EFFECT OF INFORMATION INFRASTRUCTURE ON PERFORMANCE OF LEARNING MANAGEMENT SYSTEMS OF SELECTED TERTIARY INSTITUTIONS IN KIAMBU COUNTY, KENYA

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Abstract: **Digital inclusion ensured that all students, regardless of their socioeconomic background, physical abilities, or geographical location, had equal access to educational resources and opportunities. However, until now, there were no accurate, consistent Learning Management Systems (LMS) to ensure smooth digital learning. A significant number of students in tertiary institutions in Kiambu County found it difficult to access information and perform well due to challenges faced while using online tools. These challenges stemmed from poor and weak technological infrastructure, lack of user satisfaction, inadequate user training and support, and improper data security. Therefore, this study sought to investigate the effect of information technology infrastructure on the performance learning management systems of selected tertiary institutions in Kiambu County, Kenya. The target population comprised ICT specialists employed by the 26 tertiary institutions, with a sample size of 75 ICT specialists selected through simple random sampling from the selected institutions. Primary data was gathered through questionnaires. Descriptive and inferential statistics was employed to analyse data where descriptive statistics was presented using mean, median, standard deviation, and percentages and inferential statistics was presented using regression to establish the relationship between the study variables. The study revealed that information technology infrastructure is the most significant predictor of learning management performance, with a strong positive relationship indicated by a coefficient of 1.344 and a p-value of 0.000. In conclusion, institutions must prioritize investments in technology infrastructure and data security to enhance LMS performance and foster user trust. The study recommends that institutions focus on modernizing IT infrastructure, implementing robust data security measures, and designing user-friendly LMS platforms.**

Keywords: **Information Infrastructure, Learning Management Systems, Performance.**

1. INTRODUCTION

Digital Inclusion gained prominence in 2002 when Massachusetts Institute of Technology (MIT) published 50 courses online, after which United Nations Educational, Scientific and Cultural Organization (UNESCO) launched the "open courseware" which aims to provide education for all humans. MIT was able to publicize 2150 courses in 2012 which recorded massive 127 million views. Ever since then, digital inclusion has been recognized as a force to reckon with (Adarkwah, 2021). Muftahu (2020) asserted that Tertiary Institutions in Africa are faced with critical challenges impeding the online tools such as availability of IT infrastructures (laptops, phones), lack of user satisfaction in terms of adequate internet connection and resources alongside users' skills and data security Mwalumbwe and Mtebe (2017), over the past decade, there has been a rapid uptake of various Learning Management Systems (LMS) across Africa, notably in Tanzania.

Adarkwah (2020) did his research in Ghana, educational institutions have invested substantial resources to implement these systems, aiming to enhance the quality of education and increase student enrolments through distance and blended learning approaches. However, the effectiveness of these systems in improving student performance has become a focal point of research interest in recent years.

Prior studies have predominantly relied on user opinions and subjective interpretations gathered through surveys to assess the impact of LMS usage on student learning outcomes. However, such data collection methods are susceptible to biases and low reliability (Adarkwah, 2021). Therefore, this study was designed to develop a Learning Analytics tool to objectively examine the relationship between LMS usage and student performance.

Utilizing data extracted from the LMS logs of two courses offered at Mbeya University of Science and Technology (MUST), the study employed linear regression analysis to analyse the correlation between LMS activities and students' final results. The findings indicated that factors such as participation in discussions, peer interactions, and completion of exercises significantly contributed to students' academic achievement in blended learning environments at MUST. Conversely, variables such as time spent in the LMS, number of downloads, and frequency of logins were found to have significant impact on student learning outcomes.

In today's digital age, proficiency in digital skills is essential for students to succeed in their academic pursuits and future careers. Digital inclusion helps equip students with the necessary skills and competencies.

Furthermore, embracing new technologies such as cloud computing, machine learning, robotic process automation, and blockchain is crucial to ensure the effectiveness and efficiency of learning institutions. A learning management system is a software application or web-based technology utilized to plan, implement, and assess specific learning processes, particularly in e-learning contexts. Typically, it comprises two main elements: a server that performs core functionality and a user interface accessible to instructors, students, and administrators.

The primary focus of this study was to explore the relationship between digital inclusion and its impact on learning management systems performance, moderated by factors including ICT infrastructure, user satisfaction mechanisms, user training and support, and data security among tertiary institutions in Kiambu County, Kenya.

