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Designing a Cloud-Based Smart-EduVerse Management System for Prescriptive Quality Governance in Higher Education: A Mixed-Methods Study

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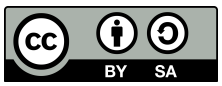
ABSTRACT

The purpose of this study is to develop a Cloud-Based Smart-EduVerse Management System (S-EMS) architecture as a digital quality mapping framework designed to strengthen Sustainable Competitive Advantage (SCA) in Indonesian State Universities with Legal Entity (PTNBH) status amid the VUCA era. This study employed a mixed-methods approach using a concurrent embedded design with qualitative dominance. The research involved 22 PTNBHs, with qualitative data collected through in-depth interviews, observations, and document analysis, while quantitative data were obtained through questionnaires. Both datasets were integrated during the interpretation stage using constant comparative analysis and descriptive statistics to formulate the system architecture and governance requirements. The results indicate that S-EMS consists of three cloud-based functional layers: (1) a prescriptive data mapping layer integrating institutional quality indicators, (2) a cloud-hosted knowledge asset management module for organizing human and intellectual capital, and (3) an adaptive governance dashboard supporting real-time cross-campus decision-making. Quantitative findings show that 19 of the 22 universities (86.4%) have integrated digital infrastructure, while strategic collaboration and adaptive quality assurance practices were implemented across nearly all participating institutions. These findings demonstrate that the proposed architecture reduces data fragmentation, improves interoperability, and supports evidence-based governance, facilitating a transition from compliance-based to impact-based institutional management. This study contributes a validated cloud-based Smart-EduVerse Management System (S-EMS) framework integrating digital quality mapping, knowledge asset management, and prescriptive governance to strengthen sustainable competitive advantage in higher education.



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1. INTRODUCTION

The development of cloud computing and big data analytics technologies opens opportunities to redesign quality governance models through more flexible, scalable cross-unit data integration. However, previous research is often fragmented: higher education management research focuses on policy and governance, while information systems research focuses on technical aspects and overlooks institutional strategy. No framework has been found that explicitly integrates cloud-based system architecture with digital quality mapping grounded in strategic management theories such as Dynamic Capabilities, the Knowledge-Based View, and Strategic Agility. More importantly, previous studies have largely examined these perspectives in isolation, leaving a limited understanding of how integrating them can strengthen adaptive digital governance and Sustainable Competitive Advantage (SCA) in higher education. This gap is the focus of this research. Higher education governance is currently facing significant transformational pressures due to the VUCA landscape (Volatility, Uncertainty, Complexity, Ambiguity) and accelerated technological advancements. In the midst of complex global competition demands, the ability, independence, and quality of HEIs are fundamental needs. To maintain global relevance and competitiveness, HEIs are required to manage resources nimbly and build a Sustainable Competitive Advantage (SCA) that goes beyond mere administrative compliance. Urgently, institutional quality should be seen as a strategic investment, a need to build the foundation for a better future and nurture human resources, not just an operational compliance issue [1–3]. Key theoretical foundations, including Knowledge-Based Views (KBV) and Dynamic Capabilities, emphasize that effective knowledge management and dynamic capability development are essential for SCA amid rapidly changing environments [4–6]. In addition, Strategic Agility enables IPTs to respond quickly and effectively to external changes [7–9]. While Sustainable Leadership and Social Innovation are important mechanisms to drive sustainable performance [10, 11].

Previous research has consistently supported the central role of digital transformation and knowledge management in strengthening SCA. Digitalization forces HEIs to develop sustainable curricula, increase innovation, and strengthen competitiveness through technology integration, data analysis, and knowledge asset management [12–16]. For the institution to achieve SCA and World Class University (WCU) status, as a key benchmark for excellence, there must be a concentration of talent and systems, with better-quality governance as a key instrument. However, the data shows that although broad autonomy is granted to State University Legal Entities (PTN-BH) through their statutes, only a small fraction of the 22 PTN-BH in Indonesia have made it to the Top 500 QS World University Rankings, highlighting the ongoing challenges in realizing competitive advantage (QS World University Rankings 2026: Best Global Universities). It demands sound governance, supported by policy and accountability [17, 18], leveraged to transition quality into strategic investments focused on innovation and sustainable leadership. Although the need for agile governance and digital transformation is recognized, fundamental obstacles to technology implementation remain significant barriers in PTN-BH. Research on the Indonesian context reveals that academic management systems are often fragmented, with core platforms such as Academic Information Systems (AIS) and Learning Management Systems (LMS) failing to integrate, hindering timely data integration. This fragmentation extends beyond the academic system to vital operational units, including remuneration systems, integrated laboratory services, and other administrative support. In addition, this fragmented ecosystem is greatly exacerbated by the lack of sustainable human resource (HR) mapping tools, which leads to suboptimal resource planning and competency development and prevents PTN-BH from making full use of its knowledge assets amid the demand for advanced technologies such as AI and Big Data. As a result, the systems implemented remain largely descriptive, reporting only past performance, and fail to shift to prescriptive analytics that provide actionable, real-time recommendations, severely jeopardizing PTN-BH's ability to achieve the agility needed to navigate VUCA dynamics.

Previous studies have highlighted the importance of digital technologies in improving higher education governance through the integration of academic management systems. Proposed a REST-based integration model connecting Academic Information Systems (AIS) and Learning Management Systems (LMS) to improve data exchange across educational platforms [19]. Similarly, introduced the SMAART model to support evidence-based academic management and developed a conceptual Education Management Information System (EMIS) that integrates institutional information to improve administrative efficiency. These studies demonstrate that digital information systems play a significant role in supporting university governance; however, their primary focus remains on technical system integration and operational management rather than strategic institutional governance [20, 21].

Recent advances in learning analytics and artificial intelligence have further expanded the capability of higher education information systems. Whereas [22] introduced explainable machine learning combined with automated prescriptive analytics to improve students' academic performance. Within the Indonesian context, [23] discussed the future development of Learning Management Systems, while [24] emphasized the importance of leadership and change management in supporting digital transformation toward World-Class Universities. Collectively, these studies confirm that digitalization, analytics, and adaptive leadership are increasingly important for institutional competitiveness.

Building upon these streams of literature, this study develops a conceptual framework that integrates four complementary theoretical perspectives into a unified digital governance model for higher education. Knowledge-Based View (KBV) provides the foundation by conceptualizing institutional knowledge, human resources, research outputs, and intellectual capital as strategic assets

that must be systematically captured, integrated, and leveraged to generate Sustainable Competitive Advantage (SCA). Dynamic Capabilities Theory explains how universities continuously sense environmental changes, seize emerging opportunities, and reconfigure institutional resources to respond effectively to the uncertainties of the VUCA era. Strategic Agility complements this perspective by emphasizing rapid organizational adaptation through strategic sensitivity, leadership unity, and resource fluidity, enabling institutions to implement timely governance decisions. Meanwhile, Cloud Computing serves as the enabling technological infrastructure that orchestrates institutional data across academic, research, financial, human resource, and quality assurance domains into an interoperable digital ecosystem. As illustrated in the proposed conceptual framework, these four theoretical pillars collectively underpin the Smart-EduVerse Management System (S-EMS), in which cloud-enabled data integration transforms fragmented institutional information into knowledge assets, dynamic organizational capabilities, adaptive governance mechanisms, and ultimately prescriptive decision intelligence that strengthens institutional quality and Sustainable Competitive Advantage.

