

Entrepreneurial an Integrated Model for Optimal Learning Management System Adoption in South African Higher Education: A Multidisciplinary Consortium Approach

Shonisani Percy Masibigiri^{1*}, Alex Tichavasia Dandadzi², Solly Matshonisa Seeletse³

¹ Department of Statistical Sciences, Sefako Makgatho Health Sciences University, Ga-Rankuwa, SOUTH AFRICA

² Department of Computer Science and Information Technology, Sefako Makgatho Health Sciences University, Ga-Rankuwa, SOUTH AFRICA

³ Department of Statistical Sciences, Sefako Makgatho Health Sciences University, Ga-Rankuwa, SOUTH AFRICA

*Corresponding Author:

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ABSTRACT

This study proposes an integrated entrepreneurial model to optimize Learning Management System (LMS) adoption in South African higher education (HE). It addresses connectivity, content, and technical support barriers through multidisciplinary collaboration, expanding LMS use for teaching, research, and community engagement. It employed a mixed-methods approach involving a multidisciplinary consortium from computer science, IT, statistics, operations research, and education. Data included a literature review, surveys (337 responses), interviews, and workshops to co-design an integrated LMS adoption model. Results revealed major barriers in connectivity, digital content, and technical support. The proposed model emphasizes infrastructure upgrades, localized content, capacity-building, and strategic policies, showing initial pilot improvements in LMS usage and stakeholder satisfaction. The study concludes that effective adoption of LMS requires a holistic, multidisciplinary approach addressing interconnected barriers of infrastructure, content, technical support, and institutional strategy. The integrative entrepreneurial model developed offers a scalable and contextually relevant framework to optimize LMS use across teaching, research, and community engagement. Key recommendations include prioritizing broadband expansion with hybrid connectivity solutions tailored to diverse regional needs, co-creating localized and culturally relevant digital content, and implementing comprehensive capacity-building programs involving ongoing user training and AI-supported help desks. Institutionalizing LMS integration through clear policies and nurturing entrepreneurial partnerships with technology providers and government agencies is essential for sustainability. Continuous monitoring and adaptive refinement based on data-driven evaluations can ensure responsiveness to emerging challenges and evolving technological landscapes. This comprehensive strategy can overcome persistent inequities and unlock the transformative potential of digital education in South Africa's HE sectors.

Keywords: Digital Infrastructure, digital learning equity, educational technology integration, Learning Management Systems, multidisciplinary consortium, Teaching, Research, Community Engagement.

INTRODUCTION

Higher education (HE) these days has become an aspect of competition for various reasons, including attracting best students, best faculty, and producing highest research output units. Consequently, higher education

institutions (HEIs) all over the world progressively depend on Learning Management Systems (LMS) to distribute digital education, facilitate research collaboration, and extend community engagement (Maluleke & Maake, 2025). Thomas et al. (2025) decry that in South Africa, significant inequalities in digital infrastructure, content availability, and technical support critically weaken the potential of LMS platforms as enablers of equitable, quality education and institutional outreach. There is high student engagement frequency with LMS platforms, but persistent barriers threaten to reinforce existing educational inequalities (Alfianto & Rajab, 2025). These barriers are mostly connectivity challenges and inadequate digital content. They prevent optimal use of LMS.

Omweri (2024) clarifies that attempts to address these intricate challenges requires a systemic, innovative model that integrates infrastructure improvement, content development, and user support, adapted for the diverse South African context. According to Gonzalez-Urango and Mu (2025), this initiative appeals for a multidisciplinary consortium consisting of computer scientists, IT specialists, statisticians, operations researchers, and educationists to co-create actionable strategies. This manuscript conceptualizes and proposes an entrepreneurship model aimed at assisting HEIs in South Africa to adopt LMS platforms optimally, for teaching and learning and in facilitating research and community engagement.

Background and Literature Review

LMS Adoption barriers in South African Higher Education

Nemes (2025) explains that LMS are essential instruments in enhancing access to education, supporting blended learning modalities, and facilitating administrative processes in HE worldwide. In South Africa, LMS platforms such as Moodle, Blackboard, and Canvas are increasingly adopted to widen educational reach and modernize teaching and learning practices (Ijov & Manasseh, 2025). However, the effective adoption and sustained use of LMS within South African HEIs experience various barriers that hinder their full potential.