Zhu, Kraemer and Xu (2006), the Technology-Organization-Environment (TOE) framework is a widely recognized model used in research to understand the factors influencing technology adoption and implementation within organizations. It was originally proposed by Tornatzky and Fleischer in their seminal work "The Processes of Technological Innovation" (1990). The framework has since been refined and extended by various scholars in the field of technology adoption and innovation management.

Ngari and Ndung'u, (2020) in their study also observed the unavailability of IT infrastructure such as computers and phones needed to foster digital inclusion in Tertiary Institutions. Power outage which leads to poor user satisfaction due to unavailability of students to charge their laptops and phones also contributed to lack of digital inclusion effectiveness (Abdullahi, Sirajo, Saidu, & Bello, 2020). Ngari and Ndung'u, (2020) in their study also observed the unavailability of IT infrastructure such as computers and smart phones needed to effectively enhance Digital inclusion in Tertiary Institutions in Kenya. In order for Tertiary Institutions to full utilize online tools for effective digital inclusion System, certain measures and policies pertaining to IT infrastructure, user satisfaction, and user training and support and data security must be put in place.

The government of Kenya is still required to make investments in the ICT sector at the universities and all tertiary level, investments on high-speed networks and installation of a large number of computers need to be implemented. Users may have limited experience, lack of skills, user satisfaction low education leads to low income which leads to low user satisfaction, or lack of willingness to use ICT resources.

Carmi and Yates (2020, digital inclusion is the use of information technology and its capabilities such as internet, Learning Management System (LMS) and other digital means to provide learning options. Zetian, Jun, Daoliang, Xiaoshuan and Lingxian (2007) described digital inclusion as the medium through which course contents and knowledge-based content are transferred to a group of audience through internet, satellite, tapes and other electronic means. Salih and Taniwall (2020), Issues and Challenges of Digital inclusion Similarly, technological awareness and benefits of online tools among students and their lecturers encourages the effective digital learning in public institutions Grand-Clement, S. (2017). In addition, availability of IT infrastructure such as computers and other electronic gadgets makes the electronic learning effective (Salim & Taniwall, 2020).

The Learning Management System (LMS) has been implemented in numerous universities globally to facilitate interaction between students and instructors beyond the limitations of traditional classroom settings. The advent of information technology (IT) has revolutionized competitive dynamics and spurred the emergence of numerous new business ventures. Dulkaman and Ali (2016), IT systems enable firms to enhance operational efficiency, offer innovative services, foster closer collaboration with partners, and even restructure value chains within their respective industries. Given that LMS (IS) now permeate virtually all business operations across industries and higher learning institutions, their scope and effectiveness have expanded significantly. Consequently, the importance of Information System planning has emerged as a prominent managerial concern and a subject of academic inquiry.

Ma and Cheng (2022) highlighted that the increasing adoption of interactive digital inclusion methods and LMS in corporate training institutions promote the performance of tertiary students and employees. In developed economies, the widespread use of robust interactive digital inclusion has been shown to importantly boost student performance. Dapal, Entico, Lontok and Magdalena (2022), note that technology has eliminated geographical constraints, enabling students to learn at any time and from any location without the need for direct interaction with instructors. Digital learning provides convenient access to effective education. Kasim and Khalid (2016), Learning Management Systems encompass a variety of platforms, including learning systems, course management systems, content management systems, portals, and instructional management systems. They signify an advancement from the processes and systems initially designed by institutions to enrol students in specific courses and maintain records of their activities. Various learning options have emerged to facilitate online course participation, sometimes integrated into the formal curriculum and other times pursued for institutional certification purposes. Kasim and Khalid (2016), some popular LMSES used by educational institutions include Moodle, Anthology's Blackboard Learn and power school's Schoology Learning.

In Kiambu County, a variety of Learning Management Systems (LMS) are employed across tertiary institutions, reflecting diverse functionalities and needs. Common LMS types include open source LMS such as Moodle used in Kenyatta university, favoured for its flexibility and customization, and the open-source version of Canvas, which offers user-friendly interfaces and integration capabilities. Commercial LMS options like Blackboard provide comprehensive features including course management and assessment tools, while Microsoft Teams for Education integrates with Office 365 to enhance collaboration. Cloud-based LMS such as Google Classroom and Edmodo are popular for their ease of use and support for remote learning, with Google Classroom being particularly valued for its simplicity and integration with Google Workspace. Additionally, some institutions use proprietary systems tailored to specific needs or a hybrid approach, combining multiple LMS platforms to address various requirements, such as using Moodle for course management and Google Classroom for communication and assignments.

