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Leveraging Open-Source Learning Management Systems (LMS) for Resilient and Inclusive Higher Education in Ghana: Lessons from the Sakai LMS Journey

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Abstract

Over the past decade, the Sakai Learning Management System (LMS) has played a central role in advancing digital learning at the University of Ghana, offering insights for higher education in Sub-Saharan Africa. Despite adoption, institutions face challenges including high costs, limited scalability, accessibility gaps, and constraints on technological autonomy. Proprietary LMS solutions often restrict customisation, limiting alignment with local pedagogical, cultural, and infrastructural needs. This article examines the potential of open-source LMS platforms to foster resilient, inclusive, and sustainable digital learning, using Sakai as a case study. Guided by Dynamic Capabilities Theory, the paper employed qualitative approach, including semi-structured interviews with ten purposively selected participants: three LMS administrators, three instructors or e-learning leads, three teaching and learning policy leads, and one faculty champion. Findings

reveal that Sakai enhances institutional resilience by maintaining continuity of instruction during disruptions and supporting flexible pedagogical approaches. The platform promotes inclusion through mobile access, adaptable content, and mentorship-driven adoption, though challenges persist in faculty training, technical support, and policy enforcement. Sustainability depends on strategic governance, funding, capacity development, and engagement with global open-source communities. The study contributes by demonstrating how open-source LMS platforms function as dynamic organisational capabilities, enabling higher education institutions to respond to evolving challenges, advance digital inclusion, and leverage technology for effective and sustainable teaching and learning.

Keywords: Sakai, open-source LMS; higher education; digital inclusion; Dynamic Capabilities Theory; Ghana.

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Introduction

The digital transformation of higher education has increasingly positioned learning management systems (LMS) as critical infrastructure for teaching, learning, and institutional continuity (Allam, et al., 2024). Globally, universities have adopted LMS platforms to support blended and fully online learning, facilitate assessment, and enhance student engagement. However, in many low- and middle-income contexts, the implementation of digital learning technologies has been shaped by financial constraints, infrastructural limitations, and uneven digital skills among faculty and students (Andreoni et al., 2021). In Sub-Saharan Africa, reliance on proprietary LMS solutions has often resulted in high licensing costs, limited flexibility, and dependence on external vendors, constraining institutions' ability to adapt platforms to local pedagogical, cultural, and accessibility needs. These challenges have renewed interest in open-source LMS platforms as viable alternatives for sustainable digital learning.

Universities in Ghana have embraced digital learning platforms to respond to growing student enrolments, limited physical infrastructure, and rising expectations for flexible and technology-enhanced education (Amponsah et al., 2024). These developments were further accelerated by the COVID-19 pandemic, which exposed both the potential and the fragilities of existing digital learning systems. As higher education institutions transition into a post-pandemic environment, questions of resilience, inclusivity, affordability, and technological autonomy have become central to digital learning policy and practice.

In Ghana, the University of Ghana represents one of the longest and most extensive experiences with open-source LMS adoption through its use of the Sakai Learning Management System. Over the past decade, Sakai has served as the core platform for online teaching, learning, and assessment, supporting institutional efforts to expand access and maintain academic continuity during periods of disruption. The Sakai LMS journey illustrates how open-source platforms can

enhance institutional resilience by enabling local control, cost management, and system customisation. At the same time, it reveals persistent challenges related to governance structures, faculty capacity, technical support, and the integration of emerging digital innovations.

Digital inclusion and accessibility have emerged as critical dimensions of higher education quality and equity (Matsieli & Mutula, 2024; Amjad et al., 2024). For that matter, LMS platforms play a central role in shaping learners' access to course content, assessments, and academic support services. In the Ghanaian context, disparities in internet access, device availability, and digital literacy continue to affect students' learning experiences. Although open-source LMS platforms offer opportunities to embed accessibility features and inclusive design practices, empirical evidence on how these potentials are realised in practice remains limited. Understanding how the Sakai LMS supports inclusive and accessible teaching and learning is therefore essential for informing broader digital education strategies.

From a theoretical perspective, Dynamic Capabilities Theory provides a useful lens for examining how universities sense digital opportunities, seize technological options, and reconfigure institutional resources to sustain digital learning systems (Renz & Hilbig, 2023). The ability of higher education institutions to adapt open-source LMS platforms over time depends not only on technical infrastructure but also on organisational learning, human capacity development, and collaborative governance arrangements. In Ghanaian higher education, the extent to which institutions have developed such capabilities remains underexplored.