According to Lei et al. (2025), connectivity challenges are persistent, particularly amongst institutions and students situated in rural and peri-urban regions. These areas classically suffer from limited internet infrastructure, unreliable connections, and high data costs, which jointly obstruct consistent access to LMS platforms (Ali et al., 2025). The uneven dispersal of digital infrastructure across South Africa's diverse geographical and socio-economic landscape increases disparities in educational opportunity, as connectivity restrictions reduce the flexibility and inclusivity of digital learning environments.

Digital content deficiencies present another critical barrier to LMS adoption (Goarty & Gupta, 2025). The quality, relevance, and localization of e-learning content available on LMS platforms often fall short of satisfying students' academic and contextual requirements. Many digital resources are outdated, generic, or inadequately aligned with South African curricula and cultural contexts (Ajani & Govender, 2025). This lack of customized content diminishes student engagement and motivation. It contributes to sporadic LMS use despite widespread access. Moreover, disparities in content availability between well-resourced and financially constrained HEIs further worsen educational inequality.

Technical support limitations further inhibit effective LMS integration (Athavanraj & Meenakshi, 2025). Many HEIs encounter shortages of trained personnel to provide timely and adequate support for lecturers and students exploring LMS functionalities. Issues such as delayed troubleshooting, insufficient training sessions, and limited institutional resources regularly obstruct users' ability to entirely leverage LMS capabilities (Yusuf & Murtala, 2025). However, evidence indicates that users often compensate for these gaps through peer support or self-learning. It allows sustained LMS use even when formal support is lacking.

Collectively, these barriers contribute to a complex digital divide within South African HEIs. They limit the equitable use of LMS instruments and risk embedding existing socio-economic and educational inequalities (Sulisworo & Diningrat, 2025). Addressing these entwined challenges requires a holistic approach that concurrently targets infrastructure enhancement, content development, and support capacity building, tailored to the unique needs and contexts of South Africa's higher education system.

Multidisciplinary approaches to digital learning challenges

The complex and multifaceted barriers to effective LMS adoption in HE demand solutions that exceed single-discipline perspectives. Addressing issues such as connectivity constraints, content inadequacy, and limited technical support requires expertise from diverse fields, including computer science, information technology (IT), statistics, operations research (OR), and education. Udensi et al. (2025) concur that multidisciplinary collaboration encourages comprehensive understanding and innovative approaches to these challenges.

From a computer science and IT perspective, the focus hubs on enhancing the technological infrastructure and optimizing LMS platforms (Harahap & Mahardhani, 2025). Computer scientists work on improving system

architecture. It ensures platform scalability, security, and adaptability to diverse user contexts. IT specialists evaluate network capabilities, investigate alternative connectivity solutions (such as satellite or mobile networks), and address cybersecurity concerns to ensure that LMS platforms remain reliable and safe (Dulaj et al., 2025). They also develop instruments that enable offline access and low-bandwidth operation, critical for mitigating infrastructure limitations common in South Africa's rural areas.

Statisticians play a fundamental role in designing robust methodologies to evaluate LMS usage patterns (Thompson & Harris, 2025). They identify essential barriers and measure the effectiveness of interventions. Their expertise in data collection, analysis, and modelling helps in monitoring system adoption trends, assessing equity of access, and predicting the impact of different factors on LMS engagement. The application of advanced statistical techniques, such as ordinal logistic regression or multivariate analysis, provides evidence-based insights that guide strategic decision-making (Şengöz, 2025).

According to Güntem and Kılıç (2025), operations researchers' contribution lies in the optimization of resource allocation and institutional processes needed for effective LMS incorporation. They apply quantitative modelling and simulation to determine the most efficient investments in infrastructure, training, and support services. Through scenario analysis and capacity planning, operations researchers help HEIs prioritize interventions that maximize digital learning outcomes while minimizing costs and operational inefficiencies (Ambarwati & Sischasari, 2025).

Educationists and instructional designers certify that digital content and LMS utilization align with educational best practices and student needs (Srinivas & Yadav, 2025). They emphasize the creation of culturally relevant, engaging, and curriculum-aligned materials that are accessible and inclusive. Patiño et al. (2023) further explain that education specialists also develop training programs for educators and students to build digital literacy, facilitate effective use of LMS functionalities, and promote active learning approaches. Moreover, they assess how LMS embracing impacts teaching effectiveness, student motivation, and academic performance.