Nevertheless, several important limitations remain. Existing studies generally address academic information systems, learning analytics, artificial intelligence, leadership, and digital transformation as separate research domains. Most digital governance models continue to operate within fragmented institutional environments in which academic, research, financial, human resources, and quality assurance systems remain disconnected. Consequently, institutional data cannot be comprehensively integrated to support strategic decision-making across organizational units. Furthermore, existing platforms predominantly provide descriptive reporting that monitors historical performance, with limited capability to generate prescriptive recommendations for institutional policy and governance. This limitation is particularly evident in Indonesian State Universities with Legal Entity (PTN-BH), where fragmented digital ecosystems constrain organizational agility, knowledge asset utilization, and sustainable competitive advantage under the increasingly dynamic VUCA environment.

To address these limitations, this study positions the Smart-EduVerse Management System (S-EMS) as an integrated prescriptive digital governance framework rather than merely a technology platform. Unlike previous studies that focus separately on system integration, learning analytics, or organizational change, S-EMS synthesizes cloud-based orchestration, knowledge asset integration, adaptive quality governance, and strategic management theories, including the Knowledge-Based View (KBV), Dynamic Capabilities, and Strategic Agility, into a unified governance architecture. Through this integration, S-EMS transforms fragmented institutional data into strategic intelligence that supports real-time, evidence-based, and prescriptive decision-making. Consequently, this study contributes theoretically by extending digital governance research beyond operational system implementation and, practically, by providing a strategic roadmap for PTN-BH to transition from fragmented, compliance-oriented quality management to adaptive, integrated, and sustainable institutional governance. Recent studies emphasize that Enterprise Architecture (EA) provides a strategic framework for integrating institutional business processes, digital infrastructure, and governance into a unified ecosystem. Rather than focusing solely on technological integration, EA aligns organizational objectives, information systems, and decision-making processes, thereby improving interoperability, institutional agility, and data-driven governance in higher education [25].

Therefore, this qualitative study aims to propose and explore the Smart-EduVerse Management System (S-EMS) framework as a strategic roadmap for quality management transformation in Indonesian PTN-BH in the VUCA era. In particular, this study sets the following research objectives: (1) exploring the components of higher education needs through Digital Mapping of the resources owned to improve quality in the VUCA era, (2) finding a digital integration map of Mapping Suistainable Competitive Advantage Based on Smart-EduVerse Management System (S-EMS) to improve the quality of universities in the VUCA era; and (3) find the results of the achievement of improving the quality of higher education in the VUCA era through Digital Mapping of Suistainable Competitive Advantage Based on the Smart-EduVerse Management System (S-EMS) in Indonesia.

2. RESEARCH METHOD

2.1. Research Approach and Design

The design was carried out using a qualitative initial research design, then strengthened with quantitative data weighted differently. Syntax sequence aspects are carried out simultaneously, and qualitative weights dominate. The design justification is in the form of reconstructing the generalization of qualitative findings reinforced by quantitative findings. Concurrent embedded models can be selected by determining which approach dominates other approaches. The justification of this research design seeks to reconstruct a generalization of the qualitative findings reinforced by quantitative findings. In the process, a qualitative model is employed, which serves as the main research method in this study. While the quantitative method as a reinforcing method or secondary method. In practice, the implementation of data collection for the two methods is carried out simultaneously. Integration of qualitative and quantitative data occurred during the interpretation stage, where qualitative findings from interviews, observations, and document analysis were compared and strengthened using descriptive quantitative results from the questionnaires. This integration enabled the validation of emerging themes and supported the formulation of the Smart-EduVerse Management System (S-EMS) architecture based on convergent evidence from both datasets.

2.2. Data Sources and Informants

This research was conducted in 22 Legal Entity State Universities (PTN-BH) in Indonesia. Purposive sampling was employed to select informants who possessed strategic responsibilities related to institutional governance, quality assurance, digital transformation, and higher education management. The number of informants for each university being 5 key informants, including: Rector/Vice Chancellor/Head of Quality Assurance Unit, Cooperation/Planning/Branding, Research and Community Service and Education Development institutions, data and information centers, Lecturers and Students which are divided into four zones: (1) Zone I: East Java (UNAIR, ITS, UB, UM, UNESA), (2) Zone II: Central Java-DIY (UGM, UNDIP, UNY, UNNES, UNS), (3) Zone III: West Java-DKI (ITB, UNPAD, UPI, UI, IPB, UT, UIII), and (4) Zone IV: Outer Java (USU, UNAND, UNP, UNHAS, and UNSYIAH).

After determining the zones, purposive sampling successfully identified stakeholders from all 22 universities. Each university involved an average of 7–10 participants consisting of institutional leaders, quality assurance personnel, academic staff, and students, resulting in a diverse representation of managerial and operational perspectives. Two universities were represented directly by Vice Rectors from Zones I and IV, while the remaining institutions were represented by quality assurance units, planning offices, cooperation offices, research institutes, educational development centers, data centers, lecturers, and students. The interview process lasted approximately 30–60 minutes using semi-structured interview guidelines that had been reviewed by experts to ensure content validity and consistency across institutions.

2.3. Data Collection Techniques

Qualitative data were collected through semi-structured interviews, direct observations, and document analysis, while quantitative data were collected using a Likert-scale questionnaire. The interview instrument was developed based on the theoretical constructs of Knowledge-Based View (KBV), Dynamic Capabilities, Strategic Agility, Sustainable Competitive Advantage, and digital governance. The questionnaire measured respondents' perceptions regarding strategic assets, digital infrastructure integration, system fragmentation, institutional collaboration, adaptive quality assurance, and readiness for Smart-EduVerse Management System (S-EMS) implementation. Prior to data collection, both instruments were reviewed by higher education management and information systems specialists to ensure content validity and clarity. Qualitative data analysis included data condensation, data display, and conclusion drawing, while quantitative analysis employed descriptive statistics to calculate frequency distributions, mean scores, and percentages for each research indicator, including strategic assets, system fragmentation, digital integration, strategic collaboration, adaptive quality assurance, and institutional readiness for S-EMS implementation. Direct observations focused on the implementation of academic management systems and institutional dashboards to identify the gap between existing descriptive information systems and the need for prescriptive governance. Documentary studies reviewed institutional strategic documents, including university statutes, development master plans, annual performance reports, and Internal Quality Assurance System documents, to validate the qualitative findings.

2.4. Data Analysis Techniques

Qualitative data were analyzed using the Constant Comparative Method. The analysis began with open coding to identify significant concepts from interview transcripts, followed by axial coding to group related concepts into categories, and selective coding to develop overarching themes representing institutional needs and governance challenges. Themes emerging from individual PTN-BH cases were continuously compared across the 22 universities to identify recurring patterns, similarities, and contextual differences. Quantitative data were analyzed using descriptive statistics to compare findings across the 22 PTN-BH. The indicators analyzed included strategic asset management, digital infrastructure integration, knowledge asset utilization, system fragmentation, strategic collaboration, adaptive quality assurance, and institutional readiness for implementing S-EMS. Descriptive statistics were selected because the quantitative component functioned as an embedded method intended to reinforce and validate qualitative findings rather than to test causal relationships. This analytical process directly supported the conceptualization of the Smart-EduVerse Management System (S-EMS) integration roadmap.

