elaboration of quantitative data by qualitative means.

Theoretical model for m-learning in developing countries

[21] proposed a theoretical model for mobile learning in developing countries as shown in figure 2.4. The model identified nine critical success factors, m-learning environment consisting of communication infrastructure, learning institution, m-learning policies and guidelines and stakeholders such as device vendors, system designers, parents, learners, teachers and support staff.

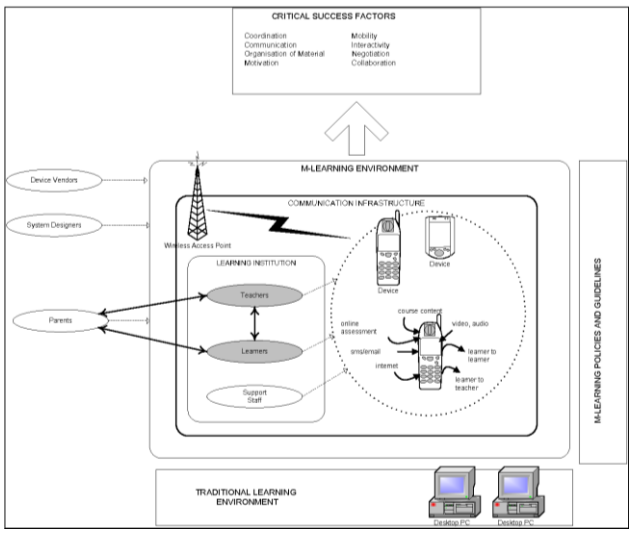

Figure 2: Proposed theoretical model for m-learning in developing countries (Baker A. et al., 2005)

The model outlines key elements for mobile learning adoption but failed to outline deployment and sustainability components like training, awareness, cost of implementation and evaluation that are important for deployment and sustainability as noted by [15].

2.1 Research design

The study adopted the deductive research approach. Deductive approach was employed because the study reviewed existing literature in mobile learning, identified existing gaps, and created hypotheses that guided the establishment of a sustainable deployment model for mobile learning in Kenyan universities. Design science research (DSR) methodology was applied in developing the sustainable mobile technology mediated learning model for universities.

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DSR is a research paradigm that is applied in solving problems that involve human elements leading to production of artifacts such as models, concepts and frameworks.
A sustainable mobile learning deployment model is an artifact that was developed in this research. DSR methodology involves identification of a research problem, objectives, design and development of artifacts, demonstration, evaluation and communication.
According to [27], an artifact is a "coherent human-made entity that constitutes an interface between its inner workings and the elements of its environment" [17] and may consist of constructs, models, frameworks, architectures, design principles, methods and instantiations. In the current research, a sustainable mobile learning deployment model in HEIs was developed. In DSR, a specific real-world problem is addressed by a researcher and the development of a sustainable model for mobile technology mediated learning in HEIs may be considered a real-world problem.

2.2 The Study Population

The target population is the collection of cases in which the researcher is ultimately interested in, and to which they wish to make generalization. The accessible population is the portion of the target population that is accessible to the researcher for the purposes of a specific study [28]. The respondents were selected from departmental heads of the universities, undergraduate students enrolled in the digital school program and lecturers of two Kenyan Universities. The target population in Kenyatta University was 4000 students enrolled in online study program and 1000 students in Gretsa University enrolled in online study program. 80 lecturers teaching online programs in Kenyatta University were targeted for the study and 20 lecturers from Gretsa University. 18 chairs of departments were also targeted for the study, 15 from Kenyatta University and 4 from Gretsa University.

Table 5: Frequency of teachers based on gender, teaching experience, and education grade and their level of familiarity with m-learning.

	Category	Frequency	Percentage %
Gender of the respondent	Male	219	64.1%
	Female	124	35.9%
Age of the respondent	18-30 years	272	79.3%
	31-40 years	60	17.4%
	41-50 years	9	2.5%
	Above 50 Years	2	0.7%
Year of study of the respondent	Year 1	34	9.8%
	Year 2	109	31.9%
	Year 3	36	10.5%
	Year 4	145	42.4%
	Year 5	19	5.4%
The environment where you normally conduct your learning activities is generally?	Within University	116	33.7%
	Outside University	68	19.9%
	Both within and outside university	159	46.4%

The male and female student respondents were 219 and 124 respectively which correspond to 64.1% and 35.9% respectively.