Although existing literature highlights the potential of open-source LMS platforms to enhance resilience, inclusion, and sustainability (Nanayakkara, 2017), there is a lack of in-depth, context-specific studies examining long-term institutional experiences in Ghana. Few studies integrate organisational theory to explain how universities develop the capabilities required to sustain digital learning systems over time. Moreover, the interaction between institutional capacity, inclusive practices, and technological sustainability remains underexplored. By applying Dynamic Capabilities Theory, this study addresses these gaps by examining how the University of Ghana has developed, constrained, and transformed its digital learning capabilities through the Sakai LMS journey.

Against this backdrop, the article investigates how the Sakai open-source LMS supports resilience in digital learning at the University of Ghana (objective 1), identifies institutional, technical, and human capacity challenges affecting its effective use (objective 2), assesses its role in promoting inclusive and accessible teaching and learning practices (objective 3), and develops a framework for strengthening the sustainability of open-source LMS platforms in Ghanaian higher education institutions (objective 4). By grounding the analysis in Dynamic Capabilities Theory, the paper contributes to the literature by linking open-source LMS adoption to institutional resilience and inclusion, while proposing a sustainability framework grounded in empirical evidence from a leading Ghanaian university.

Related Literature and Theory

Learning Management Systems and Digital Learning Resilience in Higher Education

Learning management systems have become integral to institutional resilience in higher education, functioning as critical infrastructure for instructional continuity and academic coordination. Digital learning resilience refers to an institution's capacity to sustain teaching and learning during disruption while adapting digital systems to evolving pedagogical and organisational demands. The COVID-19 pandemic demonstrated that universities with established LMS ecosystems were

better positioned to maintain academic operations, while those with fragmented or underdeveloped systems experienced significant disruption (Sims, 2025).

In resource-constrained contexts, resilience is shaped less by technological sophistication and more by institutional adaptability and control over digital systems. Studies in Sub-Saharan Africa emphasise that locally managed LMS platforms enable universities to respond more effectively to infrastructural instability, policy shifts, and fluctuating enrolments. Open-source LMS platforms offer greater flexibility for contextual customisation and cost management, thereby supporting long-term resilience.

Dynamic Capabilities Theory provides a useful analytical lens for understanding LMS-enabled resilience as an organisational process. Institutions exhibit resilience when they can sense environmental disruptions, seize appropriate digital solutions, and reconfigure internal resources to sustain academic delivery. Long-term engagement with open-source platforms such as Sakai illustrates how digital resilience emerges through iterative learning, institutional experimentation, and adaptive governance rather than through one-off technology adoption (Owusu-Ansah & van der Walt, 2021).

Institutional, Technical, and Human Capacity Challenges in Open-Source LMS Adoption

Despite their strategic potential, open-source LMS platforms present significant implementation and sustainability challenges (Nanayakkara, 2017). Institutional constraints often include weak governance arrangements, limited policy coherence, and the marginal positioning of digital learning within broader academic strategies. When LMS initiatives are treated primarily as technical projects, institutional ownership and accountability tend to be fragmented, undermining effective use.

Technical challenges remain prominent in open-source environments, where institutions assume responsibility for system hosting, maintenance, and security. While open-source platforms reduce licensing costs, they require sustained investment in infrastructure and specialised expertise. In developing contexts, shortages of skilled technical staff and limited funding frequently result in delayed upgrades, performance inefficiencies, and user dissatisfaction (Asamoah, 2021; Olugbade et al., 2023). Furthermore, human capacity challenges are equally critical. Faculty engagement with LMS platforms is shaped by digital competence, pedagogical readiness, and institutional incentives. Empirical evidence suggests that inadequate training, high workloads, and limited recognition of digital teaching reduce sustained faculty adoption. Students may also face digital literacy constraints, further limiting the pedagogical effectiveness of LMS platforms (Bwalya, 2021).

Within Dynamic Capabilities Theory, these challenges reflect gaps in institutions' ability to seize and transform digital opportunities. Open-source LMS platforms provide autonomy, but without deliberate investment in organisational learning and capacity development, their potential remains under-realised. Context-specific evidence on how Ghanaian universities navigate these challenges, particularly in long-standing LMS deployments, remains limited.

Open-Source LMS Platforms, Inclusion, and Accessibility in Higher Education

Digital inclusion and accessibility have become central to higher education quality and equity (Amjad et al., 2024). LMS platforms structure access to learning materials, assessments, and academic support, thereby shaping students' participation and outcomes. Inclusive digital learning environments accommodate diverse learning needs, technological conditions, and socio-economic backgrounds. Open-source LMS platforms offer distinct advantages for inclusion through flexible

design and customization (Chatzialexiou & Anastasiadou, 2025). Institutions can adapt interfaces for low-bandwidth environments, integrate assistive technologies, and localise content delivery without vendor restrictions. Munna et al. (2024) concord that such flexibility is particularly relevant in contexts where students rely on mobile devices or experience intermittent connectivity.