2.5. Data Trust

To ensure the validity and reliability of qualitative findings, this study applied the four criteria of trustworthiness. Credibility was established through source triangulation, method triangulation, prolonged engagement, and member checking, where interview summaries and preliminary interpretations were returned to selected informants for confirmation. Dependability was maintained through an audit trail documenting interview transcripts, coding procedures, category development, analytical memos, and the constant comparative analysis process, enabling transparency and research replication. Confirmability was strengthened through

investigator triangulation involving experts in educational management and information systems who independently reviewed coding results, thematic interpretations, and analytical decisions to minimize researcher bias. Transferability was supported through thick descriptions of institutional contexts, participant characteristics, research settings, and cross-zonal comparisons among the 22 PTN-BH, allowing readers to assess the applicability of the findings to similar higher education environments. The following figure summarizes the techniques used to maintain data integrity and analytical accuracy. It illustrates how triangulation, audit trails, investigator collaboration, and thick descriptions were strategically employed to strengthen the credibility, dependability, confirmability, and contextual validity of the qualitative findings. Techniques to Ensure Data Trust in Figure 1.

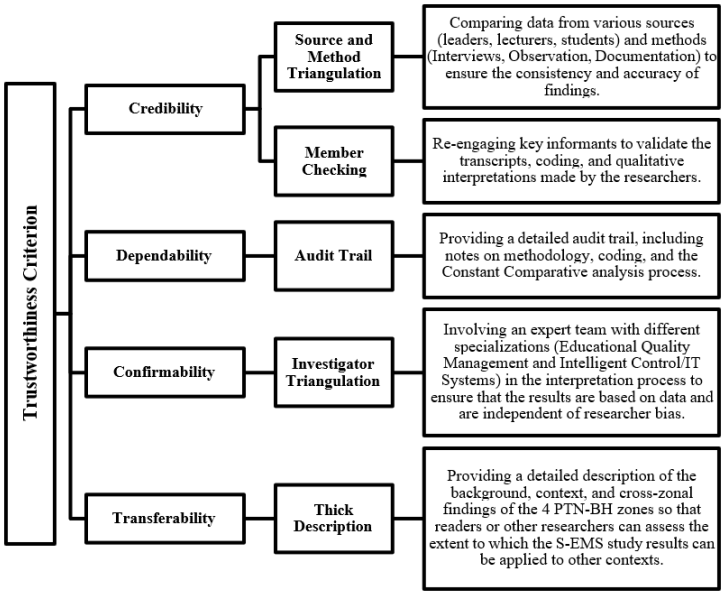

Figure 1. Techniques to ensure data trust

3. RESULT AND ANALYSIS

Exploration of the components of higher education needs through Digital Mapping of resource assets to improve quality in the VUCA era, Data analysis from 22 Indonesian State Universities with Legal Entity (PTN-BH), involving institutional leaders, quality assurance managers, lecturers, and students through interviews, observations, document analysis, and questionnaires, indicates that the needs of higher education institutions in facing the pressures of the VUCA era are no longer singular or administrative, but rather multidimensional and interconnected across institutional units. Cross-case comparative analysis across the four institutional zones revealed consistent patterns despite contextual differences, indicating that institutional competitiveness is increasingly determined by the integration of strategic resources rather than by isolated quality initiatives. Through a digital mapping process of institutional resource assets, four key components of institutional needs were identified.

3.1. Strengthening Human Resources and Intellectual Assets

Field data show that the majority of informants place human resource capacity and intellectual asset management (publications, patents, research results) as the primary foundations of institutional competitiveness. Digital mapping of personnel data, research track records, and academic productivity revealed disparities in the distribution of competencies between faculties and the lack of an integrated intellectual asset recording system across units. Quality is no longer measured solely by output, but by its practical application and tangible contribution to industry, society, and the national economy. ITS defines quality as the tangible impact of research and innovation. UNDIP measures quality based on the value of measurable research and community service. UNPAD measures the quality of research results that are directly beneficial to the wider community. UNS integrates research with the industrialization agenda. ITB views VUCA as a paradigm that demands maximum use of technology and a focus on innovation as the key to competition. UNAND prioritizes improving the quality of research and intellectual capital (patents) to ensure real contributions. USK emphasizes that institutional quality must be connected to the integration of society, industry, and graduates into the job market.

Comparative findings indicate that although each PTN-BH possesses different institutional priorities, all institutions consistently identified human capital and intellectual assets as the most critical strategic resources for achieving Sustainable Competitive Advantage (SCA). Furthermore, qualitative coding revealed that strengthening research productivity, developing competent academic staff, and optimizing intellectual property management emerged as the three most frequently discussed institutional priorities across the 22 universities.

3.2. Digital Infrastructure Integration

It was found that most State-Owned Legal Entities still operate information systems in a fragmented manner (academic, financial, personnel, and research running on separate platforms). The results of the digital infrastructure asset mapping indicate low levels of data interoperability, which impact the slow quality reporting process and overlapping data input between work units. Quality is measured by consistent system implementation, measurable planning, and commitment to sustainability. UNAIR defines quality as a core value that must be measured, well planned, and applied consistently. UB shows its commitment to becoming an "accountable and sustainable" campus through the implementation of engagement assurance. UNP views quality as a strategy to strengthen data-driven governance and competitiveness. UT (Open University) adjusts quality to achieve the status of a world-class university with the unique character of an open university in the VUCA era.

Empirical synthesis across the 22 PTN-BH indicates that digital integration has become a common institutional priority. However, institutional maturity varies considerably, with several universities already implementing integrated governance systems, while others remain dependent on standalone information systems. Overall, digital infrastructure integration emerged as one of the strongest institutional needs because fragmented information systems continue to limit evidence-based decision-making.

3.3. Strategic Collaboration

The next component of needs is strengthening strategic collaboration, both internally (across faculties/study programs) and externally (with industry, government, and international partners). The mapping shows that current collaboration is still formal-administrative (MoU) and is not systematically linked to the institution's performance database, making its impact on quality difficult to measure sustainably. Quality is considered to be publicly verifiable accountability, with a focus on balancing academic integrity, innovation, and social and global utility. UGM defines quality as a balance between academic integrity, innovation, and socio-global utility. UNS defines quality as the capacity to maintain academic relevance, international reputation, and data-driven governance. UNHAS views quality as the ability to maintain and improve sustainability. USU faces the demands of adaptation, innovation, and strengthening data-based governance. UI explicitly states its commitment to quality, workforce relevance, and research innovation. UIII defines quality through increasing research capacity and strengthening international networks.

Cross-case comparison demonstrates that almost all PTN-BH have established strategic partnerships; however, only a limited number have integrated collaboration outcomes into institutional quality indicators. Consequently, the impact of partnerships on institutional performance remains difficult to evaluate systematically. These findings indicate that future quality management systems should integrate collaboration performance into institutional dashboards to enable continuous monitoring of research impact, stakeholder engagement, and internationalization.