2.21. Demographic characteristics of KU lecturers

The male and female lecturers who participated in the survey were 54 and 46 respectively corresponding to 53.8% and 46.2% respectively.

Table 6: demographic characteristics of KU lecturers

	Category	Frequency	Percentage %
Gender of the respondent	Male	54	53.8%
	Female	46	46.2%
Age of the respondent	30 and below years	3	2.5%
	31-40 years	20	20.0%
	41-50 years	28	28.8%
	51-60 years	49	48.8%
	60 and above years	0	0.0%
Teaching experience of the respondent	1 year	2	2.5%
	2 years	8	7.5%
	3 years	0	0.0%
	4 years	14	13.8%
	Above 5 years	76	76.2%
Academic qualification of the respondent	Tutorial Fellow	3	2.5%
	Lecturer	28	27.5%
	Senior lecturer	62	62.5%
	Associate Prof	0	0.0%
	Professor	7	7.5%
	Others	0	0.0%

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2.22. Demographic characteristics of GU lecturers

The male and female lecturers from GU who participated in the survey were 13 and 7 respectively corresponding to 65.0% and 35.0% respectively.

Table 7: demographic characteristics of GU lecturers

	Category	Frequency	Percentage %
Gender of the respondent	Male	13	65.0%
	Female	7	35.0%
Age of the respondent	30 and below years	0	0.0%
	31-40 years	9	45.0%
	41-50 years	5	25.0%
	51-60 years	6	30.0%
	60 and above years	0	0.0%
Teaching experience of the respondent	1 year	0	0.0%
	2 years	7	35.0%
	3 years	2	10.0%
	4 years	1	5.0%
	Above 5 years	10	50.0%
Academic qualification of the respondent	Tutorial Fellow	6	30.0%
	Lecturer	6	30.0%
	Senior lecturer	7	35.0%
	Associate Prof	0	0.0%
	Professor	1	5.0%
	Others	0	0.0%

Source: research data (2022)

2.3 Area of Study

The study employed a survey of two Kenyan universities offering distance learning programs to their students, a key characteristic for the researcher in studying existing frameworks, perception of learners and lecturers and existing challenges in order to develop a sustainable mobile mediated learning deployment model for Universities.

2.4 Sample size

It is not practical or economical to consider the entire population in a research study [29]. Purposive sampling was used to select two universities: Kenyatta University and Gretsa University as they contained m-learning system for their students and therefore were suitable in studying key success factors for m-learning sustainability. Simple random sampling was used to select respondents from the study population in Kenyatta University and Gretsa University. Krejcie & Morgan formula on sample determination was used to determine the sample size.

Formula for determining sample size

$$s = X^2NP(1-P) \div d^2(N-1) + X^2P(1-P)$$

s = required sample size.

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N = the population size.

P = the population proportion (assumed to be .50 since this would provide the maximum sample size).

d = the degree of accuracy expressed as a proportion (.05).

Source: Krejcie & Morgan, 1970

Random sampling enabled in selection of respondents or research participants who had the characteristics the researcher was interested in. The sample was selected from students who are currently enrolled in electronic learning using computers or mobile phones and lecturers of two Kenyan Universities that was sampled for the study. The margin of error was set at 10% which means the confidence level was 90%.

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Table 8: constructs for measuring deployment and sustainability of m-learning

Measure	Description
Deployment factors	Student and lecturer awareness and training
Readiness factors	Learner readiness, lecturer readiness, financial readiness
Mobile technological factors	Mobile device technical features, usability and learning content
Sustainability factors	Security, efficiency, effectiveness, coexistence, freedom of action and adaptability

Source: research data (2022)

The institutional factors, user readiness factors, mobile technological factors and m-learning sustainability factors were used to develop the model for deployment and sustainable implementation of m-learning in HEIs.