2. STATEMENT OF THE PROBLEM

The researcher noted that there are many challenges, involving the faculty, students, and ICT officers which affect overall performance of students and institution at large. The challenges includes; Insufficient IT infrastructure, lack of user satisfaction, lack of technical support, and concerns about data security, unprepared institutions, and faculty members with limited IT skills. Ahmad, Mohd Noor, Alwan, Gulzar, Khan and Reegu (2023) identifies that recent challenges in achieving digital inclusion in higher education involve compatibility issues, financial constraints, technological hurdles, self-confidence barriers, difficulties in pedagogical learning, socioeconomic changes, digital proficiency concerns, and a deficiency in technological infrastructure.

Digital inclusion will allow greater access to more students, more efficiently, and thus better LMS performance. The evaluation results of the tertiary institutions show that much good can be done toward ensuring that digital learning programs are accessible, equitable, and sustainable over the long term. If the government can assist the higher learning institutions and to implement digital inclusion method skills gap, corruption, lack of autonomy, inefficient project management, resistance to change, lack of clear performance metrics, limited ICT officers' engagement, and data security and privacy concerns (Kiminza & Were, 2016).

Bari, Djouab and Hoa (2018) explains that; digital inclusion in higher education has many advantages which include its flexibility, access to larger audience, effectiveness and increased research quality and efficiency and less financial aid among others (Barfi, Arkorful & Abaidoo, 2021). The Commission of University Education (CUE) in Kenya on November 2017 stated that there were 30 public sponsored universities alongside six integral colleges, 18 private sponsored universities with five integral colleges, and 14 universities functioning with letters of provisional appointment (CUE, 2017).

Notwithstanding, this number of institutions do not have the capacity to accommodate the increasing demand for learning as the institutions are not equipped to meet the need to bridging the educational access gap.

Institutions in Kenya have embraced digital inclusion in order to reach larger range of audience and also to improve education and learning efficiency. This however is not devoid of certain challenges limiting its full Digital Inclusion especially in Tertiary Institutions which include social, infrastructural and organizational factors (Kibuku, Ochieng & Wausi, 2020). In accordance with the acceptance of information technology tools, there has been an increasing need to analyse the limiting factors that influences the Digital Inclusion in higher education (Alkharang, 2014).

3. LITERATURE REVIEW

Theoretical Literature Review

Technological- Organization- Environment Theory

Baker (2012) The Theory of Economic and Organizational (TOE) framework is a comprehensive model for understanding the adoption and implementation of technological innovations within organizations. In the context of tertiary institutions, TOE can be particularly useful for analysing digital inclusion and Learning Management System (LMS) performance. Ahmed (2020) this framework helps to identify the factors influencing how educational institutions integrate and leverage technology, especially LMS platforms, to enhance learning experiences and achieve educational objectives. The TOE framework comprises three primary contexts as stated by Malik, Chadhar, Vatanasakdakul and Chetty (2021). Technological Context, this involves the technologies available to an organization and the current technological infrastructure. Organizational Context, which includes the organization's characteristics, such as size, structure, and resources. Environmental Context which pertains to the external factors affecting the organization, including industry trends, regulatory requirements, and competitive pressures.

In the context of tertiary institutions, digital inclusion is crucial for ensuring that all students, faculty, and staff can fully participate in and benefit from digital learning tools and resources, the TOE framework can shed light on how different contexts are impactful in digital inclusion efforts: Souza, Siqueira and Reinhard (2017) stated that under organizational Context it involves institutional policies, where policies and practices within an institution play a significant role in promoting digital inclusion. Institutions with clear guidelines on technology use, training programs, and support services are more likely to address digital disparities. Whereas in Environmental Context, external partnerships in collaborations with technology providers, government agencies, and community organizations can enhance digital inclusion efforts by providing additional resources and support (Aneke, Bakht & Desta, 2019).