However, inclusive outcomes are not automatic. As espoused by Obeid (2024) accessibility features are underutilised due to limited faculty awareness, absence of inclusive design standards, and weak institutional enforcement. In developing country contexts, structural inequalities related to income, geography, and disability further complicate digital inclusion efforts. Dynamic Capabilities Theory frames inclusion as an outcome of institutional sensing and reconfiguration. Universities must identify patterns of learner exclusion, seize appropriate technological and pedagogical responses, and realign teaching practices accordingly. Despite increasing policy attention to inclusive education in Ghana, empirical analyses of how LMS platforms are operationalised to advance accessibility remain scarce.

Sustainability of Open-Source LMS Platforms in Higher Education

Sustainability remains a persistent concern in LMS implementation, encompassing technical viability, pedagogical relevance, and organisational integration (Akacha & Awad, 2023). For open-source LMS platforms, sustainability is closely linked to institutional ownership, governance stability, and continuous innovation. Unlike proprietary systems, open-source platforms depend on local capacity and collaborative ecosystems rather than vendor-driven support (Haque, 2025). Empirical studies (e.g. Nanayakkara, 2017) indicate that sustainable open-source LMS deployment is strengthened through institutional participation in developer communities, shared support arrangements, and long-term funding commitments. However, many African universities implement LMS platforms in isolation, limiting opportunities for shared learning and innovation.

Dynamic Capabilities Theory conceptualises sustainability as a process of continuous transformation (Teece, 2007). Institutions sustain LMS platforms when they repeatedly reconfigure technical infrastructure, develop human capacity, and integrate emerging technologies such as learning analytics and artificial intelligence. In Ghanaian higher education, sustainability is often undermined by project-based funding, leadership turnover, and weak national coordination of digital learning initiatives. The literature offers limited context-specific frameworks that integrate organisational, technical, and pedagogical dimensions of open-source LMS sustainability. This study addresses this gap by drawing on the Sakai LMS experience at the University of Ghana to inform a capability-driven framework for resilient and inclusive digital learning in Ghanaian higher education.

Theoretical Framework: Dynamic Capabilities Theory

This paper is grounded in Dynamic Capabilities Theory, which explains how organisations adapt, renew, and sustain competitive and functional advantage in environments characterised by uncertainty and rapid change (Teece, 2020). Originating from the resource-based view of the firm, Dynamic Capabilities Theory extends beyond the possession of valuable resources to emphasise an organisation's capacity to purposefully integrate, build, and reconfigure internal and external competencies over time. In the context of higher education, dynamic capabilities are reflected in universities' ability to continuously adapt organisational processes, technologies, and human resources to meet evolving educational demands.

Dynamic capabilities are commonly conceptualised as three interrelated processes: sensing, seizing, and transforming. In this study, Dynamic Capabilities Theory provides an analytical framework for examining the Sakai LMS journey at the University of Ghana. The theory informs

the analysis of how the institution has developed resilience in digital learning, navigated institutional, technical, and human capacity challenges, and promoted inclusive teaching and learning practices through an open-source LMS platform.

Empirical studies highlight the role of dynamic capabilities in open-source ecosystems. Fukawa et al. (2021) show that organisations pursuing open-source strategies during digital transformation must develop sensing and seizing capabilities to align open technologies with strategic objectives. Faridian and Neubaum (2021) emphasise the importance of ambidexterity in open-source ecosystems, noting that organisations require dynamic capabilities to balance exploration, exploitation, and shared asset utilisation. Abbate et al. (2022) extend this perspective by conceptualising digital platforms as capability ecosystems, where value co-creation depends on an organisation's ability to continuously reconfigure relationships, knowledge, and technological assets.

Despite these advances, most empirical applications of Dynamic Capabilities Theory in open-source contexts focus on commercial organisations and innovation-driven firms. There remains limited application of the theory to higher education, particularly in developing country contexts and in relation to digital learning platforms. This study addresses this gap by applying Dynamic Capabilities Theory to examine the long-term institutional use of an open-source LMS in a Ghanaian university. By situating the Sakai LMS journey within a dynamic capabilities framework, the paper contributes theoretically by extending the application of the theory to higher education digital infrastructure.

Methodology

Research Design

Our paper adopted a qualitative case study design to examine the long-term adoption and governance of the Sakai LMS at the University of Ghana. A case study approach was considered appropriate because it enables in-depth exploration of complex, context-dependent phenomena within real-life institutional settings (Tasci et al., 2020). Rather than aiming for statistical representativeness, the study seeks analytical depth and theoretical insight into how open-source LMS platforms operate within resource-constrained higher education environments. The study was guided by Dynamic Capabilities Theory, which informed both data collection and analysis. The theory provided a conceptual lens for examining how the institution sensed digital learning challenges, seized strategic opportunities through open-source adoption, and transformed organisational practices over time. The intent is therefore analytical generalisation, whereby insights from a theoretically significant case contribute to broader understanding of digital learning resilience and inclusion in similar higher education contexts.