The synergy of these disciplines highlights the development of an integrated, sustainable model for addressing LMS adoption hurdles (Munisamy et al., 2025). Data-driven evaluation, operational efficiency, and educational soundness insinuate a multidisciplinary consortium capable of designing customized strategies that reflect the complex realities of South African HE by merging technological innovation. Such collaboration enhances the quality and inclusivity of digital learning and prepares HEIs to leverage LMS platforms holistically, extending their use to research collaboration and community engagement.

Existing frameworks and gaps

Various models and frameworks have been proposed internationally to facilitate the adoption and effective use of LMS in HE (Shard et al., 2024). These frameworks usually address technological readiness, pedagogical integration, and institutional support, acknowledging the multifactorial nature of LMS adoption. Walker-Swinton (2025) states that among them are the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Community of Inquiry (CoI) framework. Each framework offers valuable insights into user acceptance, interaction, and learning experience.

TAM emphasizes perceived usefulness and ease of use as principal determinants influencing the adoption of new technologies, including LMS (Basyah et al., 2025). Although widely applicable, TAM's focus is primarily on individual user perceptions. This offers limited guidance on systemic institutional factors and infrastructural constraints common in under-resourced contexts such as South Africa.

UTAUT expands on TAM by incorporating social influence and facilitating conditions as additional predictors of technology use (Qatanani et al., 2025). This model accounts for environmental factors influencing LMS adoption, empirical applications in South African HEIs are scarce, and the model's operationalization often (Ahmad Malik et al., 2025). However, Deriba (2025) complains that it ignores specific infrastructural and content-related challenges.

CoI framework centres on social, cognitive, and teaching presence (Alshammari & Alrehaili, 2025). It provides a robust conceptual foundation for designing engaging and meaningful online learning experiences (Carroll et al., 2025). CoI substantially advances the educational dimension of LMS use. However, it is based on a criterion of technological access and support that may not exist in many South African HEIs.

Outside theoretical frameworks, practical models focusing on LMS implementation in resource-constrained environments are limited (Obiajulu, 2025). Most prevailing approaches tackle infrastructural, educational, or support challenges separately, but usually without integrated strategies or multidisciplinary collaboration. For instance, infrastructure initiatives tend to prioritize broadband growth without simultaneous content development and user training. Similarly, educational interventions that enhance digital content quality often misalign with infrastructural realities or institutional support capabilities. This leads to fragmented or unsustainable outcomes.

Moreover, existing models rarely extend LMS applications beyond teaching and learning to encompass research collaboration and community engagement (Wastira & Waluyo, 2025). Thus, it violates the critical missions of contemporary HEIs. The absence of holistic frameworks addressing LMS integration across all institutional functions represents a significant gap. In the South African context, only few studies have proposed integrative and contextually adapted models that mix infrastructural investment, content localization, technical support enhancement, and stakeholder collaboration (Mohammed & Amoah, 2025). This gap deters the design of comprehensive, scalable, and sustainable LMS adoption strategies customized to the specific socio-economic and geographic diversity of South African HE.

Addressing these gaps identifies a novel entrepreneurial model co-created by multidisciplinary experts. This model should holistically encompass technological, pedagogical, operational, and policy dimensions to advance equitable and effective LMS adoption in teaching, research, and community engagement across South African HEIs.

RESEARCH PROBLEM AND OBJECTIVES

Even though LMS play a critical role in advancing digital education globally, South African HEIs experience relentless barriers that constrain the effective adoption and optimal application of these platforms. Empirical evidence (Güntem & Kılıç, 2025; Lasekan et al., 2024; Rizwan et al., 2025) indicates that connectivity issues and content inadequacies are the leading factors limiting frequent and meaningful LMS engagement among students and faculty similarly. These challenges are intensified by inequities in infrastructure and institutional capacity, which excessively affect rural and under-resourced HEIs. Therefore, the promise of LMS to democratize access to quality education, enable collaborative research, and facilitate community engagement can only be partially realized.