III. RESULTS OF PROPOSED MODEL EVALUATION

Table 9: shows the Cronbach's alpha and correlation for a set of items of each model component.

Cronbach's alpha coefficients

Construct	Number of items	Cronbach's alpha coefficient
Awareness	6	0.76
Training	4	0.74
Learner readiness	11	0.81
Financial readiness	6	0.78
Mobile device infrastructure	4	0.89
Learning content	4	0.77
Device ownership	6	0.74
Internet connectivity	5	0.76
Device constraints	4	0.82
Mobile device usability	4	0.75
Electronic waste	3	0.79
Security	6	0.74
Coexistence	3	0.78
Adaptability	4	0.85
Existence	4	0.84
Effectiveness	3	0.72
Freedom of action	3	0.86

Source: research data (2022)

Table 10: squared multiple correlations

Indicators	weight
Awareness	0.308
Training	0.159
Lecturer readiness	0.232
Student readiness	0.239
Infrastructure readiness	0.294
m-learning policy	0.377
Financial readiness	0.114
Mobile learning content	0.012
Pedagogical factors	0.330
Platform factors	0.213
Network factors	0.275
Electronic waste	0.175
Interoperability	0.246
Security	0.782
Effectiveness	0.235
Adaptability	0.351
Freedom of action	0.258
existence	0.403

These indicators were grouped into four domains – institutional factors, user-readiness factors, mobile technological factors and m-learning sustainability factors. The sustainability constructs were adapted from orient or theory. Squared multiple correlation (r-squared correlation values) were measured. The measures aided the interpretation of the fraction of variance that accounted for by each predictor variable. Table 5.1 shows the squared multiple correlation weight for all the predictor variables of the study.

3.1. Hypotheses Testing and Test for Normality

One sample t-test was used for testing the hypotheses. All the three hypotheses hold that the respective factors (institutional, readiness, mobile technological and mobile learning factors) have significant effect on mobile learning sustainability. However, before the test was run, it was necessary to test the normality of the data. Table 3.8 shows the results of the normality tests performed using Kolmogorov-Smirnov Test and Shapiro-Wilk Test.

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The above statistics for Shapiro-Wilk Test shows that the data is normally distributed since the statistical significance is greater than 0.05 (p>0.05).

Table 11: Test of normality for all variables

Tests of Normality							
	Gender	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Readiness factors	Male	.095	29	.200*	.983	29	.915
	Female	.143	21	.200*	.927	21	.118
Technological factors	Male	.107	29	.200*	.975	29	.711
	Female	.107	21	.200*	.983	21	.964
Institutional Factors	Male	.097	29	.200*	.967	29	.490
	Female	.136	21	.200*	.952	21	.370
Sustainability factors	Male	.089	29	.200*	.945	29	.133
	Female	.096	21	.200*	.985	21	.980

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Source: research data (2022)

The proposed deployment model for sustainable implementation of mobile learning in universities is discussed in this section. It provides HEIs with key elements for deploying and sustaining mobile learning. Figure 3 outlines key elements and associated correlation weights (variance accounted for by each construct). In order to deploy mobile learning and sustain it over time, awareness factors should be considered because the significance level of 0.308 shows that there exists a relationship between awareness and sustainability of mobile learning. Training factor has a significance level of 0.308 which means that it is important to conduct regular training to students and lecturers to guarantee sustainability. On readiness of learners and lecturers, lecturer readiness had a significance weight of 0.232, student readiness had a significance weight of 0.239, infrastructure readiness had a significance level of 0.294, financial readiness had a weight of 0.114, pedagogical factors had a significance value of 0.330, and mobile learning content had a significant weight of 0.012. The statistics therefore show that the readiness factor has a positive effect on sustainable implementation of mobile learning in universities. Mobile technical factors such as platform factors, network connectivity factors, and electronic waste management were also found to be significant in sustaining mobile learning. Platform factors that include availability of hardware infrastructure, usability of mobile devices, software applications were found to be significant in deployment and sustainable implementation of mobile learning. In general platform factors had a significant level of 0.213, network connectivity had a significant level 0f 0.275 and electronic waste disposal had a significant level of 0.175. M-learning sustainability factors that include: interoperability, security, effectiveness, adaptability, freedom of action and existence had significance levels of 0.246, 0.782, 0.235, 0.351, 0.258, and 0.403 respectively.