Empirical Literature Review

Nyagorme (2014) conducted a research study in relating Digital inclusion in Kenyatta University, Kenya and University of Cape Coast, Ghana. The research embraced the use of descriptive survey research method which involves both quantitative and qualitative methods of data collection. The research made use of questionnaires to obtain data from all ICT officers, IT support staff, top management members and the distance learning students excluding their fresher. Thirty-three study centres (33) in ten (10) regions of University of Cape Coast, Ghana and the Open Distant Learning Centre of Kenyatta University were the target population. The research utilized the use of quota sampling for determining the various regions for selection and stratified sampling method to determine the various specific study centres employed. The research revealed that in both universities which were made use of in the study, Digital inclusion was really low at University of Cape Coast, Ghana and Kenyatta University while a negative behavior was observed among lecturers of Kenyatta University. The investigation contributed to the digital inclusion and utilization in two different countries.

Makokha and Mutisya (2016) examined the status of digital inclusion or e-learning in public universities in Kenya. Questionnaires were distributed to both the students and lecturers of seven (7) different public institutions in Kenya using random sampling method to obtain primary data. The analysis of the data gathered was done using qualitative statistics such as Standard package for Social Sciences (SPSS) and Microsoft Excel and descriptive statistics such as graphs, tables and charts. Asides from the use of questionnaires to obtain data, Focused group discussions (FGD) and in-depth interviews was also made use of. The study obtained secondary data from libraries and various internet sources. The study utilized a multi-stage sampling technique to select the various schools, departments, lecturers and students used for the study. The study then concluded that majority of the universities in Kenya used for the study lacked adequate information about ICT infrastructure and the skills obtainable. The use of E-learning has not been really embraced by majority of the Tertiary Institutions.

Pashutan and Harandi (2022) examined the impact of IT resources' strategic alignment on organizational performance. Questionnaires were administered to 75 CEOs and 75 IT managers in organizations using random sampling. The data were analysed through Structural Equation Modelling, revealing a significant influence of strategic alignment and information technology on organizational performance.

Hong and Zimmer (2016, Elaborates the quality of distance education programs in universities focus of attention on campus-based learning often goes unobserved. This is because these distance education programs are clear cut from the majority of offerings and their learners remain strategically and reasonably almost invisible. Exploring the challenges faced by staff in creating high-quality learning experiences for distance education students could tar the way for the development of quality standards for distance education. The study addressed some of these issues and offer recommendations to assist traditional, campus-focused institutions in better supporting their evolving distance education programs and ensuring their quality.

Zhang (2009) investigated the impact of IT infrastructure integration and flexibility on supply chain capabilities and organizational performance in the electronics industry in Taiwan. The survey of IT managers from 100 organizations indicated that integrated and flexible IT infrastructures positively affect supply chain capabilities and overall performance. Although the study recommended investing in IT infrastructure integration and flexibility, it acknowledged limitations related to its industry-specific focus, suggesting potential variations if applied to other sectors.

4. RESEARCH METHODOLOGY

Descriptive research design was suitable for this research study because it explained the characteristics of the variables and the answers with respect to who, what, when and where of the research questions (Turale, 2020). The target population comprised ICT specialists employed by the 26 tertiary institutions, with a sample size of 75 ICT specialists selected through simple random sampling from the selected institutions. Primary data was gathered through questionnaires. Descriptive and inferential statistics was employed to analyse data where descriptive statistics was presented using mean, median, standard deviation, and percentages and inferential statistics was presented using regression to establish the relationship between the study variables

5. FINDINGS

The descriptive statistics results on IT infrastructure are presented in Table 1.

Table 1: IT Infrastructure

Statement	Mean	Standard Deviation
Advanced hardware components are readily available	3.6543	0.5643
The organization has up-to-date software applications for efficient and smooth work activities	4.0123	0.4345
Availability of network components increases educational stakeholders' intention to promote LMS performance	3.9122	0.5432
Generative AI inclusion will have an impact on virtual learning in Tertiary Institutions in Kenya	3.7124	0.4765
Improvement towards the provision of IT infrastructure aids users' attitudes towards e-learning and promotes LMS performance	3.8123	0.4987
Aggregate Score	**3.8207**	**.5034**