Study Context

The University of Ghana, established in 1948, is the oldest and largest public university in Ghana, with a total student population of 63,646 including 667 international students, 9,509 graduate students, and the remainder enrolled in undergraduate programmes as at. The university has a long-standing commitment to digital learning (University of Ghana, n.d.) and represents one of the longest sustained implementations of an open-source LMS in Ghanaian higher education, with over a decade of continuous use.

The Sakai LMS serves as the institution's primary learning management platform, supporting blended and online teaching, assessment, and academic communication. While the system is centrally managed, it is implemented across multiple colleges, schools, and departments, providing

a rich and diverse context to examine institutional governance, technical and human capacity development, and practices promoting inclusive digital learning. The sustained use of Sakai at the University of Ghana offers unique insights into how open-source LMS platforms can enhance resilience, accessibility, and innovation in higher education settings in Sub-Saharan Africa.

Participants and Sampling

The sample size of ten (10) was guided by the principle of information power, whereby fewer participants are required when the study aim is narrow, the case is information rich, and participants hold deep expertise in the phenomenon under investigation. Each participant occupied a strategic position within the LMS ecosystem and was directly involved in decision-making, implementation, or advanced use of Sakai, ensuring that the data captured institutional rather than peripheral perspectives. Data were collected through purposive sampling of key institutional actors directly involved in the governance, implementation, and pedagogical use of the Sakai LMS. Purposive sampling was employed to ensure that participants possessed in-depth knowledge and practical or experiential experience relevant to the study objectives. A total of ten participants were recruited, comprising:

- Three central LMS administrators or systems engineers responsible for technical management and system development
- Three instructors or e-learning leads involved in course design and faculty support
- Three teaching and learning policy leads with responsibility for institutional digital learning strategy
- One faculty champion recognised for advanced and innovative use of the Sakai LMS.

This multi-stakeholder sample allowed for triangulation of perspectives across technical, pedagogical, and policy dimensions of LMS implementation. Although the sample is limited to one institution and ten participants, it was carefully selected to capture the depth and diversity of experience necessary for analytical generalisation, rather than statistical generalisation, as recommended in qualitative case study research (Yin, 2018). The inclusion of both implementers and strategic decision-makers ensures that findings reflect a holistic understanding of the LMS ecosystem within the University of Ghana.

Data Collection Method and Procedure

For data collection method, semi-structured interviews were conducted with ten purposively selected participants directly involved with Sakai LMS adoption and implementation. Participants included three LMS administrators or systems engineers responsible for technical management, three instructors or e-learning leads involved in course design and faculty support, three teaching and learning policy leads responsible for institutional digital learning strategy, and one faculty champion recognised for advanced LMS use and innovation.

The semi-structured interview guide was designed to align with the study objectives and the analytical lens of Dynamic Capabilities Theory, focusing on sensing, seizing, and transforming capabilities, as well as inclusion, accessibility, and sustainability. The guide comprised seven sections: *background and role, sensing capabilities, seizing capabilities, transforming capabilities, inclusion and accessibility, sustainability, and reflections*. It contained fifteen open-ended questions exploring participants' experiences with Sakai LMS adoption, perceived benefits and challenges, capacity development initiatives, accessibility practices, governance, and views on future innovation, including integration of artificial intelligence.

In June 2025, participants were first contacted through formal institutional channels and provided with an information sheet outlining the purpose of the study, ethical considerations, and expectations regarding participation. Interview sessions were scheduled between August 2025 at times convenient to participants and conducted either face to face or via secure online platforms, depending on participant availability. Each interview lasted approximately thirty to forty-five minutes. Prior to commencement, informed consent was obtained, and participants were reminded of their right to withdraw at any stage. Interviews followed the guide systematically while allowing flexibility to probe emerging issues and clarify responses. This procedural approach ensured consistency across interviews while supporting the generation of rich and contextually grounded qualitative data.

All interviews were conducted with participants' informed consent, audio-recorded, and transcribed verbatim to ensure accuracy. The semi-structured format allowed for consistency across interviews while providing flexibility to probe emerging themes and clarify responses, enhancing the depth and richness of the data collected. All interviews were conducted with participants' informed consent, audio-recorded, and transcribed verbatim to ensure accuracy.

Data Analysis

Data analysis followed a thematic analysis approach, combining deductive and inductive coding. An initial coding framework was developed based on the core constructs of Dynamic Capabilities Theory, namely sensing, seizing, and transforming. This deductive phase enabled systematic examination of how institutional capabilities shaped LMS resilience, inclusion, and sustainability. Inductive coding was subsequently applied to capture emergent themes not fully explained by the theoretical framework, such as faculty workload, informal support networks, and perceptions of technological autonomy. Codes were iteratively refined through constant comparison across interview transcripts. To enhance analytical rigour, coding was conducted in multiple cycles, with themes reviewed and refined to ensure coherence, internal consistency, and alignment with the study objectives.