3.4. Adaptive Quality Assurance System

The findings indicate a shift in expectations from a static, accreditation-cycle-based quality assurance system to one that responds to real-time changes in the strategic environment. Informants emphasized the need for a quality monitoring mechanism that can dynamically adjust indicators, rather than simply meet documented standards. The qualitative findings reveal a collective and deliberate shift in the institutional definition of quality in all 22 that clearly moves from a purely Compliance-Based framework to Impact-Based Governance. This paradigm shift is structured around four core dimensions that reflect the new demands for SCA in the VUCA era. Quality is driven by the setting of internal standards that are deliberately higher than national standards, in addition to a focus on curriculum adaptation and asset management. IPB sets internal quality standards that are consciously higher than national standards to foster an innovative climate. UNNES maintains quality through the guarantee of all documented tridarma processes. UM runs an internal quality assurance system that allows asset mapping results to be used for periodic planning and evaluation. UPI views quality as a focus on building student character and adapting to the latest curriculum and dynamic stakeholders. UNESA defines institutional quality through the development of excellence in disability research, sports, and the arts supported by an ISO-based quality management system. UNY views institutional quality as relevance, competitiveness, and sustainable adaptation to global dynamics, prioritizing strengthening the Internal Quality Assurance System.

Across all four institutional zones, adaptive quality assurance emerged as a shared strategic priority despite differences in institutional characteristics. Universities increasingly perceive quality assurance not as a cyclical accreditation process but as a continuous governance mechanism that supports strategic planning, institutional learning, and organizational agility. Overall, the results of the digital mapping of these four components confirm that the fundamental needs of PTN-BH are no longer merely meeting formal quality standards, but rather the development of an integrated data ecosystem capable of accurately mapping resource assets and supporting evidence-based decision-making. These findings serve as an empirical basis for formulating the Smart-EduVerse Management System (S-EMS) architecture, in which these four components of need are translated into functional system modules (HR & knowledge asset management module, infrastructure integration module, strategic collaboration module, and adaptive quality monitoring module). Each PTN-BH region has unique qualities. For example, Zone 1 (East Java) emphasizes technology and management effectiveness, including artificial intelligence, as seen in the AI Talent Factory at UB. On the other hand, Zone 2 (Central Java-Yogyakarta) emphasizes the idea of "Locally Rooted, Globally Respected" through the improvement of laboratories that meet international requirements.

A synthesis of findings from 22 PTN-BH revealed four dominant institutional needs that consistently emerged throughout the analysis: strengthening human resources and knowledge assets, integrating fragmented digital infrastructure, enhancing strategic collaboration, and developing adaptive quality assurance systems. While these needs were identified across all institutional zones, each university prioritized implementation differently based on its organizational context and strategic objectives. This convergence of institutional needs provides strong empirical support for developing the Smart-EduVerse Management System (S-EMS), an integrated cloud-based governance framework comprising four interconnected modules: Human Resources and Knowledge Asset Management, Digital Infrastructure Integration, Strategic Collaboration, and Adaptive Quality Monitoring.

Cross-zone comparison further enriches these findings. Zone I (East Java) predominantly emphasized technology adoption, artificial intelligence, and institutional management effectiveness, exemplified by UB's AI Talent Factory initiative. Zone II (Central Java–Yogyakarta) prioritized internationally benchmarked academic quality and laboratory excellence. Zone III highlighted international collaboration, research commercialization, and digital governance integration, whereas Zone IV focused on strengthening digital readiness, administrative transformation, and institutional data governance. Despite these contextual variations, all four zones consistently recognized integrated digital governance as the principal strategy for strengthening Sustainable Competitive Advantage in the VUCA era. Strategic Institutional Needs Identified Across 22 PTN-BH and Their Implications for Quality System Development in Table 1.

Table 1. Strategic Institutional Needs Identified Across 22 PTN-BH and Their Implications for Quality System Development

Need	Empirical Evidence	Implications for Quality Systems
Strengthening Human Resources and Intellectual Assets	Cross-case analysis revealed that most PTN-BH identified human capital, research productivity, patents, and intellectual assets as the primary drivers of institutional competitiveness. Digital mapping exposed disparities in staff competencies, fragmented research databases, and the absence of integrated intellectual asset management across faculties. Institutions such as ITS, UNDIP, UNPAD, UNS, ITB, UNAND, and USK emphasized research impact, innovation, and graduate employability as indicators of quality	Quality systems should evolve from output-oriented evaluation toward integrated knowledge asset management. A centralized HR and intellectual capital repository enables competency mapping, strategic talent development, research commercialization, and evidence-based planning to strengthen Sustainable Competitive Advantage (SCA).
Digital Infrastructure Integration	Most PTN-BH continue operating fragmented academic, financial, HR, and research systems with limited interoperability, causing duplicated data entry and delayed reporting. Institutions including UNAIR, UB, UNP, and UT emphasized consistent digital governance, sustainability, and integrated institutional management as prerequisites for quality improvement.	An integrated digital infrastructure is required to eliminate data silos, improve interoperability, and provide real-time institutional information. Unified platforms enable continuous quality monitoring, faster decision-making, and more efficient governance across organizational units.
Strategic Collaboration	Internal and external collaborations remain predominantly administrative (MoUs) without systematic linkage to institutional performance indicators. Universities such as UGM, UNS, UNHAS, USU, UI, and UIII highlighted international partnerships, industry engagement, research collaboration, and academic relevance as strategic priorities.	Quality management systems should integrate collaboration indicators into institutional dashboards, enabling continuous monitoring of partnership outcomes, stakeholder engagement, research impact, and internationalization performance as strategic quality dimensions.

(Continued on the next page)

Table 1 (Continued)

Need	Empirical Evidence	Implications for Quality Systems
Adaptive Quality Assurance System	Institutions reported a paradigm shift from accreditation-driven compliance toward continuous, impact-based quality assurance. Universities including IPB, UNNES, UM, UPI, UNESA, and UNY emphasized higher internal standards, curriculum adaptation, periodic evaluation, stakeholder responsiveness, and continuous improvement aligned with institutional excellence.	Quality assurance systems should become adaptive, data-driven, and predictive rather than cyclical. Real-time monitoring, dynamic key performance indicators (KPIs), and continuous improvement mechanisms enable universities to respond proactively to changes in the VUCA environment while strengthening institutional resilience.
Integrated Institutional Data Ecosystem (Overall Finding)	The synthesis of findings across 22 PTN-BH demonstrates that institutional needs have shifted beyond compliance toward integrated digital ecosystems capable of mapping strategic assets and supporting evidence-based governance. These empirical findings underpin the design of the Smart-EduVerse Management System (S-EMS), consisting of HR & Knowledge Asset Management, Digital Infrastructure Integration, Strategic Collaboration, and Adaptive Quality Monitoring modules. Regional variations further indicate contextual priorities, with Zone I emphasizing AI-enabled institutional management and Zone II prioritizing internationally benchmarked academic quality.	The quality system should function as an intelligent governance ecosystem rather than a reporting mechanism. S-EMS operationalizes institutional intelligence through integrated data mapping, prescriptive analytics, adaptive governance, and strategic decision support, enabling universities to achieve sustainable competitive advantage in the VUCA era.