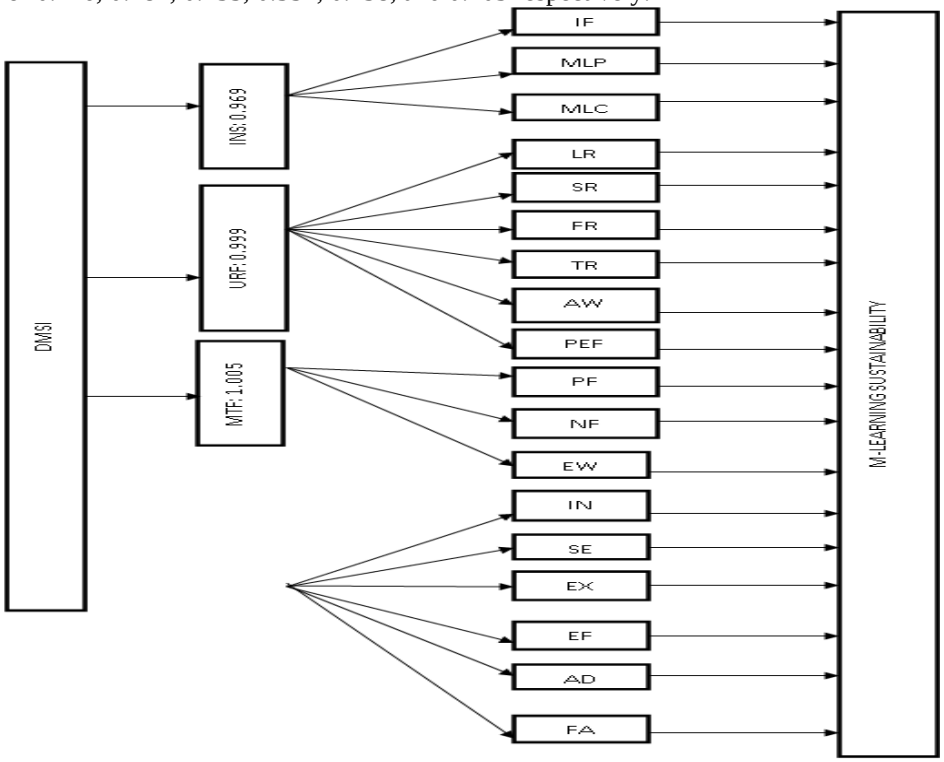

Figure 3: proposed m-learning sustainability model

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1.2 Chi-square test for independence of variables

The Chi-square test for independence was carried out to test the relationship between two variables. In this case, the statistics were done on the assumption of the two variables for independence. The tests were to show if there was an association between m-learning sustainability and the institutional factors, user readiness factors, mobile technological factors and m-learning sustainability factors. The results are shown below.

1.2.1 M-learning sustainability and institutional factors

Table 12: Chi-Square test for m-learning sustainability and institutional factors

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3731.335[a]	1892	.000
Likelihood Ratio	888.680	1892	1.000
Linear-by-Linear Association	104.958	1	.000
N of Valid Cases	343		
a. 2001 cells (100.0%) have expected count less than 5. The minimum expected count is .00.			

Source: research data (2022)

Table 12: shows Chi-square results of institutional factors and sustainability factors Chi-square (2) =3731.335, $p < 0.05$ which tells us that there is a statistically significant association between institutional factors and sustainability factors.