Trustworthiness and Rigour

Several strategies were employed to ensure the trustworthiness of the findings. Data triangulation was achieved by integrating interview data with institutional document analysis and perspectives from multiple stakeholder groups. Peer debriefing was conducted during the coding process to enhance interpretive consistency and reduce researcher bias. Thick description was used to provide contextual detail, enabling readers to assess the transferability of the findings. An audit trail documenting data collection decisions, coding processes, and analytical reflections was maintained throughout the study. These measures collectively strengthened the credibility, dependability, and confirmability of the findings.

Ethical Considerations

Ethical approval for the study was obtained from the appropriate institutional review body at the University of Ghana. All participants were informed about the purpose of the study, their voluntary participation, and their right to withdraw at any stage without penalty. Confidentiality was ensured through anonymisation of participant identities and secure storage of data. Findings are reported in a manner that protects participants and the institution from potential harm.

Methodological Limitations

While the qualitative case study design enabled in-depth and contextually grounded analysis, the findings are not intended to be statistically generalisable to all Ghanaian universities. However, the study explicitly pursues analytical and theoretical generalisation by linking empirical insights to Dynamic Capabilities Theory.

The selection of a single, mature case allows examination of processes and mechanisms that are often inaccessible in short-term or multi-site studies, particularly in relation to sustainability, institutional learning, and governance of open-source systems. Rather than claiming representativeness, the article offers transferable insights that may inform similar higher education institutions facing comparable digital learning challenges in Sub-Saharan Africa and other resource-constrained contexts. Future research could extend this study through comparative case studies across multiple Ghanaian universities, longitudinal designs examining capability development over time, or mixed-method approaches incorporating student learning outcomes and usage analytics.

Analysis of Interview Data

The analysis reveals a layered and evolving account of how the Sakai LMS has shaped digital learning resilience, inclusion, and sustainability at the University of Ghana. Rather than a linear implementation narrative, participants described an ongoing institutional learning process marked by adaptation, negotiation, and uneven capacity development. Five interrelated themes structure the findings.

Resilience as Organisational Adaptation Rather Than Mere Continuity

Participants framed resilience not simply as the ability to keep teaching going, but as the institution's capacity to absorb disruption and reorganise core academic processes under pressure. While the COVID period served as a catalytic moment, administrators emphasised that Sakai had already become embedded in academic routines before the crisis, which enabled rapid institutional response. An interviewee shared his view:

"When the pandemic arrived, we were not starting from scratch. Sakai was already part of our teaching culture, so the challenge was scaling its use rather than introducing it." (LMS Administrator 2)

An LMS administrator reflected that resilience emerged from prior experimentation rather than emergency improvisation, noting that the university had already invested in internal technical expertise and governance structures. Instructors echoed this view, describing how the platform allowed them to rethink pedagogy rather than merely replicate face to face teaching online. Several noted that asynchronous tools became particularly valuable for students with connectivity challenges, allowing learning to continue despite infrastructural constraints. However, resilience was described as fragile and uneven. Participants acknowledged that server performance, bandwidth limitations, and student digital skills periodically undermined continuity. Another interviewee commented:

"There were periods when heavy traffic slowed the system, and some students struggled because they lacked the digital skills to fully utilise the platform." (LMS Administrator 1)

These tensions reveal resilience as a dynamic and ongoing process rather than a fixed outcome, aligning with the transforming dimension of dynamic capabilities in which systems are continually adjusted in response to stressors. This theme demonstrates how institutional sensing of disruption translated into adaptive reconfiguration of digital learning practices.

Technical, Institutional, and Human Capacity Challenges

Rather than isolated obstacles, participants described capacity challenges as mutually reinforcing constraints shaping LMS effectiveness. Administrators emphasised the hidden labour involved in maintaining an open-source system, including upgrades, integrations, and security management. An LMS Administrator remarked:

"People often think open source means free, but maintaining Sakai requires skilled personnel, constant upgrades, server optimisation and security monitoring." (LMS Administrator 3)

They stressed that technical sustainability depends on institutional recognition of this labour as strategic rather than merely operational. Instructors also foregrounded human capacity challenges, particularly uneven faculty confidence and pedagogical fluency. An instructor shared his view:

"Most lecturers know how to upload lecture notes, but many are still unfamiliar with interactive tools such as quizzes, peer discussions and collaborative learning features." (Instructor 2)

Several observed that while basic LMS use was widespread, deeper engagement with interactive and collaborative tools remained limited. This was attributed not to resistance, but to competing academic pressures and insufficient pedagogical support structures. Policy leads highlighted institutional tensions, noting that while digital learning policies existed, enforcement and coordination across faculties varied significantly. Without consistent incentives or accountability mechanisms, LMS engagement depended heavily on individual motivation rather than institutional expectation. Together, these insights illustrate sensing capabilities at work, as participants identified internal misalignments that constrain the full realisation of LMS value.

