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A Framework for Enhancing Maintainability of CMS in Kenyan Universities' LMS

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ABSTRACT: The maintainability of Content Management Systems (CMS) within Learning Management Systems (LMS) is critical in educational institutions to ensure efficient content management, system scalability, and security. This paper presents a framework aimed at enhancing the maintainability of CMS within LMS in Kenyan universities. The research utilizes Cognitive Load Theory and Software Evaluation Theory to address CMS challenges, focusing on perfective, corrective, adaptive, and preventive maintenance. This paper also discusses key factors influencing CMS maintainability, including system documentation, modularity, and error handling. Findings from this study contribute to the development of a framework and advancing CMS design in LMS, providing a robust, scalable, and secure platform for educators and administrators.

KEYWORDS: Maintainability, Content Management Systems (CMS), Learning Management Systems (LMS), Cognitive Load Theory, Software Evaluation Theory, Scalability, Usability.

I. INTRODUCTION

In the dynamic landscape of education, a Learning Management System (LMS) is defined as a software application designed to streamline the management, monitoring, and reporting of educational or training activities (Alia, 2022). LMS has revolutionized the way knowledge is imparted and received, providing a centralized platform for educational institutions to manage their courses, track student progress, and facilitate learning. The LMS serves as a comprehensive solution for educators to deliver content, assess learning, and engage students through various interactive tools (Bradley, 2021). The importance of LMS lies in its ability to support the evolving needs of modern education, ensuring that learning is accessible, scalable, and adaptable to various contexts (Greenberg & Leonard, 2002).

LMS is utilized in various ways within educational institutions to facilitate learning and administrative processes. It is used to deliver online courses, host virtual classrooms, manage assignments, and provide resources such as lecture notes, videos, and quizzes. The system also supports communication between students and instructors through forums, messaging, and announcements. In Kenyan universities, LMS is instrumental in managing e-learning programs, tracking student progress, and providing feedback, thus enabling a seamless learning experience for both students and educators aspects (Simpson & Doug, 2005).

The study draws on several theoretical frameworks to enhance the maintainability of CMS within LMS. Cognitive Load Theory is employed to understand how information is processed and retained by users, which is crucial in designing user-friendly CMS interfaces. Software Evaluation Theory guides the assessment of the CMS's performance, focusing on aspects such as modularity, reusability, and testability, which are essential for maintainability (Rahime & Feza, 2024).

Existing literature reflects a growing interest in the integration and effectiveness of CMS within LMS, particularly in educational contexts. Studies have highlighted the challenges associated with the maintainability of CMS, including issues related to system stability, scalability, and user experience. Research has also shown that while LMS adoption is widespread, there is a need for a more focused approach to ensuring the long-term sustainability of these systems (Al-Fawaz, 2019), particularly in the context of Kenyan universities.

The successful operation of an LMS heavily relies on the robustness and maintainability of the underlying Content Management System (CMS). CMS serves as the backbone for creating, managing, and delivering digital content within the LMS. It allows educators to easily update and modify course content without needing extensive technical expertise. The CMS facilitates the seamless integration of various multimedia resources, ensuring that the LMS remains

dynamic and responsive to the needs of both educators and students (Veluvali & Surisetti, 2022).

Recent trends in the development of CMS focus on enhancing user experience, improving scalability, and integrating advanced technologies such as artificial intelligence and machine learning. There is a growing emphasis on creating CMS platforms that are more adaptable, allowing for easier customization and integration with other educational technologies. The development of open-source CMS solutions has also gained traction, providing institutions with more flexibility and control over their content management processes (Delgado & Delgado, 2007).

The technologies currently in place for developing CMS include a range of programming languages such as HTML5, PHP, JavaScript, and MySQL, which form the foundation of most CMS platforms. Additionally, there is an increasing use of cloud-based technologies, enabling more scalable and accessible CMS solutions. Advanced database management systems, content delivery networks (CDNs), and AI-powered analytics tools are also being integrated into CMS to enhance performance, security, and user engagement aspects (Simpson & Doug, 2005).