1.2.2 M-learning sustainability and user readiness factors

Table 13: Chi-Square test for user readiness factors

chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4146.784[a]	2838	.000
Likelihood Ratio	1225.551	2838	1.000
Linear-by-Linear Association	106.970	1	.000
N of Valid Cases	343		
a. 2958 cells (100.0%) have expected count less than 5. The minimum expected count is .00.			

Source: research data (2022)

Table 4.41 shows Chi-square results of institutional factors and sustainability factors Chi-square (2) =4146.784, $p < 0.05$ which tells us that there is a statistically significant association between user readiness factors and sustainability factors.

1.2.3 M-learning sustainability and mobile technological factors

Table 14: Chi-Square test for technological factors

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4639.516[a]	2838	.000
Likelihood Ratio	1193.231	2838	1.000
Linear-by-Linear Association	170.256	1	.000
N of Valid Cases	343		
a. 2958 cells (100.0%) have expected count less than 5. The minimum expected count is .00.			

Source: research data (2022)

Table 4.42 shows Chi-square results of technological factors and sustainability factors Chi-square (2) =4639.516, $p < 0.05$ which tells us that there is a statistically significant association between user readiness factors and sustainability factors.

1.2.4 M-learning sustainability and m-learning sustainability factors

Table 15: Chi-Square test for m-learning sustainability factors

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5927.335[a]	3526	.000
Likelihood Ratio	1231.658	3526	1.000
Linear-by-Linear Association	171.383	1	.000
N of Valid Cases	343		
a. 3654 cells (100.0%) have expected count less than 5. The minimum expected count is .00.			

Source: research data (2022)

Table 4.42 shows Chi-square results of technological factors and sustainability factors Chi-square (2) =4639.516, $p < 0.05$ which tells us that there is a statistically significant association between user readiness factors and sustainability factors.

Table 4.45 shows the regression model statistical output. The value of regression equation in the unstandardized coefficients are used to measure since they use natural units.

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Table 15: Model coefficients

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.582	1.925		1.861	.064
	Institutional factors	.969	.030	.252	31.922	.000
	Readiness factors	.999	.016	.447	62.449	.000
	Technological factors	1.005	.023	.366	44.366	.000
	Sustainability factors	.973	.016	.474	62.171	.000

a. Dependent Variable: M-learning sustainability

1.3 Evaluation and validation of the proposed model

Evaluation and validation is grounded by the assessment process steps of the Design Science Research Methodology. It justifies the purpose of the study and affirms validity of the proposed model. The proposed deployment model for sustainable implementation of m-learning in HEIs was underpinned on theories, models and frameworks from the disciplines of ecology, learning and information technology. They include: Orientor theory, Theory of Connectivism, FRAME, Person-centred framework for sustainable mobile learning in schools, a sustainable model for deployment of mobile learning in schools and a proposed model for deployment of m-learning in developing countries.

1.3.1 Model variables

The proposed deployment model for sustainable implementation of m-learning has four variables. These are institutional factors, user readiness factors, mobile technological factors and m-learning sustainability factors.

Institutional factors variable addresses; m-learning infrastructure readiness, mobile learning content and m-learning policy.

User readiness factors variable addresses; student readiness for m-learning, lecturer readiness for m-learning, financial readiness for m-learning, m-learning awareness, training and pedagogical factors.

Mobile technological factors variable addresses; software and hardware platform factors, mobile network factors and electronic waste disposal.

M-learning sustainability factors variable addresses; interoperability of m-learning with other learning management systems, effectiveness of m-learning, adaptability of m-learning, existence, freedom of action and security.

1.3.2 Validation of the proposed model

The concept of validation is closely related to triangulation and consists of member validation or member checks. This means research contributors decide whether the researcher's interpretation of meaning is in agreement with their own. The technique is used to check on bias and quality of research. The current study adopted the expert validation technique to validate the proposed model. A total of 10 experts (4 lecturers, 2 content developers, 2 ICT directors and 2 network administrators) participated in the model validation. A Likert scale questionnaire covering the four domains of the model (institutional factors, user-readiness factors, mobile technological factors and m-learning sustainability factors) was constructed and used to seek the views of the experts. The expert's levels of agreement were measured on a nominal five-point Likert scale of strongly disagree (1), disagree (2), neutral (3), agree (4) and strongly agree (5).