Finding a digital integration map of Mapping Sustainable Competitive Advantage Based on Smart-EduVerse Management System (S-EMS) to improve the quality of universities in the VUCA era. This S-EMS diagram is not simply a list of features; it is a visual representation of how higher education institutions can navigate the complexities of the VUCA era. Through a systematic exploration of the components of needs ranging from student access to semantic knowledge representation, and using digital mapping of resource assets as a primary tool, institutions can transform from passive education providers to data-driven, adaptive learning orchestrators for continuous and meaningful quality improvement. The proposed architecture was developed based on empirical findings obtained from the cross-case analysis of 22 PTN-BH. Rather than representing a purely conceptual information system, each functional component of S-EMS corresponds directly to institutional needs identified during interviews, observations, document analysis, and questionnaire findings. The architecture therefore reflects the synthesis of recurring institutional challenges, including fragmented governance, disconnected information systems, limited interoperability, and the need for evidence-based strategic decision-making. Validation by participating institutions confirms the strategic relevance of this framework for strengthening institutional governance and educational excellence. Across the four institutional zones, respondents consistently emphasized the importance of integrating academic information, research management, human resources, quality assurance, and institutional planning into a unified cloud-based ecosystem that supports adaptive governance. The novelty of this system lies in its socio-technical convergence and architectural orchestration designed to address the challenges of the VUCA era. Conceptual Framework of S-EMS for Digital Mapping of Higher Education Resource Assets in the VUCA Era in Figure 2.

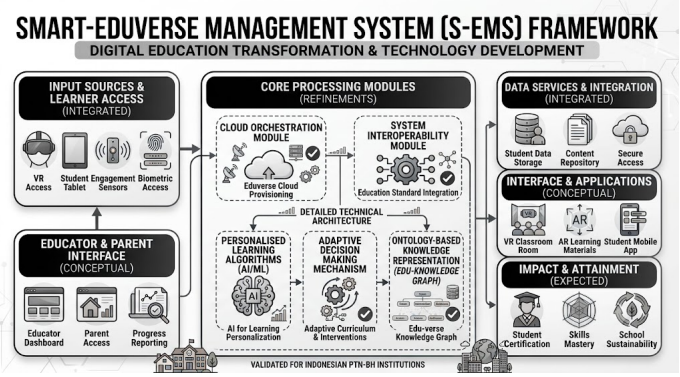

Figure 2. Conceptual framework of S-EMS for digital mapping of higher education resource assets in the VUCA era

The cloud orchestration in S-EMS is designed to serve multi-tenants (22+ PTN-BH) with varying scalability and data autonomy requirements per institution. Multi-tenant cloud architecture: each PTN-BH has an isolated tenant (logical separation) within a shared cloud infrastructure, enabling autonomous data management for each institution while still enabling cross-campus data aggregation for national/consortium SCA analysis. Microservices governance: services are separated by governance function quality indicator mapping services, knowledge asset management services, and adaptive dashboard services are containerized and orchestrated via Kubernetes to scale independently according to each institution's load (e.g., during concurrent accreditation/assessment periods). Centralized storage, distributed accessibility: cloud computing principles explicitly mentioned in the abstract HR data and intellectual asset storage are centralized (data lake/warehouse), but can be accessed in a distributed manner by stakeholders on each campus through the same API, without duplication of local databases that create silos.

Elasticity and availability: Auto-scaling based on dashboard query load (e.g., when cross-campus leadership meetings access data simultaneously), and multi-region redundancy to ensure governance continuity even if a single cloud region is disrupted. Institutional data compliance: Data residency policies and at-rest/in-transit encryption for HR and intellectual property data, given the sensitivity of personnel and research data across PTN-BH (PTN-BH) institutions. These architectural characteristics directly address one of the principal empirical findings of this study, namely the fragmentation of institutional information systems across the 22 PTN-BH. By integrating heterogeneous databases into a unified cloud infrastructure, S-EMS enables institutional leaders to obtain comprehensive institutional intelligence without duplicating administrative processes or maintaining isolated databases.

The fundamental need in 22 PTN-BH is to integrate strategic assets (Human Resources, research, systems) into an integrated Digital Mapping SCA ecosystem. Gaps The main qualitative needs identified are the fragmentation of the system and the descriptive orientation of current asset management practices. Comparative analysis in 22 PTN-BH revealed several recurring strategic needs related to human resources, thematic research focus, and digital system integration. The table below presents a synthesized mapping of these needs, supported by qualitative descriptions of several institutional cases. It highlights the pervasive challenges of system fragmentation and the use of dominant descriptive systems, underscoring the urgency of the transition to an integrated and prescriptive asset management ecosystem. This architecture aligns with recent advances in intelligent decision support systems, where artificial intelligence, cloud-based computing, and predictive analytics are integrated to transform large-scale organizational data into real-time strategic recommendations. Rather than functioning solely as a data visualization platform, S-EMS is conceptualized as an intelligent decision support system capable of assisting university leaders in evidence-based governance and adaptive institutional planning [26].

Cross-case synthesis further indicates that although institutional priorities differ according to regional characteristics, all universities consistently reported similar governance gaps. These include fragmented digital platforms, duplicated institutional databases, limited interoperability, and quality assurance systems that primarily generate descriptive reports rather than strategic recommendations. This convergence strengthens the empirical foundation for developing an integrated Smart-EduVerse Management System. Strategic Asset Category and Systemic Needs Gap Among Indonesian State Universities and Universities in Table 2.

Table 2. Strategic Asset Category and Systemic Needs Gap Among Indonesian State Universities and Universities

Needs Category	Qualitative Description (Comparative Cases in 22 PTN-BH)
Culture & Human Resources	Strengthening Human Resources through the research development center (UNPAD) and the tiered funding scheme (UNNES). UNAIR focuses on building a consistent research university culture. USU emphasizes the digitization of business processes and building competent and professional human resources. UPI highlights the need to strengthen Digital Asset Management (DAM) and Quality Assurance (QA) competencies among academics.
Thematic Focus & Niche Research	All PTN-BH maps unique thematic advantages as their SCA. ITS focuses on renewable energy, robotics, and maritime. UNS on renewable energy (lithium batteries). UNAND directs research to support communities and strategic sectors. ITB focuses on technology and innovation as a response to VUCA. UI emphasizes international collaboration and encourages innovation in research and technology.
System Integration & Asset Management	An important need is standard synchronization and system integration. UNDIP and IPB require the integration of a cross-unit quality system. UT launched the E-Asset and MyUT Management applications for integrated asset management and business processes. UNP views quality as a strategy to strengthen data-based governance. UNAND launched myUNAND Mobile and SAKU (Public Financial Application System) to accelerate administrative and financial transformation.
Needs Gap: Fragmentation & Descriptive Systems	The main obstacle in the 22 institutions: The system is sectoral (UGM, UNS) and descriptive recording data, does not provide strategic recommendations (UNDIP, IPB). UNSYIAH faces challenges with the interoperability of the old system. The universal gap is the transition from a descriptive system to a prescriptive system.

Digital Mapping of SCA Integration Schemes using Smart-EduVerse Management System (S-EMS) This study found that the incorporation of continuous competitive advantage (SCA) through S-EMS requires the incorporation of previously unconnected information into an integrated ecosystem. S-EMS is a data-driven strategic platform that combines research, community engagement,

quality standards, and financial data. More measurable and objective decision-making is made possible by systems such as SPMS (at UNAIR) and SIAIM (at UB), thereby supporting the shift from a teaching-oriented institution to a research-focused one. The next integration plan focuses on developing an AI-based dashboard that provides automated policy recommendations (a real-time decision-support system) to reduce risk in the VUCA world.