In Kenyan universities, the CMS within LMS plays a crucial role in supporting the delivery of educational content and managing the learning process. The integration of CMS in LMS has enabled universities to offer more flexible and accessible learning opportunities, particularly in the context of distance education and e-learning initiatives (Kannadhasan, Shanmuganantham, & Nagarajan, 2020). However, the unique challenges faced by Kenyan universities, such as too much customization, security vulnerabilities, and complexities highlight the need for a tailored approach to CMS maintainability.

Research on maintainability has primarily focused on the technical aspects of software engineering, including system stability and modularity. Studies have explored the limited resources and technological infrastructure of software systems, particularly in complex digital ecosystems like those found in universities. There has been a growing interest in developing frameworks that address the specific challenges of maintaining CMS within LMS, with an emphasis on scalability and user experience (Nishtar & Rahman, 2006).

Despite the extensive research on LMS and CMS, there remains a noticeable gap in studies specifically addressing the maintainability of CMS within LMS in the context of Kenyan universities. Most studies have focused on broader issues such as LMS implementation and user experiences, leaving a gap in the technical aspects of CMS maintainability. Additionally, there is a need for research that takes into account the unique challenges faced by Kenyan universities, including error handling and security, to develop more effective maintainability strategies.

A. Statement of the Problem:

The maintainability of Content Management Systems (CMS) within Learning Management Systems (LMS) is critical to ensuring long-term system functionality, security, and scalability (Bataieneh, Ziadeh, & Al-Qora'n, 2024). In Kenyan universities, the widespread adoption of e-learning platforms like Moodle has revolutionized the delivery of education. However, many of these systems suffer from poor maintainability due to excessive customization, lack of proper documentation, and inadequate security measures. These challenges make it difficult for IT staff to manage, update, or scale systems, leading to frequent system downtime, outdated content, and security breaches.

The problem is further exacerbated by the rapid evolution of technology, increasing the need for systems that can adapt to new requirements, user expectations, and security threats. Despite the growing reliance on LMS for both in-person and remote learning, many institutions lack a comprehensive framework to ensure effective CMS maintainability. This research paper seeks to bridge this gap by developing a framework that addresses the specific challenges faced by Kenyan universities, ensuring that their LMS platforms remain secure, scalable, and easy to maintain over time.

II. LITERATURE REVIEW

This chapter explores types of maintenance, theoretical frameworks, maintainability challenges of CMS in LMS and factors influencing maintainability of CMS in LMS.

A. Types of Maintenance

1) Perfective Maintenance:

Perfective maintenance in computer systems is a proactive approach focused on enhancing and optimizing software, hardware, or IT systems to improve their performance, usability, and efficiency. Unlike corrective maintenance, which addresses defects or issues, perfective maintenance aims to refine and extend the system's functionality based on evolving user needs, technological advancements, and changing business requirements (Chapin, Joanne, & Khaled, 2001).

This type of maintenance involves making modifications to the system's code, architecture, or design to enhance its capabilities and user experiences. Examples of perfective maintenance activities include optimizing algorithms for faster processing, improving user interfaces for better usability, and adding new features to meet expanding functionality demands.

Perfective maintenance is guided by the goal of enhancing the system's overall quality and user satisfaction (Parida, Kumar, & Galar, 2015). It involves a thorough analysis of user feedback and market trends to identify areas for improvement. By incorporating user-centric design principles and staying abreast of emerging technologies, perfective maintenance ensures that computer systems remain

relevant and competitive in dynamic environments. While perfective maintenance does not address immediate defects, it contributes to the system's long-term success and longevity. By continuously refining and enriching software and hardware, organizations can provide users with more robust, efficient, and user-friendly systems that cater to their evolving needs and preferences (Chapin, Joanne, & Khaled, 2001). This proactive approach enhances customer satisfaction, fosters innovation, and positions computer systems for sustained success in an ever-changing technological landscape.

2) Corrective maintenance:

Corrective maintenance in computer systems involves identifying, diagnosing, and rectifying defects, errors, or malfunctions that occur in software applications, hardware components, or IT systems after they have been deployed (Raza & Abrahao, 2018). The primary goal of corrective maintenance is to restore the system's intended functionality and eliminate any issues that might impact its performance, reliability, or user experience.