Earlier studies (Martínez-Mireles et al., 2025; Sahni et al., 2025; Veseli et al., 2025) have identified leading barriers to LMS adoption, but there is a notable absence of inclusive models that integrate infrastructural improvement, content development, and support mechanisms within a unified framework. Further, existing attempts often disregard offering LMS application beyond teaching and learning to encompass the broader institutional missions of research and community outreach. The absence of a contextually grounded, multidisciplinary entrepreneurial model limits the capacity of HEIs to implement sustainable LMS adoption strategies that address the unique socio-economic and geographic complexities of South Africa's HE environment. The present study's predominant problem therefore concerns the lack of an integrated, scalable, and sustainable model planned using collective expertise to optimize LMS use holistically across teaching, research, and community engagement functions within South African HEIs. Addressing this problem, the study sets forth the following five objectives:

- To co-design an integrated entrepreneurial model for LMS adoption that blends input from computer science, information technology, statistics, OR, and education disciplines.
- To develop practical frameworks and guidelines that enable HEIs to overcome barriers related to digital infrastructure, content quality, and technical support.
- To expand the scope of LMS application by promoting innovative applications in research collaboration and community engagement alongside teaching and learning.
- To propose policy sanctions aimed at facilitating equitable digital access and standardization of LMS platforms within South African HE.
- To establish evaluation mechanisms using data-driven approaches that monitor LMS adoption effectiveness and inform continuous improvement.

The study aims to offer HEIs and policymakers robust, evidence-based strategies to enhance the inclusive and effective integration of LMS platforms, eventually contributing to more equitable and impactful HE outcomes in South Africa by accomplishing these objectives.

METHODOLOGY: CONSORTIUM COLLABORATION AND MODEL DEVELOPMENT

To address the complex and multifaceted challenges surrounding LMS adoption in South African HEIs, this study adopts a thorough, multidisciplinary methodology centred on collaborative model development. It acknowledges that no single discipline can completely capture or resolve the tangled barriers of connectivity, content, technical support, and institutional strategy. A consortium approach has been proposed to bring together experts from computer science, IT, statistics, OR, and education.

Formation and Composition of the Consortium

The consortium was purposefully assembled to leverage complementary expertise essential for a holistic intervention. The core members include:

- Computer Scientists: To analyze prevailing LMS platform architectures, propose system enhancements, and develop solutions to improve scalability, security, and offline functionalities appropriate for South Africa's infrastructural contexts.
- IT Specialists: To assess network infrastructures, explore hybrid connectivity models such as satellite integration and mobile broadband, manage cloud service options, and establish cybersecurity protocols to ensure dependable and secure LMS environments.
- Statisticians: To design data collection instruments, conduct rigorous quantitative analyses (descriptive statistics, inferential tests, and ordinal logistic regression), evaluate LMS usage patterns and barrier impact, and develop monitoring and evaluation frameworks for ongoing assessment.
- Operations Researchers: For optimizing resource allocation strategies by using quantitative models and simulations to identify the most effective combinations of infrastructural investments, content production, and support services, maximizing institutional capacity and cost-effectiveness.
- Educationists: To focus on educational frameworks, instructional design, localization of digital content, and the development of capacity-building programs. They also led qualitative data collection through stakeholder interviews and designed training curricula for lecturers and students.

Research Design and Approach

This study used mixed-methods research design, integrating qualitative and quantitative strategies to develop, validate, and refine the entrepreneurial model for LMS adoption.

- Systematic Literature Review (SLR): A wide-ranging review of published studies between 2015 and 2025 was conducted to identify global and local LMS adoption barriers and effective interventions, complemented by policy document analysis relevant to South African HE.
- Quantitative Data Collection and Analysis: A structured questionnaire was administered to 455 students enrolled in a distance-learning module at a South African HEI. The 337 responses collected was a 74% response rate. Descriptive statistics spotted the prevalence of connectivity, content, and support barriers. Chi-square tests and ordinal logistic regression examined the associations between these barriers and LMS usage frequency.
- Qualitative Inquiry: Focus group discussions and semi-structured interviews with educators, IT personnel, and institutional managers across several HEIs provided contextual insights into challenges and best practices, enriching the quantitative findings.
- Participatory Workshops: Consortium members and HE stakeholders jointly engaged in workshops to co-design the integrated entrepreneurial model, iteratively refining the framework based on empirical evidence and practical considerations.

Model development and validation

The multidisciplinary inputs and mixed-methods findings informed the conceptualization of an integrated LMS adoption model structured around four pillars: infrastructure enhancement, content development, technical support, and organizational strategy. The model emphasizes entrepreneurial thinking, encouraging institutions to innovate, seek diverse funding sources, and build strategic partnerships. Initial prototypes of intervention strategies developed within the model were piloted at select HEIs, with iterative monitoring and evaluation performed through predefined indicators such as LMS login frequency, student satisfaction, and infrastructural improvements.