This framework is an advanced management system that combines multiple institutional data sources into one unified platform. The evaluation of the S-EMS shows that the system consists of several important layers: The first layer integrates institutional data originating from governance, research, education, community engagement, finance, and quality assurance units. The second layer applies data analytics, machine learning, and big data technologies to identify institutional trends and generate predictive insights. The third layer aggregates analytical outputs into institutional intelligence presented through adaptive digital dashboards, allowing university leaders to formulate responsive strategic policies. The resulting governance model operationalizes five interconnected dimensions of Sustainable Competitive Advantage: academic excellence, digital capability, research and innovation, stakeholder engagement, and adaptive governance agility. Comparative analysis across the participating PTN-BH indicates that these five dimensions consistently emerged as the principal institutional capabilities required to maintain competitiveness in the VUCA environment.

It should be emphasized that the present study focuses on developing and validating the conceptual architecture of S-EMS based on an institutional needs assessment, rather than evaluating the software implementation. Consequently, usability testing, system performance measurement, response time evaluation, accuracy testing, and user satisfaction assessment were beyond the scope of this research and constitute important directions for future implementation studies. The current findings therefore validate the functional requirements and governance architecture of S-EMS rather than its operational software performance. Overall, the digital integration map demonstrates that S-EMS functions as an institutional governance ecosystem rather than merely an information system. By integrating fragmented institutional resources into a unified cloud-based platform, S-EMS enables higher education institutions to transition from descriptive governance to prescriptive, adaptive, and evidence-based governance that strengthens Sustainable Competitive Advantage.

Finding the results of higher education quality improvement achievements in the VUCA era through Digital Mapping Suistainable Competitive Advantage Based on Smart-EduVerse Management System (S-EMS) in Indonesia, the S-EMS framework was conceptualized as a collective response by 22 PTN-BH to the gap, the need for data fragmentation, and the demand for impact-based governance, created an adaptive and prescriptive institutional neural center. Along with the increase in patent applications and IPR requests, the volume of important international academic publications has increased sharply (for example, UNAIR has increased from 150 to more than 3,300 papers annually). Advances in world university rankings, growth of collaborative research projects around the world, and an increase in the percentage of foreign students (reaching 40% at UIII. Improve the competitiveness of graduates through a curriculum that meets industry demands, promote startups, and use digital tracking studies to evaluate educational impact. The emphasis on quality has shifted from carrying out administrative responsibilities (compliance-oriented) to impact-oriented governance that benefits industry and society.

The results showed a clear improvement in several quality indicators, including academic and governance aspects. Academically, education levels are increasing, as evidenced by the use of more technology-based teaching methods, higher student satisfaction, and better alignment of graduates with the needs of the job market. From a governance perspective, the use of S-EMS accelerates, clarifies, and accounts for the decision-making process. This can be seen from a shorter strategic planning cycle and increased harmony between planning and program implementation. Additionally, this approach makes it easy to continuously monitor and assess through dashboards that display key performance indicators in real time. In terms of competitiveness, higher education institutions that use this approach show progress in institutional prestige, research production, and world collaboration. This implies that the convergence of digital mapping and intelligent management systems improves the institution's position on the international stage while enhancing the effectiveness of internal operations.

This platform is specifically designed to assist higher education institutions, particularly State Universities with Legal Entities (PTN-BH), in managing and improving their institutional quality in an integrated manner in the era of digital transformation. Key Features & Benefits: University Mapping Dashboard, S-EMS provides a directory page displaying real-world data from various leading universities in Indonesia (such as UI, ITB, IPB, Airlangga University, UGM, and others). Each institution card transparently presents key metrics: Zoning: Maps the locations of university clusters (e.g., Zone 1, Zone 2, Zone 3). Number of Study Programs: Monitors the number of active study programs on each campus. Number of Lecturers (Faculty): Tracks the availability and distribution of teaching staff. Number of Publications: Measures the productivity of research and scientific papers produced by the academic community.

Intuitive & Modern Interface: with a clean, minimalist UI/UX design, this platform is equipped with a user-friendly navigation system. It includes a search/filter results feature, pagination indicators, and main menus such as Advantages, Features, Statistics, and About for quick access to information. Target Users & Benefits: This platform is ideal for policymakers in campus environments, ministries of education, and researchers to monitor performance, map human resource assets, and develop strategies to improve the

quality of higher education institutions for global competitiveness. S-EMS is a one-stop solution that transforms raw university data into valuable digital insights to advance the quality of national education. The implementation of S-EMS is realized in the form of a digital dashboard that integrates quality parameters in real-time can be seen in Figures 3 and 4.

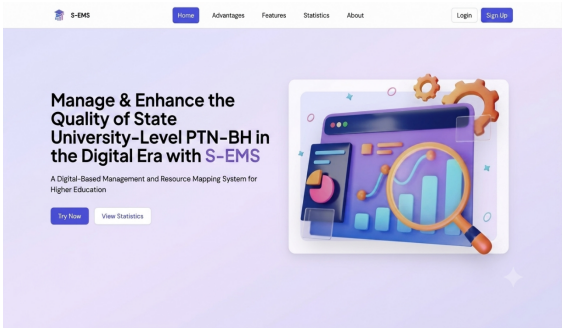

Figure 3. Initial views

This finding is consistent with recent studies on information system evaluation, which emphasize that the effectiveness of digital governance systems should be assessed through information quality, system quality, service quality, user satisfaction, and decision-support capability. Although the present study focuses on conceptual architecture rather than full implementation testing, the proposed S-EMS incorporates these evaluation dimensions as design considerations for future validation [27].

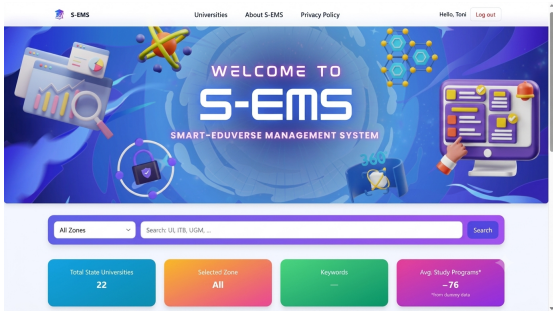

Figure 4. Dashboard

This image displays the institutional dashboard page on the S-EMS platform, which presents a list of leading universities in Indonesia in the form of neat information cards. The header displays navigation menus such as Universities, About S-EMS, and Privacy Policy, as well as a user greeting. Each university displays its campus logo, regional information (such as Zones 1-4 and the city name), and three key statistical indicators: the number of study programs (Programs), the number of lecturers (Faculty), and the number of scientific publications (Publications). Mapping PTN-BH Universities in Figure 5.