Inclusion and Accessibility for Supporting Diverse Learners

Participants widely endorsed inclusion and accessibility as core values underpinning Sakai adoption. Administrators pointed to technical affordances such as mobile access, flexible content formats, and compatibility with assistive technologies. An interviewee narrated:

"Students can access course materials on their phones, revisit recorded lectures and use different content formats depending on their learning needs." (LMS Administrator 1)

Instructors described deliberate instructional design choices intended to accommodate diverse learning styles and participation patterns. Another interviewee remarked:

"I intentionally upload videos, PDFs and narrated presentations because not all students learn effectively through one format." (Instructor 3)

Yet participants were candid about the gap between aspiration and practice. Policy leads acknowledged that inclusive design was not uniformly embedded across departments and often depended on individual champions rather than systematic enforcement. The faculty champion

described inclusion as a cultural practice that spreads through demonstration and peer influence rather than policy alone.

These accounts suggest that seizing capabilities are present but unevenly institutionalised. The LMS provides the tools for inclusion, but organisational routines and incentives have not fully matured to ensure consistent application.

Sustainability as Strategic Alignment and Institutional Commitment

Sustainability was framed less as a technical issue and more as a question of long-term institutional commitment. Administrators stressed that open-source systems reduce licensing costs but increase the need for stable internal investment in skills and infrastructure. An administrator narrated thus:

"Apart from the software requiring licence fees, sustainability depends on investing in people, infrastructure and continuous system improvement." (LMS Administrator 2)

Instructors linked sustainability to continuous professional development, arguing that without regular training, faculty engagement declines over time. An instructor commented:

"Training cannot be a one time workshop. Every semester new lecturers need support and experienced staff need refresher training." (Instructor 1)

Policy leads emphasised strategic alignment, noting that Sakai's sustainability depends on its integration into broader teaching and learning strategies rather than treatment as a standalone system. Engagement with the global Sakai community was described as both a technical and strategic resource, enabling knowledge exchange, shared problem solving, and system evolution. An administrator expressed his view:

"The global Sakai community allows us to learn from other universities, solve technical problems collaboratively and continuously improve the platform." (LMS Administrator 3)

This theme reflects transforming capabilities, as sustainability emerges from deliberate reconfiguration of governance, funding, and partnerships.

Innovation as Controlled Experimentation Rather Than Rapid Disruption

Innovation was described as incremental and cautious rather than disruptive. Administrators discussed pilot initiatives involving learning analytics and early AI applications, emphasising the need to balance experimentation with reliability. An LMS administrator shared his opinion:

"We are testing AI features gradually because reliability and educational quality are more important than adopting technology simply because it is new." (LMS Administrator 1)

Instructors also reported using analytics to refine assessment and feedback practices, while remaining cautious about data interpretation and workload implications. Policy leads highlighted the importance of evaluating emerging technologies against institutional values of equity and accessibility. The faculty champion described innovation as a process of guided experimentation,

where success depends on institutional support and peer learning rather than individual enthusiasm alone. A faculty Champion narrated:

"Innovation succeeds when lecturers are supported to experiment, share experiences and learn from one another rather than being forced to adopt new technologies." (Faculty Champion)

This theme underscores how dynamic capabilities enable innovation through deliberate seizing and transforming processes rather than uncritical adoption of new technologies.

Table 1: Mapping Themes to Study Objectives and Dynamic Capabilities

Theme	Objective	Dynamic Capabilities Dimension
Resilience: Continuity of Digital Learning	Objective 1	Sensing & Transforming
Capacity Challenges	Objective 2	Sensing
Inclusion and Accessibility	Objective 3	Seizing
Sustainability	Objective 4	Transforming
Innovation and Emerging Technologies	Objective 1 & 3	Seizing & Transforming

Discussion of Findings

The findings of this study provide important insights into the role of open-source LMS, specifically Sakai, in fostering resilient, inclusive, and sustainable digital learning in Ghanaian higher education. The discussion below integrates the study objectives with the Dynamic Capabilities Theory, situating the findings within current literature and highlighting broader implications for practice and policy.

Resilience in Digital Learning

The findings indicate that the Sakai LMS substantially strengthened the University of Ghana's ability to sustain teaching and learning during periods of disruption, particularly during the COVID 19 pandemic. Participants consistently reported that the platform enabled continuity of lectures, assessments, and academic communication, thereby reducing instructional downtime. This reinforces earlier studies that identify open source LMS platforms as critical enabling operational continuity in resource constrained higher education environments (Allam et al., 2024).