PROPOSED INTEGRATIVE MODEL FOR LMS ADOPTION

In response to the complex barriers identified, the consortium developed a holistic, integrated model to guide South African HEIs in optimally adopting LMS across teaching, research, and community engagement functions. This entrepreneurial model creates multidisciplinary expertise to address infrastructural content, support, and strategic dimensions, highlighting sustainability, scalability, and contextual relevance.

Infrastructure component

Robust and affordable digital infrastructure serves as the foundation for effective LMS integration. The model advocates *broadband expansion and connectivity solutions, low-bandwidth and offline LMS features, and cloud-based architecture with security* (Dritsas & Trigka, 2025).

- Broadband Expansion and Connectivity Solutions: Imran et al. (2025) encourage HEIs to join forces with telecommunications providers and government agencies to expand affordable internet access, particularly

focusing on rural and peri-urban campuses. Hybrid approaches that blend fixed broadband, satellite internet, and mobile data networks offer flexible connectivity adapted to diverse geographic conditions (Mrabet & Sliiti, 2024).

- Low-Bandwidth and Offline LMS Features: LMS platforms should integrate functionalities that enable offline content access and synchronization to reduce reliance on continuous internet connectivity (Sharma et al., 2025). This can ensure uninterrupted learning opportunities for students experiencing intermittent access.
- Cloud-Based Architecture with Security: Pendyala (2025) notes that leveraging scalable cloud services improves platform availability while centralizing maintenance. Strong cybersecurity measures are critical to safeguarding institutional data and user privacy.

Content Development and Management

Effective LMS application depends profoundly on relevant and engaging digital learning content: Co-Creation and Localization, OER and modular content, and Regular Updates and Quality Assurance (Bharath Raj & Hans, 2025).

- Co-Creation and Localization: Developing of content requires academics, instructional designers, and local experts to produce curricula-aligned and culturally relevant learning materials (Ishrat et al., 2025). Wang et al. (2025) also adds that backing numerous languages normally spoken by the student body increases accessibility.
- Open Educational Resources (OER) and Modular Content: Schön and Ebner (2025) suggest that mixing of OER reduces costs and promotes resource sharing across institutions. Moreover, Assad et al. (2025) claims that modular content structure permits flexibility and easier updates.
- Regular Updates and Quality Assurance: According to Assad et al. (2025), continuous revision and peer review mechanisms are vital to maintain content relevance and accuracy, nurturing sustained student motivation.

Support and Capacity Building

Addressing technical support challenges is essential for user confidence and LMS sustainability through *comprehensive training programs, multi-tiered help desk structures, AI-enabled support tools, and Ongoing Feedback Loops*:

- Comprehensive training programs: Alanoglu et al. (2025) propose structured digital literacy training for lecturers and students to provide them with essential LMS exploration and troubleshooting skills.
- Multi-tiered help desk structures: These are essential for establishing dedicated institutional support units complemented by peer mentoring networks to provide timely assistance (Zhu et al., 2025).
- AI-enabled support tools: This occurs by deploying chatbots and automated knowledge bases to handle routine queries, freeing human resources for complex issues (Oyugi et al., 2025).
- Ongoing feedback loops: Romano and Conti (2024) explain through systematic collection of user feedback that informs continuous improvement of support services.

Research and community engagement integration

Expanding LMS utility beyond teaching enhances institutional impact: *research collaboration, community training and outreach, and impact tracking* (Ghoulam, 2025).

- Research collaboration: Ghoulam (2025) explains that LMS platforms can host virtual laboratories, data repositories, and project management tools enabling interdisciplinary and cross-institutional research activities.
- Community training and outreach: According to Leal Filho et al. (2025), the model encourages using LMS for delivering training and educational programs to community stakeholders to enhance HEI societal engagement.
- Impact tracking: According to Otundo Richard (2024), monitoring tools inserted in LMS track participation and outcomes in research and outreach initiatives support institutional reporting and funding justification.

Organizational strategy and policy advocacy

Strategic institutional and policy frameworks for sustainable LMS adoption in rural areas are *institutional policy development, government and sectoral standards, and entrepreneurial mindset* (Ilyas et al., 2025).