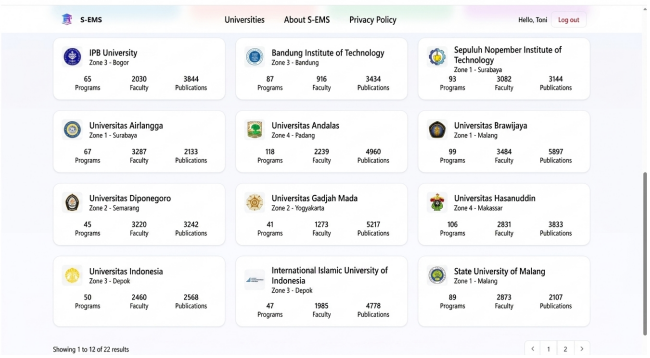

Figure 5. System integration visualization

Through collaborative digital mapping projects in various PTN-BH regions (as seen in Figures 1 and 3), these hands-on activities confirm that institutions largely need data centers that enable predictive analytics rather than simply digitizing documents. This research resulted in a prototype of the Smart-EduVerse Management System (S-EMS), an advanced management framework, to meet this need. As shown in the dashboard interface in Figure 5, the system's execution demonstrates its ability to integrate research data, people profiles, and key performance indicators (KPIs) into a single, coherent platform. This real-time view allows university officials to move from descriptive governance (which relies solely on historical data) to prescriptive governance, ensuring that every strategic decision is guided by accurate data to maintain quality in the ever-changing VUCA world. This integrated architecture also reflects Enterprise Architecture principles that emphasize standardized data governance, scalable infrastructure, interoperability, and centralized access to institutional information. Such integration enables continuous monitoring and evidence-based decision-making rather than isolated administrative reporting [28].

The qualitative findings of this study confirm that the main determinant of sustainable competitive advantage (SCA) in Legal Entity Indonesian State Universities (PTN-BH) lies in their capacity to move from compliance-based digital governance to impact-based digital governance. Comparative analysis across 22 PTN-BH shows that the main obstacle to institutional agility remains the fragmentation of academic and administrative systems, as well as the dominance of descriptive dashboards that only report past performance. The emergence of the Smart-EduVerse Management System (S-EMS) framework addresses this critical gap by introducing an integrated, prescriptive, and adaptive management architecture that transforms institutional data into strategic intelligence. Such a transformation is critical for higher education institutions (HEIs) navigating a volatile, uncertain, complex, and ambiguous environment (VUCA). Through S-EMS, the institutional ecosystem evolves towards real-time decision-making, improving agility, accountability, and impact-based performance evaluation.

These findings support the theoretical premise of the Knowledge-Based View (KBV), which posits that organizations' continued profits come from their ability to effectively manage, integrate, and utilize knowledge resources. In this theoretical lens, S-EMS operationalizes knowledge management as a dynamic capability that transforms fragmented institutional data into actionable knowledge. This framework is also aligned with Dynamic Capability Theory, as it enables continuous reconfiguration of resources and systems in response to environmental turbulence. This dynamic reconfiguration is evident in various digital initiatives, such as One Data UNS, the Executive Information System (EIS), and SPMS, developed by PTN-BH to improve institutional responsiveness. In addition, this study strengthens the role of Strategic Agility as a mediating ability that bridges technological innovation and competitive sustainability [29], showing that PTN-BH that integrates digital governance with adaptive leadership structures tends to exhibit higher institutional resilience. The integration of the principles of Sustainable Leadership in digital governance further ensures that technology functions not only as an operational instrument but as a strategic driver of institutional learning and social innovation.

Cross-zone comparisons further reinforce the contextual richness of the S-EMS framework. In Zone I (UNAIR, ITS, UB, UM, UNESA), institutional agility is mainly driven by the development of integrated performance systems such as SPMS and SIMAS, which reflect a strong alignment between strategic planning and data utilization. Zone II UNIVERSITIES (UGM, UNDIP, UNY, UNNES, UNS) have shown progress towards prescriptive analytics by establishing the One Data UNS, EIS, and SICP systems, which emphasize interoperability and impact-based quality governance. Zone III institutions (ITB, UNPAD, UPI, UI, IPB, UT, UIII) contribute to this model by embedding digital governance through Decision Support Systems (DSS) and MyUT Management platforms, and by upholding high internal quality standards and fostering international collaboration. Meanwhile, Zone IV universities (USU, UNAND, UNP, UNHAS, and USK) describe adaptive governance and administrative acceleration through initiatives such as my UNAND Mobile, smile UNP, and the appointment of data stewards to ensure data integrity. Collectively, these variations enrich the qualitative resilience of S-EMS as a flexible yet coherent digital governance framework applicable across a wide range of institutional contexts.

In addition, the conceptualization of S-EMS broadens the perspective on Sustainable Leadership, emphasizing long-term, ethically grounded, and socially responsible decision-making. This integration ensures that leadership and governance drive co-creation and innovation, emphasizing that governance in higher education must evolve from compliance to innovation and sustainability to achieve the Sustainable Development Goals (SDGs). S-EMS acts as a catalyst for building Digital Institutional Resiliency, a concept that underscores the university's ability to withstand disruption and continuously update its governance models through the integration of smart technologies [30, 31]. By connecting data-driven decision-making systems with ethical and sustainable leadership, the S-EMS model operationalizes strategic responsiveness, positioning quality assurance as a dynamic capability and a strategic asset.

Conceptual Proposition: S-EMS as a Qualitative Digital Governance Model Based on cross-zonal findings, this study proposes the Smart-EduVerse Management System (S-EMS) as a qualitative digital governance model that transforms higher education institutions into smart organizations. The model is characterized by three core mechanisms: (1) Prescriptive Data Mapping shifts analytics from descriptive reporting to strategic recommendation making. Cloud orchestration is a mechanism that governs how all S-EMS digital services (VR/AR rendering, sensor processing, biometric verification, AI, dashboards) are run, scaled, and remain available automatically without manual intervention. This function allows leaders to identify institutional risks and opportunities,

ensuring that governance decisions are based on predictive insights rather than static performance reports. (2) Integrated Knowledge Assets connect human resources, research outputs, and digital infrastructure in an integrated ecosystem. This integration ensures that intellectual capital and institutional assets are optimally utilized to strengthen SCA capacity and innovation [32–34], (3) Adaptive Governance, embedding change management and continuous improvement cycles (PPEPP) into institutional routines, encourages transparency and stakeholder participation. This mechanism transforms the governance culture into a learning-oriented system that continues to evolve along with the changing environment [35]. Through this mechanism, S-EMS serves as an institutional digital nerve center, synchronizing data, people, and processes under a single quality management framework that enhances institutional responsiveness and sustainability.

The results of this study strengthen the growing evidence that digital transformation and knowledge integration are decisive factors in advancing institutional competitiveness. This study validates that data-driven governance increases innovation capacity and academic performance when supported by a strong technological backbone. However, unlike previous research that primarily explored digital transformation as a result, this study demonstrates its strategic function as a governance supporter embedded in institutional architectures. The S-EMS model also complements the insights, which highlight that an effective education management system requires seamless interoperability between academic, administrative, and research subsystems. In the Indonesian context, these findings reveal that without prescriptive integration mechanisms as conceptualized in S-EMS, universities risk remaining reactive to policy changes rather than becoming proactive learning organizations. This synthesis also demonstrates that the Smart-EduVerse Management System (S-EMS) serves as an integration platform, bridging system fragmentation at PTN-BH. S-EMS integrates academic services, research, and quality management into a single, unified digital ecosystem.