Administrators highlighted that Sakai supported both synchronous and asynchronous teaching, allowing flexibility in course delivery for students located in remote or underserved areas. Instructors emphasised that tools such as discussion forums, multimedia uploads, and assignment workflows facilitated pedagogical adaptation under constrained conditions. At the same time, participants acknowledged persistent challenges, including intermittent server downtime, bandwidth limitations, and uneven student digital literacy, which posed risks to sustained resilience if left unaddressed.

From the perspective of Dynamic Capabilities Theory, these findings reflect the institution's sensing and transforming capabilities. The university demonstrated an ability to recognise external shocks and internal system gaps, and to reconfigure teaching processes to preserve instructional continuity. This illustrates how digital learning platforms function not only as technical tools but also as strategic resources that enhance organisational resilience in volatile and uncertain environments.

Institutional, Technical, and Human Capacity Challenges

Participants identified a range of challenges related to infrastructure, human capacity, and institutional governance that constrained the effective use of the Sakai LMS. Administrators pointed to the technical demands of server management, system integration, and continuous software updates. Faculty members noted that limited training and uneven digital competence restricted their ability to utilise advanced LMS features such as learning analytics and adaptive tools. Policy leads emphasised gaps in funding models and governance structures that affected system sustainability.

These findings are consistent with prior research showing that successful adoption of open source technologies in higher education depends on the alignment of infrastructure, institutional support, and human resource capacity (Nyamboga et al., 2024; Namayala et al., 2024). Without such alignment, LMS use may remain largely transactional, limiting its potential to enhance pedagogical quality and learning outcomes.

Viewed through Dynamic Capabilities Theory, these challenges underscore the centrality of sensing capabilities. Universities must continuously identify deficiencies in technical systems, faculty skills, and policy frameworks in order to respond effectively to evolving digital demands. The findings therefore highlight the need for sustained investment in capacity building and institutional learning to fully leverage the transformative potential of open source LMS platforms.

Inclusion and Accessibility

The study found that Sakai supports inclusive and accessible teaching and learning through features such as mobile compatibility, flexible content formats, and adaptable assessment design. Participants noted that these features expanded access for students with varying learning needs and technological constraints. Faculty champions played a key role in demonstrating inclusive practices and mentoring colleagues, thereby encouraging broader uptake of accessibility oriented LMS use.

Despite these strengths, participants observed that inclusive practices were unevenly implemented across faculties. While institutional policies promoting inclusion exist, their translation into consistent pedagogical practice remains limited (Van Wingerden, 2021). This suggests that inclusion is shaped not only by system functionality but also by faculty capacity, institutional incentives, and monitoring mechanisms.

These findings align with literature indicating that open source LMS platforms can enhance equity and access when deliberately aligned with inclusive pedagogical strategies (Bogers et al., 2019; Teece, 2020). From a Dynamic Capabilities perspective, this reflects seizing capabilities, as institutional actors actively mobilise technological features and human resources to address diverse learner needs and reduce structural barriers to participation.

Sustainability and Long Term Adoption

Sustainability emerged as a central concern among participants, extending beyond technical system maintenance to include staffing continuity, funding stability, and strategic alignment. Administrators emphasised the importance of robust infrastructure and dedicated technical personnel, while instructors highlighted the role of continuous professional development in sustaining meaningful LMS use. Policy leads stressed that embedding LMS adoption within institutional strategy enhanced long term viability.

Participants also underscored the value of engagement with the global Sakai community, which facilitated knowledge sharing, peer support, and cost effective system maintenance. Such collaborations were viewed as particularly important in mitigating resource constraints and supporting incremental system improvement over time.

These findings support earlier studies which argue that long term adoption of open source LMS platforms depends on strategic governance, stakeholder engagement, and resource planning (Teece, 2020; Faridian and Neubaum, 2021). Within the Dynamic Capabilities framework, sustainability reflects transforming capabilities, as the university continually reconfigures internal structures and external partnerships to maintain system relevance and effectiveness (Akacha, & Awad, 2023).

Innovation and Emerging Technologies

Participants identified significant opportunities for integrating emerging technologies such as artificial intelligence and learning analytics into the Sakai LMS. Administrators described pilot initiatives that tracked student engagement and performance data to support early intervention. Instructors noted the pedagogical value of analytics in refining assessment design and providing targeted learner support.

At the policy level, participants emphasised the need for strategic evaluation of emerging technologies to ensure alignment with institutional priorities, accessibility goals, and ethical considerations. Innovation was therefore framed not as rapid technological adoption, but as a measured and contextually grounded process.