Corrective maintenance in systems involves a systematic and responsive approach to identifying, diagnosing, and rectifying issues, defects, or malfunctions that arise within hardware, software, or IT environments (Aliee & Oviesi, 2020). This type of maintenance focuses on restoring the intended functionality of systems, mitigating disruptions, and ensuring optimal performance. Defects can be reported by users, detected through monitoring, or arise unexpectedly. Upon issue identification, a careful analysis is undertaken to understand the root cause, often involving the examination of code, system logs, and user interactions (Aliee & Oviesi, 2020). Once the root cause is determined, developers work on implementing effective solutions to eliminate the issue and restore system integrity. Rigorous testing is a critical phase, ensuring that the fix functions as intended without introducing new problems. Communication is paramount throughout the process, providing users and stakeholders with updates on progress and resolution. Documentation captures the entire journey, from defect identification to the implemented solution, serving as a reference for future troubleshooting and knowledge sharing(Brian & Klaas, 2017). Corrective maintenance enhances system reliability, user satisfaction, and operational continuity, making it an integral aspect of effective system management.

Corrective maintenance plays a vital role in the maintainability of CMS within LMS, Regular corrective maintenance ensures that any errors, whether due to system malfunctions, software bugs, or hardware issues, are promptly addressed. This is particularly crucial in an LMS environment, where uptime and system stability are paramount for both learners and educators. Corrective maintenance not only restores functionality but also enhances the long-term maintainability of CMS by preventing the accumulation of unresolved issues, ensuring the system remains scalable, secure, and efficient for future use.

3) Adaptive Maintenance:

Adaptive Maintenance in computer systems involves making modifications to software, hardware, or IT systems to accommodate changes in external factors such as technology advancements, regulatory requirements, or evolving user needs. The primary goal of adaptive maintenance is to ensure that computer systems remain relevant, compatible, and effective in dynamic environments (Sarah, Teegan, & Adlon, 2020). This type of maintenance is essential for keeping systems up to date and aligned with the changing landscape in which they operate. In an era of rapid technological innovation, adaptive maintenance is crucial for maintaining system functionality and ensuring that CMS platforms within LMS can seamlessly integrate new tools, features, and compliance standards.

This type of maintenance is critical for Learning Management Systems (LMS), as it enables systems to adapt to new software standards, emerging technologies, and evolving user needs. CMS within LMS environments must continually evolve to meet the demands of modern education, including support for mobile learning, integration of AI-driven analytics, and compliance with data protection laws. Adaptive maintenance ensures that LMS platforms remain compatible with newer technologies, preventing system obsolescence and enhancing the overall user experience (Niels, Jorg, & Marc, 2021). As educational institutions adopt new digital strategies and tools, adaptive maintenance allows for the smooth incorporation of these changes without disrupting the learning process. Hence is essential for the maintainability of CMS in LMS. By proactively updating systems to accommodate changes in technology, user requirements, and regulatory frameworks, institutions can reduce long-term maintenance burdens. Regularly adapting to technological advances ensures that CMS platforms are scalable, secure, and optimized for future use. This forward looking approach enhances system longevity, reduces the risk of system failures due to outdated technologies, and allows LMS administrators to meet the ever changing needs of educators and learners (Alia, 2022). Ultimately, adaptive maintenance strengthens the maintainability of CMS by enabling continuous system improvements and alignment with the latest educational technologies.

4) Preventive Maintenance:

Preventive Maintenance in computer systems refers to the proactive approach of regularly inspecting, servicing, and maintaining hardware, software, and IT systems to prevent potential issues, defects, or failures before they occur (Jay, Jun, Jaskaran, & Jiang, 2020). The goal of preventive maintenance is to ensure the continued performance, reliability, and longevity of computer systems by identifying and addressing potential problems early, reducing the risk of downtime, disruptions, and costly repairs (Dirk & Mehl,

2016). Regular system updates, software patches, and performance optimizations are key activities in preventive maintenance, as they contribute to the overall health and stability of a system.