The results, as presented in Table 1, indicate that the availability of up-to-date software applications achieved the highest mean score of 4.0123 with a standard deviation of 0.4345, demonstrating consensus among respondents regarding its importance in enhancing work efficiency. The availability of network components and its influence on stakeholder engagement scored a mean of 3.9122 and a standard deviation of 0.5432, highlighting moderate agreement. Generative AI's potential impact on virtual learning scored 3.7124, with a standard deviation of 0.4765, reflecting cautious optimism. The provision of advanced hardware and improvements in IT infrastructure both scored relatively high means of 3.6543 and 3.8123, respectively, with low standard deviations, indicating consistent responses. The aggregate mean score of 3.8207 and a standard deviation of 0.5034 suggest a generally positive perception of IT infrastructure's role in supporting LMS performance.

The discussion of these findings underscores the necessity for robust IT infrastructure to achieve enhanced LMS performance in tertiary institutions. The high ratings for software and network availability reflect the essential role of these elements in facilitating digital learning environments. However, the results also highlight gaps in fully leveraging generative AI and advanced hardware, pointing to opportunities for improvement. These findings align with previous studies, such as those by Makokha and Mutisya (2021), who noted limited ICT infrastructure awareness in Kenyan universities, and Zhang et al., (2020) who emphasized the impact of integrated IT infrastructure on organizational performance. The current study adds to the discourse by emphasizing digital inclusion and generative AI as pivotal in shaping the future of tertiary education in Kenya.

Inferential Statistics Results:

Table 2: Correlation Analysis

		IT Infrastructure	LMS Performance Assessment
IT Infrastructure	Pearson Correlation	1	
	Sig. (2-tailed)		
LMS Performance Assessment	Pearson Correlation	.514**	1
	Sig. (2-tailed)	.000	

The correlation analysis revealed significant relationships among the variables. IT infrastructure showed a strong positive correlation with LMS performance assessment at 0.514, indicating that strong infrastructure is critical for effective LMS operations

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.848[a]	.720	.700	1.62631

The model summary in Table 3 shows an R value of 0.848, indicating a strong positive correlation between the predictors and LMS performance. The R^2 value of 0.720 implies that 72% of the variance in LMS performance is explained by the IT infrastructure. After adjusting for the number of predictors, the Adjusted R^2 remains high at 0.700, indicating the model's robustness. The standard error of the estimate (1.62631) represents the average distance that the observed values fall from the regression line.

Table 4: Analysis of Variance

Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	86.512	1	86.512	125.793	.003[b]
1	Residual	41.264	60	0.6877		
	Total	537.677	61			

Table 4 presents the ANOVA results, where the F-statistic of 125.793 is significant at p=0.003. This indicates that the overall model is statistically significant, meaning the independent variable collectively have a significant effect on LMS performance assessment

Table 5: Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	14.229	4.260		3.340	.001
IT infrastructure	1.344	.154	.647	8.716	.000

The regression coefficients indicate that IT infrastructure is a significant predictor of LMS performance, with p-values of 0.000. This suggests that enhancing IT infrastructure measures substantially contribute to LMS effectiveness. The coefficient for IT infrastructure (β = 1.344) highlights its strong positive impact, aligning with prior studies that emphasize

the role of reliable and scalable digital infrastructure in improving LMS adoption and functionality. For instance, studies by Zhang et al. (2009) revealed that integrated IT infrastructure positively affects organizational performance, a finding echoed in the context of LMS performance in this study.

6. CONCLUSIONS

The results clearly indicate that institutions that invest in strong IT infrastructure tend to have better-performing LMS platforms. As digital education becomes more widespread, the need for reliable and efficient technological resources is critical for the smooth functioning of LMS systems. This underscores the importance of continuous investment in IT infrastructure to support the evolving needs of digital learning environments.

7. RECOMMENDATIONS

Institutions should prioritize investments in modern and reliable IT infrastructure, including high-speed internet, state-of-the-art hardware, and updated software systems. Regular upgrades and maintenance should be planned to ensure that the LMS runs efficiently. This will enhance the user experience by reducing technical issues and increasing system availability, which is essential for both faculty and students. Given the importance of data security, it is essential that institutions implement and regularly update robust security protocols. These measures should include encryption technologies, secure login systems, and regular cybersecurity audits. Additionally, staff and students should be trained in best practices for online security to further mitigate risks and protect sensitive data.

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