- Institutional policy development: Liu (2025) advises HEIs to formalize LMS integration within academic and administrative policies to ensure dedicated funding, staffing, and accountability structures.
- Government and sectoral standards: Evans-Uzosike et al. (2025) advocate for national policies which set LMS standardization benchmarks that encourage interoperability, equitable access, and economies of scale.
- Entrepreneurial mindset: HEIs are encouraged to innovate in sourcing funding (e.g., grants, partnerships with industry), collective content creation, and adaptive management practices to accomplish sustainability (Rakhimova et al., 2025).

This integrative model is a dynamic framework adjustable to institutional contexts and evolving technological landscapes and aiming to transform LMS adoption from a technically driven process into a strategic institutional initiative to empower students, researchers, and community members.

Implementation Plan

The successful operationalization of the proposed integrative model for LMS adoption requires a phased, strategic implementation plan that ensures adaptability, continuous learning, and scalability across South African HEIs (Sabrifha et al., 2025). This plan balances infrastructural investment, capacity building, content development, and policy alignment with ongoing monitoring and feedback. This section covers *pilot phase*, *monitoring and evaluation*, *scaling and dissemination*, and *sustainability measures*.

Pilot Phase

The selection phase is made of *selection of diverse HEIs*, *baseline assessment*, *stakeholder engagement*, and *initial interventions*.

- Selection of diverse HEIs: Holmes et al. (2017) explain that to validate the flexibility of a model, pilot enactments are conducted at a representative sample of HEIs encompassing urban, peri-urban, and rural settings, as well as well-resourced and financially constrained HEIs.
- Baseline assessment: According to Jimenez Orellana et al. (2025), thorough audits of existing digital infrastructure, LMS usage patterns, content quality, and support services are used to establish baseline benchmarks and highlight institution-specific priorities.
- Stakeholder engagement: Asghari et al. (2025) encourage early involvement of students, faculty, IT staff, and administrators through workshops and interviews to encourage ownership and provide contextual insights to adapt interventions.
- Initial interventions: Using the baseline data as a start, customized infrastructural upgrades (such as enhanced broadband connectivity and cloud services) and prioritized content localization are initiated (Kagai et al., 2024). Simultaneously, training programs and support frameworks are established.

Monitoring and evaluation

The section consists of *data collection and analysis*, *iterative refinement*, and *impact assessment*.

- Data collection and analysis: Thompson and Harris (2025) advise the consortium to deploy data analytics instruments to monitor LMS usage frequency, barrier prevalence, and user satisfaction constantly. Mixed-method feedback mechanisms, which include surveys and focus groups, could complement quantitative data.
- Iterative refinement: Findings from monitoring need to inform adaptive strategies to address emergent challenges promptly (Calleo et al., 2025). This will ensure sensitivity to user needs and institutional contexts.
- Impact assessment: Kokoç et al. (2025) explain that statistical models, such as regression analyses, can assess the effectiveness of interventions in increasing LMS engagement and improving learning outcomes.

Scaling and Dissemination

In this section, the topics discussed are *documentation of best practices*, *capacity building across HEIs*, *policy advocacy* and *technology partnerships*.

- Documentation of best practices: Lessons learned, effective strategies, and implementation guides are methodically recorded to facilitate knowledge transfer (Gupta, 2025).
- Capacity building across HEIs: Using a train-the-trainer attitude, pilot HEIs mentor other HEIs, encouraging regional centres of excellence (Papastamou, 2023).
- Policy advocacy: Suazo et al. (2025) propose that evidence-based policy briefs advocating infrastructural investment, content standardization, and support enhancement are presented to government bodies and sectoral stakeholders.
- Technology partnerships: The consortium could seek collective agreements with technology providers and telecommunications companies to ensure sustainable infrastructure and platform development (Ingaldi & Ulewicz, 2025).

Sustainability Measures

This section entails *funding diversification*, *institutionalization of LMS roles*, and *continuous professional development*.

- Funding diversification: Institutions are guided to explore diverse revenue streams, including grants, public-private partnerships, and alumni contributions, to finance ongoing LMS maintenance and growth (Flores, 2025).
- Institutionalization of LMS roles: Pausits et al. (2025) advise to involve dedicated staffing and clear responsibilities for LMS management and support to be embedded within institutional structures.
- Continuous professional development: Khare and Baber (2025) state that continuous training and upskilling programs can keep educators and support staff up to date with evolving LMS functionalities and digital pedagogies.