Preventive maintenance is particularly important in Learning Management Systems (LMS), where maintaining system uptime and reliability is critical for ensuring uninterrupted access to educational resources. By scheduling regular maintenance tasks such as data backups, system health checks, and updates to CMS platforms, institutions can minimize the likelihood of unexpected system failures. Keeping software up to date with the latest security patches and updates is another essential aspect of this approach, as it safeguards systems against vulnerabilities and security breaches. Additionally, preventive maintenance encompasses data backup and recovery testing to ensure data integrity, monitoring and optimizing system performance, and implementing security audits to identify and mitigate potential risks (Sarah, Teegan, & Adlon, 2020). In LMS environments, preventive maintenance ensures that students and educators can continue to access course materials and interact with the system without disruption.

By addressing potential issues before they arise, preventive maintenance enhances the system's overall stability and prolongs its lifespan. Regular preventive checks on CMS infrastructure, content storage, and system security reduce the chances of unexpected failures or malfunctions that could otherwise disrupt the learning process (Adela, Barbora, & Hind, 2022).

B. Theoretical Frameworks

1) Cognitive Load Theory:

Cognitive Load Theory (CLT) in technology pertains to the study of how information processing capacity affects learning and problem-solving in technological contexts (Martin, 2020). It posits that individuals have limited cognitive resources available for processing information, and when these resources are exceeded, learning and task performance can be compromised (Phillip, 2019). In technology, CLT informs the design and development of user interfaces, instructional materials, and training programs to optimize learning and performance. By understanding the cognitive demands imposed by technology, designers can streamline interfaces, simplify instructions, and incorporate multimedia elements to reduce cognitive load and enhance usability. Additionally, CLT guides the implementation of instructional strategies such as chunking, scaffolding, and worked examples to manage cognitive load and promote effective learning in technology-mediated environments.

In the context of Content Management Systems (CMS) within Learning Management Systems (LMS), Cognitive Load Theory pertains to how the design and organization of educational content can impact the cognitive resources required by learners during the learning process. CLT posits that individuals have limited cognitive capacity, and when instructional materials impose excessive cognitive demands, it can overwhelm learners, impeding their ability to process information effectively (Martin, 2020). In CMS within LMS, CLT influences the design of course content, user interfaces, and navigation systems to optimize learning outcomes. Additionally, the organization of content within CMS can follow principles of CLT, such as segmenting information into manageable chunks, providing clear navigation paths, and offering scaffolded learning experiences to guide learners through complex topics. By applying CLT principles, CMS in LMS aims to enhance learning experiences by minimizing cognitive overload, promoting efficient information processing, and ultimately improving knowledge retention and transfer.

2) Software Evaluation Theory:

Software evaluation theory encompasses a range of methodologies and frameworks designed to assess the quality, effectiveness, and suitability of software applications (Daniel, Stufflebeam, & Chris, 2014). This theory provides structured approaches for evaluating software based on various criteria such as functionality, usability, performance, reliability, and security. Through systematic evaluation processes, software evaluation theory helps stakeholders make informed decisions about software acquisition, adoption, and deployment. It involves the development of evaluation criteria, the selection of evaluation methods, data collection and analysis, and the interpretation of results. By applying software evaluation theory, organizations can identify strengths and weaknesses in software solutions, compare alternatives, mitigate risks, and optimize investments in software development and procurement.

Software evaluation theory in Content Management Systems (CMS) pertains to the systematic assessment and analysis of CMS platforms to determine their effectiveness, usability, and suitability for specific purposes or user groups (Nelson, Todd, & Wixom, 2022). This theory encompasses various methodologies and frameworks for evaluating CMS software, including criteria such as functionality, performance, user interface design, security, scalability, and customization capabilities. The application of software evaluation theory in CMS involves conducting comprehensive assessments of CMS platforms through techniques such as usability testing, expert reviews, surveys, and comparative analysis.

III. METHODOLOGY

The study employed a descriptive research design to identify the factors and challenges affecting their maintainability in Kenyan universities. According to (Theo, 2019) Descriptive investigations go beyond mere fact-finding; they can also contribute to the development of fundamental knowledge concepts and the resolution of significant issues. The research was conducted at Kaimosi Friends University and Masinde Muliro University of Science

and Technology**,** both of which were chosen due to their use of the Moodle LMS platform. The target population included software/web developers, ICT management staff, and other ICT technical staff involved in maintaining and managing LMS platforms. The study used purposive sampling, selecting the two universities based on their advanced implementation of LMS platforms.