These findings are consistent with literature on open source ecosystems, which highlights their capacity to support experimentation, innovation, and collaborative value creation in educational contexts (Abbate et al., 2022; Fukawa et al., 2021). From a Dynamic Capabilities perspective, these initiatives demonstrate both seizing and transforming capabilities, as technological opportunities are selectively adopted and integrated into institutional routines to enhance learning outcomes sustainably.

Conclusion

This study explored the adoption and implementation of the Sakai open-source LMS at the University of Ghana, focusing on its role in fostering resilience, inclusion, and sustainability in higher education. Guided by Dynamic Capabilities Theory, the study examined how the university sensed emerging gaps in digital learning, seized opportunities through LMS adoption and governance, and transformed institutional practices to integrate new technologies and inclusive teaching approaches.

The findings indicate that Sakai has significantly enhanced the university's capacity to maintain continuity of instruction during disruptions, demonstrating resilience in digital learning. The LMS provides flexible teaching and learning tools that support asynchronous and synchronous engagement, improving access for diverse student populations. However, persistent challenges such as limited faculty training, technical capacity gaps, and inconsistent governance highlight the need for systematic institutional support to fully exploit the potential of open-source platforms.

In terms of inclusion and accessibility, Sakai facilitates equitable learning opportunities through mobile access, adaptable content formats, and flexible pedagogical design. Yet achieving full accessibility requires continuous faculty mentoring, awareness raising, and deliberate policy enforcement. Sustainability emerged as a critical theme, emphasizing the importance of strategic

planning, collaboration with open-source communities, and the integration of emerging technologies such as artificial intelligence and learning analytics to enhance personalization and learner engagement.

The paper contributes to both theory and practice by demonstrating that open-source LMS platforms can serve as dynamic organisational capabilities that enable higher education institutions in resource-constrained contexts to sense challenges, seize opportunities, and transform practices for long-term impact. Practically, universities can leverage these insights to strengthen technical capacity, develop inclusive digital learning policies, and foster sustainable collaboration with the global open-source community.

In conclusion, the Sakai LMS journey at the University of Ghana offers valuable lessons for Sub-Saharan Africa and other similar contexts. By strategically embracing open-source digital learning platforms, higher education institutions can achieve resilient, cost-effective, and inclusive education while positioning themselves to innovate and respond proactively to future technological and pedagogical challenges.

Implications of the Study

The findings of this article have significant theoretical, practical, and policy implications for higher education institutions in Ghana and similar contexts, particularly regarding the adoption and sustainability of open-source LMS.

Theoretical Implications

By applying Dynamic Capabilities Theory, this study demonstrates that open-source LMS platforms function as strategic organisational capabilities. The LMS enables institutions to sense emerging challenges in digital learning, seize opportunities through adoption and governance, and transform processes to integrate innovative technologies and inclusive pedagogical practices. This extends prior research on open-source technologies by showing how universities in resource-constrained settings can actively reconfigure resources and processes to achieve resilience, inclusion, and sustainability. The paper also contributes to the literature on digital learning in higher education by providing context-specific evidence from Sub-Saharan Africa, highlighting the importance of organisational capabilities in driving effective technology adoption.

Practical Implications

The study offers actionable insights for university administrators, faculty, and technical teams. First, continuous capacity building is essential. Training, mentoring, and technical support for faculty and staff enhance LMS adoption and ensure that advanced functionalities, including analytics and AI integration, are effectively utilised. Second, institutional policies and governance frameworks should embed LMS adoption into the broader digital learning strategy to promote consistent use, accountability, and sustainability. Third, fostering collaboration with global open-source communities provides access to shared knowledge, system updates, and innovation, reducing costs and increasing institutional autonomy. Fourth, integrating emerging technologies within LMS platforms can support personalised learning and improve student engagement, if usability, accessibility, and inclusivity are prioritised.

Policy Implications

At the policy level, the study underscores the need for national and regional strategies to support open-source LMS adoption in higher education. Governments and regulatory bodies should

consider developing frameworks that provide sustainable funding, technical support, and training initiatives for universities. Policies should also encourage knowledge sharing and collaboration among institutions to maximise the benefits of open-source platforms while ensuring compliance with accessibility and inclusion standards. Such strategic support can enable higher education institutions to achieve resilient, equitable, and future-ready digital learning ecosystems.

Implications for Future Research

The article highlights areas for further investigation. Future research could examine the impact of integrating advanced technologies such as artificial intelligence on teaching and learning outcomes in open-source LMS platforms. Comparative studies across universities in different Sub-Saharan African countries could also provide insights into best practices and contextual factors influencing LMS adoption and sustainability. Finally, longitudinal studies could track the long-term impact of open-source LMS adoption on institutional resilience, inclusion, and innovation.

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