This implementation plan positions the consortium as both an innovation facilitator and as a catalyst for systemic digital transformation to ensure that LMS adoption is a sustainable foundation of South African HE's future.

DISCUSSION

This study emphasizes the critical and intertwined barriers that constrain effective LMS adoption in South African HEIs. Despite high frequency of LMS usage that the students reported, significant challenges related to connectivity and content quality continue to hinder seamless engagement and equitable access. The evidence suggests that frequency of use alone is not sufficient indicator of successful LMS integration, as students experiencing infrastructural and pedagogical deficiencies may experience frustration, reduced learning effectiveness, and digital exclusion. Mohammed et al. (2025) explain that LMS adoption requires multiple layers at both technical and soft levels of the approaches used.

Connectivity issues emerged as the most insistent barrier, coherent with prior research that identifies South African rural and peri-urban regions as underserved in terms of internet infrastructure and data affordability (Baye, 2025). These restrictions reduce flexibility for students who cannot depend on continuous, stable connections, as it restricts their ability to benefit fully from digital learning environments. The model's accentuates diversified technological solutions that include offline access and hybrid broadband strategies. This directly addresses this persistent challenge. Mahdavian et al. (2021) concur that connectivity is a central enabler and its absence translates into a vital barrier.

Inadequacies of content, such as poor alignment with curricula, insufficient localization, and outdated materials, also meaningfully decrease LMS engagement. This finding highlights the importance of academically sound, contextually relevant digital resources in sustaining student motivation and participation. The participatory approach to content co-creation recommended in the model ensures materials resonate with learner experiences and academic expectations (Narot & Kiettikunwong, 2024).

Notably, technical support challenges, though frequently reported, did not significantly lessen LMS usage frequency. This suggests a resilience among students through self-directed learning and peer support networks. Feng et al. (2025) states that support is a crucial dimension influencing user satisfaction and learning efficiency. This then justifies inclusive training and AI-enabled assistance initiatives outlined in the model.

The multidisciplinary, entrepreneurial approach represents a novel, system-level solution that integrates these dimensions with institutional strategy and policy advocacy. The model encourages innovation, sustainability, and equity in digital learning by nurturing collaboration across computer science, IT, statistics, operations research, and education. Further, expanding LMS usage beyond education to research collaboration and community engagement aligns with the evolving roles of HEIs and enhances societal impact (Iyanda & Raja, 2025).

CONCLUSION AND FUTURE DIRECTIONS

It is anticipated that implementing the forthcoming recommendations will advance HEIs towards equitable, effective, and sustainable LMS integration to enhance teaching quality, research excellence, and broader societal contributions in South African HE. The six recommendations call for *investment in inclusive digital infrastructure*, *developing relevant and high-quality digital content*, *enhancement of technical support and capacity building*, *embedding LMS use in research and community engagement*, *advocating for institutional and governmental support*, and *adopting entrepreneurial and collaborative strategies*.

• Invest in inclusive digital infrastructure

HEIs should partner with telecommunications providers and government agencies to expand affordable, dependable internet access, especially in underserved rural and peri-urban areas. They should also explore innovative connectivity solutions such as satellite internet and implement offline-capable LMS functionalities.

- **Develop relevant and high-quality digital content**

HEIs should institutionalize collective content development involving academics and instructional designers with local expertise. Curriculum-aligned, multilingual, and culturally contextualized materials should be regularly updated and quality assured to advance sustained student engagement.

- **Enhance technical support and capacity building**

There should be comprehensive digital literacy training programs for faculty and students, as they are essential. Multi-tiered help desks enhanced by AI-driven support tools should be established to improve efficiency. Peer mentorship networks should be expanded to leverage existing user resilience.

- **Embedding LMS used in research and community engagement**

HEIs should broaden the use of LMS platforms to support interdisciplinary research collaboration, data sharing, and community outreach programs. Tracking mechanisms for impact assessment should also be established to demonstrate value and support funding initiatives.

- **Promoting institutional and governmental policy support**

Developing and enforcing institutional LMS policies, combined with national standards for LMS deployment and digital equity, are necessary. Policymakers should ensure equitable funding and resource allocation to avoid deepening disparities across HEIs.

- **Adopt entrepreneurial and collaborative strategies**

HEIs should cultivate partnerships with industry and stakeholders to diversify funding sources and promote innovation. Continuous monitoring, evaluation, and iterative model refinement will ensure responsiveness to evolving technological and educational landscapes.

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