Data was collected through questionnaires and interviews. The questionnaires provided quantitative data, while the interviews offered qualitative insights from ICT personnel. A pilot study was conducted at Maseno University with eight ICT staff to test the reliability and validity of the research instruments, resulting in the refinement of these tools. Quantitative data was analyzed using descriptive statistics such as mean and standard deviation, and inferential statistics were used to generalize the findings. Qualitative data was processed through thematic analysis using the ATLAS.ti tool. Ethical considerations were strictly observed, ensuring participant confidentiality and securing research permits from authorities such as NACOSTI**.** This methodology provided a solid foundation for exploring CMS maintainability challenges and proposing solutions to improve system performance in Kenyan universities.

IV. RESULTS

The study achieved a high response rate of 96.87%**,** ensuring the reliability and validity of the data. This robust participation reflects active engagement from respondents, providing a solid foundation for the analysis. Regarding demographic information, 65% of the respondents were male, while 35% were female, a typical gender distribution in ICT-related departments of Kenyan universities. The majority of respondents were in the 30-39 years' age bracket (60%**),** followed by 25% in the 40-49 years' age range, and 15% falling within the 20-29 years' category. In terms of experience, 40% respondents had 5 years and below experience. 30% of respondents had 5 to 10 years of experience working with LMS systems, while 30% had over 10 years of experience, indicating a highly experienced workforce in LMS maintenance roles.

Several challenges were identified that affect the maintainability of CMS within LMS. 45% of respondents strongly agreed, and 35% agreed, that excessive customization introduces unnecessary complexity, making the systems more difficult to maintain and understand. 80% of respondents highlighted the problems caused by incompatible upgrades, which disrupt system stability and complicate maintenance. Moreover, 55% of respondents mentioned that managing numerous plugins and extensions can create conflicts, leading to reduced system performance. Another 95% agreed that data migration during system upgrades or transitions poses a significant risk, particularly regarding the loss or corruption of essential data. Finally, 90% emphasized security vulnerabilities as a major concern, highlighting the need to manage these risks to ensure the stable and secure operation of LMS systems.

Several factors were found to strongly influence the maintainability of CMS systems. 100% of respondents agreed that comprehensive and up-to-date documentation is essential for effective CMS management, as it ensures system administrators can troubleshoot and update the system efficiently. 82% of respondents strongly agreed that modular system design improves maintainability by allowing independent updates and minimizing disruption across the entire platform. 75% of respondents emphasized scalability as a key factor, indicating that an LMS's ability to handle growing data and increasing numbers of users without performance degradation is crucial. 85% of respondents stressed the importance of robust error-handling mechanisms, noting that effective error management can significantly reduce system downtime and allow for the quick resolution of issues. Additionally, 100% of respondents agreed on the importance of regular training and proper documentation for system administrators and users. 90% of respondents highlighted the importance of system flexibility, allowing modifications without overly complicating the system's structure. Resource availability also emerged as a concern, with 50% of respondents noting that inadequate financial resources for system maintenance hinder essential updates and training.

C. Correlation analysis for factors and challenges that influence and affect maintainability.

Correlation analysis was conducted to examine the relationships between various factors influencing the maintainability of CMS in LMS. According to (Schober, Boer, & Schwarte, 2018) Correlation analysis is a statistical method used to assess the strength and direction of the relationship between two variables. It quantifies how closely the variables move in relation to one another, typically using a correlation coefficient. The key findings demonstrated that too much customization and system complexity had a moderate positive correlation with data integrity and migration ($r = .576$, $p = .020$), suggesting that excessive customization may affect the ability to manage and migrate data effectively. There was also a significant positive correlation between data integrity and migration and documentation and knowledge transfer ($r = .566$, $p = .022$), highlighting the role of proper documentation in ensuring smooth data management.

Versioning and upgrades exhibited a weak negative correlation with customization complexity ($r = -.309$) and plugins and extension management ($r = -.456$), though these were not statistically significant, indicating that excessive customization and extension management may hinder system versioning.