The findings on the validity of the proposed model show that the experts agreed with all the variables of the proposed model having a significant influence on m-learning sustainability. Table 5.3 gives a summary of each variable, frequency of experts that agreed and strongly agreed on the factors significant influence on m-learning sustainability, mean and standard deviation.

IV. CONCLUSION

The main objective of the study was to propose a sustainable deployment model for mobile learning in Kenyan Universities. The study findings show that institutional factors, user readiness factors, mobile technological factors and m-learning sustainability factors are key elements that should be put into consideration when introducing emerging technologies as enablers in a learning process in institutions of higher learning. The findings show that smart phones are the closest technology owned by learners (77.6%) followed by laptops (54.1%) and tablets (54.1%). Institutional factors that were found to be significant for mobile learning sustainability are infrastructure readiness (0.294), mobile learning content (0.012), and m-learning policy (0.377). User readiness factors that were significant include: awareness (0.308), training of learners and lecturers (0.159), lecturer readiness (0.232), student readiness (0.239) and pedagogical factors (0.330). The mobile technological factors that were found to be significant in sustaining mobile learning are electronic waste (0.175), network connectivity (0.275) and platform factors such as display size, memory size, portability, battery life (0.213). Sustainability factors that were significant include: interoperability (0.246), security (0.782), effectiveness (0.235), adaptability (0.351), freedom of action (0.258) and existence (0.403). From the focus group discussions, the findings show that learners are ready for mobile-centric learning however the main limitation that was pointed out is the poor network issue experienced by majority of learners, distractions like text messages during the learning process and expensive data bundles for internet connectivity. The implication is that for sustainability of mobile learning, the mobile network concern should be addressed by relevant stake holders with a view to improving the connectivity in areas with poor network connectivity.

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Another finding from the study is lack of mobile learning policy in institutions of higher learning. It is therefore important for learning institutions to develop mobile learning policy on the training of lecturers and students, mobile phone infrastructure support, communication and interaction support and mobile learning content support.

RECOMMENDATIONS

The main purpose of the research was to propose a sustainable deployment model for sustainable implementation of mobile-centric learning in higher learning institutions and give a contribution to the limited knowledge on sustainable deployment of mobile learning in HEIs. The study findings propose a number of recommendations that can facilitate sustainable deployment of mobile centered learning in higher learning institutions.

a) Universities should develop mobile learning policy that should address training of learners and lecturers, mobile infrastructure support, mobile phone communication and interaction, mobile learning content support.
b) Device manufacturers should design mobile devices that are waterproof and screens that are not fragile. Other technical obstacles such as network connectivity, small screen, and limited memory size should be addressed in order to ensure sustainable deployment.
c) Universities should conduct continuous training to lecturers and learners on usability of mobile devices for learning and teaching.
d) There is need to set up mobile infrastructure network in areas without connectivity to support learners residing in such areas.
e) There is need to train learners and lecturers on e-waste disposal in order to limit environmental effects of E-waste that can affect future learners. The analysis show that the respondents do not have knowledge on E-waste disposal. The statistics further indicated that respondents lack knowledge on negative effects of E-waste on the environment.
f) Universities should provide learners with free internet connectivity to enable all learners' access internet on their mobile devices. The statistics from the study show that learners find it expensive to access internet on their mobile devices.
g) Universities should set up Wi-Fi hotspots with high bandwidth to enable learners' access internet on their mobile devices with high connectivity speed.

FUTURE RESEARCH

The proposed model provides a starting point in sustainable deployment of mobile centric learning in higher learning institutions in third world countries. This study being a case study of two universities, there is a need to conduct surveys for similar studies in selected universities so that the findings can be generalized.

Future studies should focus on other m-learning frameworks and models that the current study did not explore.

The present study did not include other key stakeholders and therefore future studies can include device manufacturers, mobile phone technicians, support staff, content developers and parents of learners.

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