Other factors such as security vulnerabilities, scalability, and performance showed varying levels of correlation, with security vulnerabilities and system scalability having a weak

correlation (r = .136), underscoring the need for balanced security measures and system flexibility. The correlation between documentation and system scalability was more significant, pointing to the importance of well-documented systems for enhancing scalability and overall maintainability.

V. A FRAMEWORK FOR ENHANCING MAINTAINABILITY OF CMS IN LMS

The main objective of this study was to develop a framework to enhance the maintainability of CMS in Kenyan universities' LMS. To achieve this, the process begun by first identifying the challenges and factors affecting maintainability of CMS within LMS. The proposed framework was fully informed by the findings of the data collected, analysis of qualitative data and inferential statistics along with the literature discussed. The visual representation of this framework can be found in Figure 1.

A. Framework Formulation

The formulation of the framework named "Spinning Star Maintainability Framework (SSMF)" was informed by the research in four key ways Identification of key attributes in the literature, Theoretical Models, Empirical data, and Correlation analysis.

Identification of key attributes: Through the research, various attribute critical to the maintainability of CMS within LMS were identified. These attributes included modularity, changeability, compliance analyzability, error handling, and security these attributes were derived from the literature review, expert interviews, and surveys responses from ICT staff at the selected universities.

Incorporating Theoretical Models**:** The framework was informed by Cognitive Load Theory**,** and Software Evaluation Theory**,** which provided insights into how users process information and how software systems are assessed for functionality and maintainability. These theories helped shape the design of the framework by emphasizing on modularity, scalability and customization management.

Empirical data: The empirical data collected from the two universities provided concrete evidence of the current challenges and effective practices in maintaining CMS. This data was critical in ensuring that it addresses real-world issues faced by ICT staff responsible for maintainability in Kenyan universities emphasizing on security and error handling.

Correlation analysis: the research used correlation analysis to understand the relationships between these attributes. Significant positive correlations between the attributes informed the structure and interrelationships within the SSMF.

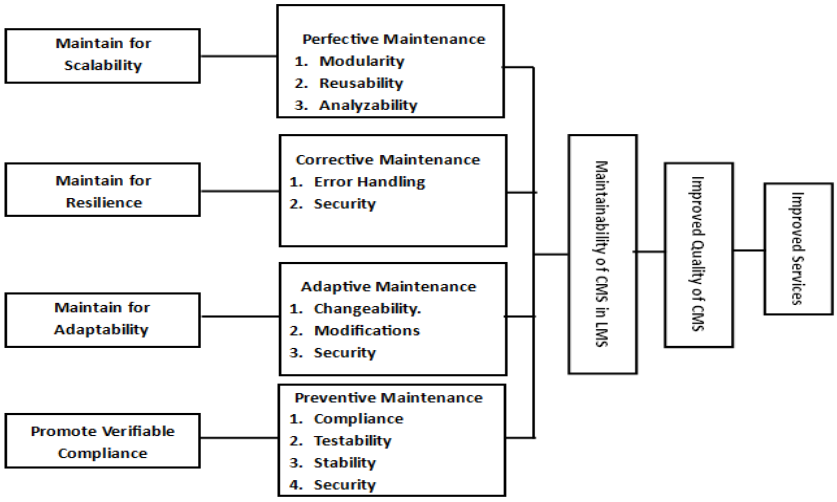

Figure 1 Spinning Star Maintainability Framework (SSMF)

B. Elements of Spinning Star Maintainability Framework

1) Maintain for Scalability, Perfective Maintenance:

This aspect of the framework focuses on enhancing the system's scalability, which means the system's ability to handle an increasing number of users or growing workloads without sacrificing performance (Weyuker & Avritzer, 2015). Perfective maintenance in this context involves activities that improve modularity, reusability, and analyzability. Modularity ensures that components can be added or removed easily, reusability allows for the utilization of existing components in different parts of the system, and analyzability involves making the code and system architecture understandable for scalability assessments.

2) Maintain for Resilience, Corrective Maintenance:

Resilience pertains to the system's ability to recover from failures or disruptions swiftly. Corrective maintenance, as part of this component, focuses on enhancing error handling mechanisms (Aliee & Oviesi, 2020). This includes identifying, addressing, and preventing errors and failures that could potentially compromise system stability and performance. Robust error handling ensures that the system can recover from unexpected issues and continue functioning effectively (Karl & Kathleen, 2015).

3) Maintain for Adaptability, Adaptive Maintenance:

Adaptability involves making the system flexible and responsive to changes (Sarah, Teegan, & Adlon, 2020). Adaptive maintenance in this context concentrates on changeability, modifications, and security. Changeability ensures that the system can be easily modified or extended to accommodate new requirements or technologies. Modifications encompass the process of making changes while preserving the system's integrity, and security focuses on maintaining the system's resistance to threats during changes and adaptations (Niels, Jorg, & Marc, 2021).

4) Promote Verifiable Compliance, Preventive Maintenance:

The objective here is to ensure that the system adheres to regulations, standards, and internal policies. Preventive maintenance activities promote system stability, testability, and compliance occur (Jay, Jun, Jaskaran, & Jiang, 2020). Stability aims to keep the system consistently operational and free from disruptions. Testability focuses on ensuring that the system can be effectively tested for compliance with regulatory and functional requirements. Compliance maintenance ensures that the system meets legal and industry standards, reducing the risk of non-compliance issues.

5) Improved Services:

Here are some anticipated improvements by the new proposed framework: Enhanced scalability, Improved resilience, Greater adaptability, Ensured compliance, Holistic perspective on maintainability, Improved user satisfaction, Enhanced operational efficiency, Facilitated decision making.

C. Framework Evaluation

Assessing the framework real-world performance was crucial to ascertain its effectiveness in solving the intended problem. The testing method followed the approach outlined by (Zacharewicz, Diallo, Ducq, Agostinho, & Jardim, 2016) for evaluating contemporary information systems and frameworks. The evaluation process commenced by identifying specific requirements and gaining a comprehensive understanding of the framework conceptual goals (Zacharewicz, et al., 2016). These objectives needed to be translated, expanded upon, and expressed as measurable metrics encompassing modularity, changeability, compliance, analyzability, error-handling and security. Drawing from (Miguel, Mauricio, & Rodríguez, 2014), an evaluation framework was suggested, spanning from a strategic perspective down to operational levels.

Following the provided framework, a survey was formulated, encompassing a compilation of challenges and factors affecting maintainability of CMS in LMS in university settings and their current extent of usage. This questionnaire was then administered to a panel of 10 evaluators. These evaluators comprised seven university ICT staff comprising ICT managers, software/website developers and other ICT technical staff purposefully selected from Kabianga University, along with three information systems experts, in alignment with the guidance provided in (Zacharewicz, Diallo, Ducq, Agostinho, & Jardim, 2016). The evaluators were tasked to review the frameworks components, subcomponents, and foundational elements in relation to the existing state of maintainability of CMS in LMS challenges and the factors that define it. They were also requested to provide their individual assessments regarding the framework potential to enhance maintainability of CMS in LMS considering the prevailing challenges and influencing factors.

When translating the objectives into measurable benchmarks, the research employed a rating system with the following parameters: 5 for "Strongly Agree (SA)," 4 for "Agree (A)," 3 for "Not Sure (NS)," 2 for "Disagree (D)," and 1 for "Strongly Disagree (SD)" for each of the factors listed. Subsequently, the assessors were asked to express their overall assessment by responding to the question of whether they believed the proposed framework had the potential to improve maintainability of CMS in LMS under the current challenges and circumstances. The outcome of this evaluation is detailed in [Table 1].

Table 1. SSMF Framework Testing Response.

Considering all aspects of the framework discussed, you feel satisfied with the Spinning Star Maintainability Framework's effectiveness and usability in your organization.	Frequency	Percent
Strongly Disagree	0	0.0
Disagree	0	0.0
Not Sure	0	0.0
Agree	7	70.0
Strongly Agree	3	30.0
Total	10	100.0

Respondent's Scores, 2023

As per the information in reference (Zacharewicz, Diallo, Ducq, Agostinho, & Jardim, 2016), a satisfaction score is determined by calculating the combined count of evaluators who rated the model with either 4 or 5 and dividing this count by the total number of evaluators, and then representing this ratio as a percentage.

Through the evaluation formula, where:

Number of evaluators who rated the systems with either 5 or 4: were 10

Total number of evaluators: 10

The approval percentage is calculated as 10 out of 10, multiplied by 100%, resulting in an approval rate of 100%. This 100% approval rating strongly suggests that the proposed SSMF framework is an effective and advisable approach for implementing maintainability of CMS in LMS. As indicated by (Craig, 2023), an approval score exceeding 80% is considered excellent.

VI. CONCLUSION

In summary, the study conducted a comprehensive examination of Content Management System (CMS) usage in Kenyan Universities' Learning Management Systems (LMS) and its implications for maintainability. The findings of study affirmed the pivotal role of the CMS in course management, scheduling, and content sharing. The overwhelming agreement among respondents on educators' reliance on the system for these purposes demonstrates the CMS's effectiveness in supporting instructors in their interactions with students.

The majority strongly agreed that the CMS facilitates these vital aspects, promoting a dynamic learning environment. Furthermore, security emerged as a strong point, with a significant consensus regarding the system's incorporation of strong security measures for authentication and verification. This consensus underscores the confidence in the CMS's ability to protect sensitive data and maintain system integrity.

On the flip side, the study delved into the various challenges affecting CMS maintainability within LMS, revealing potential areas for improvement. Respondents noted concerns about excessive customization, which, in their view, can introduce complexity. Challenges associated with system updates, plugins, data migration, and security vulnerabilities were also recognized by a majority, suggesting the need for addressing these issues to enhance maintainability. Furthermore, scalability and performance concerns, as well as the importance of adequate training and documentation, were highlighted as aspects that demand attention in the maintainability process.

Lastly, the research examined the factors that define maintainability of CMS in LMS. Notably, there was strong agreement among respondents regarding the significance of factors like system documentation, modularity, error handling, security measures, flexibility, customizability, data management, and backup practices. However, the study revealed diverse opinions regarding financial resource availability and management support, suggesting a need for clearer financial planning and improved management support to ensure effective CMS maintainability.

A. Recommendations

Based on the study's comprehensive examination of Content Management System (CMS) usage within Kenyan Universities' Learning Management Systems (LMS) and its implications for maintainability, several key recommendations can be drawn to enhance the efficiency and effectiveness of these systems.

- Institutions should conduct usability assessments and gather feedback from users to identify and address specific usability challenges.
- Institutions should invest in training and professional development programs to empower educators to fully utilize the system's capabilities.
- Sharing best practices for fostering collaboration and interaction within the CMS may help promote a dynamic learning environment.
- Establishing clear guidelines for customization and updates, along with policies for plugin and extension management.
- Institutions should invest in robust data migration strategies and regular security audits to protect sensitive data and safeguard the system and its users from potential threats.
- Institutions should engage in transparent financial planning and allocate sufficient resources for CMS maintenance.

B. Recommendations for Further Study

Maintainability is of paramount importance in the realm of technology and systems, and it holds particular significance in the context of Content Management Systems (CMS) within Learning Management Systems (LMS) used by educational institutions. The significance of maintainability cannot be overstated, as it directly impacts the long-term functionality, reliability, and efficiency of these systems. This study exclusively concentrated on assessing the maintainability of Content Management Systems (CMS) within Kenyan Universities' Learning Management Systems (LMS). It is recommended that future research broaden its scope to encompass maintainability within various educational institutions beyond the university level in Kenya.

Investigating primary and secondary schools, technical colleges, and vocational training centres this will enable a comprehensive evaluation of the framework's adaptability and effectiveness across diverse learning environments. Each of these educational settings presents its distinct requirements, resource limitations, and technological infrastructure. By incorporating these diverse educational contexts into the study, it will analyze how the proposed framework can be customized to cater to the specific needs and constraints of primary and secondary education, technical and vocational training, and the varying student demographics. This inclusive approach will offer a more comprehensive insight into the potential impact of the framework across the entire educational spectrum in Kenya.

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