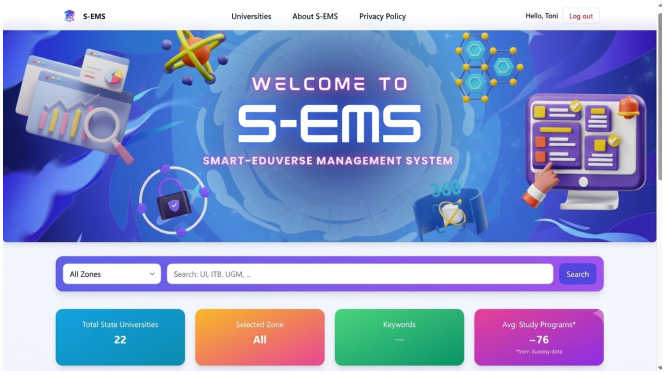

Figure 6. Enhancing university quality with S-EMS

By situating the S-EMS framework within this theoretical and empirical discourse, this study introduces a new qualitative model of digital governance integration that operationalizes prescriptive analytics, knowledge convergence, and adaptive leadership within a coherent governance ecosystem. Theoretically, it advances the discourse on Sustainable Competitive Advantage in higher education by incorporating the framework of Knowledge-Based Views, Dynamic Capabilities, and Strategic Agility into a digital governance model based on the realities of developing countries' universities [36–38]. Practically, it provides a qualitative roadmap for PTN-BH to build a prescriptive decision support system that increases responsiveness, transparency, and evidence-based policy formulation. This approach transforms quality assurance from a bureaucratic instrument into a strategic investment that strengthens long-term institutional sustainability [39]. The S-EMS model also redefines the role of quality management as a dynamic capability, which leverages intelligent systems and participatory governance to maintain competitive differentiation in the global higher education landscape [40].

Ultimately, the novelty and originality of this research lie in conceptualizing the Smart-EduVerse Management System (S-EMS) as a prescriptive digital governance framework that transforms fragmented data ecosystems into integrated platforms for strategic decision-making. Although previous research has addressed the elements of digital transformation, none has synthesized these components into an integrated qualitative roadmap that combines the dimensions of governance, technology, and leadership in the specific context of PTN-BH Indonesia. By articulating the mechanisms by which institutional intelligence can be systematized, this research contributes to the theoretical enrichment of higher education management and provides a replicable model for universities striving towards World Class University status in the VUCA era [41, 42]. In conclusion, S-EMS represents not only technological innovation but also a paradigm shift that transforms the perception of institutional quality from compliance to impact, from descriptive reporting to prescriptive strategies, and from fragmented silos to intelligent and adaptive ecosystems.

3.5. Discussion of Findings

The findings indicate that the institutional challenges faced by Indonesian PTN-BH are not merely technological but structural and organizational. The persistence of fragmented information systems reflects the historical development of higher education management, in which academic, research, financial, and quality-assurance systems have evolved independently in response to administrative requirements rather than to institutional strategy. Consequently, universities continue to operate with isolated databases that support compliance reporting but provide limited strategic value for institutional decision-making. The cross-case analysis of the 22 PTN-BHs demonstrates that this fragmentation occurs consistently across different institutional contexts, although the degree of digital maturity varies among universities. Despite these differences, the empirical evidence indicates that all participating institutions require integrated governance to transform dispersed institutional data into strategic intelligence. This finding suggests that digital transformation should be viewed as an organizational capability rather than merely a technological intervention.

This finding is consistent with previous studies highlighting the fragmentation of academic information systems and the lack of interoperability among higher education platforms. However, unlike previous research that primarily emphasized technical integration, this study demonstrates that fragmentation is also a governance issue, as disconnected institutional knowledge prevents university leaders from transforming operational data into strategic intelligence. From the perspective of the Knowledge-Based View (KBV), institutional knowledge becomes a strategic resource only when dispersed information can be integrated, shared, and utilized across organizational boundaries. Therefore, the identified needs for integrated human resources, digital infrastructure, strategic collaboration, and adaptive quality assurance should not be viewed as independent initiatives but as interconnected capabilities supporting Sustainable Competitive Advantage (SCA). This interpretation extends the Knowledge-Based View by demonstrating that institutional knowledge alone does not automatically generate competitive advantage. Instead, knowledge must be supported by interoperable digital infrastructure and adaptive governance mechanisms that enable institutional learning, strategic responsiveness, and continuous organizational improvement. Although the present study focuses on proposing the S-EMS architecture rather than evaluating its operational performance, previous studies have emphasized that the effectiveness of academic information systems should be assessed through comprehensive evaluation frameworks such as ISO/IEC 25010, including performance efficiency, reliability, usability, security, compatibility, and user satisfaction. Integrating these evaluation dimensions will enable future validation of S-EMS beyond conceptual design toward measurable system quality and institutional impact [43].

The present findings also align with recent evidence indicating that successful digital transformation in higher education extends beyond technological implementation toward comprehensive organizational transformation. Recent studies emphasize that universities with mature digital ecosystems integrate leadership, institutional governance, digital infrastructure, pedagogical innovation, and continuous human resource development into a unified strategic framework rather than treating digitalization as isolated technological projects. This perspective aligns with the empirical evidence of the present study, which found that fragmented institutional information systems stemmed from organizational silos and governance fragmentation rather than purely technical limitations. Therefore, the proposed S-EMS contributes by addressing both the technological and organizational dimensions of digital transformation through integrated institutional knowledge management and adaptive governance [44–46].

The proposed Smart-EduVerse Management System (S-EMS) emerged as a direct response to the institutional gaps identified across the 22 PTN-BH. Unlike conventional quality information systems that primarily function as repositories of historical data, S-EMS introduces a prescriptive governance approach that converts fragmented institutional information into strategic recommendations. Previous studies have emphasized the importance of digital transformation, learning analytics, and integrated management information systems. Nevertheless, these studies generally conceptualize digitalization as an operational support mechanism. The present study extends this perspective by positioning digital transformation as the institutional governance architecture through which strategic intelligence is continuously generated. Rather than functioning solely as an information management platform, S-EMS integrates organizational knowledge, digital infrastructure, quality assurance, and strategic collaboration into a unified governance ecosystem that supports adaptive decision-making.

The improvement in institutional performance observed across participating universities suggests that sustainable competitive advantage cannot be achieved solely through technological investment. Rather, competitive advantage emerges when technology is integrated with organizational learning, adaptive leadership, and evidence-based governance. Earlier studies primarily focused on knowledge management or digital transformation in isolation, whereas the present research demonstrates that these components are substantially more effective when integrated into a unified governance ecosystem. Consequently, quality assurance evolves from an administrative control mechanism into a strategic capability that continuously supports institutional innovation, resilience, and organizational agility under VUCA conditions. Importantly, the empirical findings indicate that the effectiveness of S-EMS depends not only on technological readiness but also on institutional commitment to data integration, leadership support, organizational culture, and stakeholder collaboration. This finding reinforces the Dynamic Capability perspective, which argues that organizational competitiveness depends upon the continuous capability to sense environmental changes, seize emerging opportunities, and reconfigure institutional resources.

Which functions as an integrated digital governance platform designed to address the institutional challenges identified across the 22 Indonesian State Universities with Legal Entity (PTN-BH). Rather than merely representing a prototype application, S-EMS embodies the conceptual translation of the four institutional needs identified through digital mapping, namely human resource and knowledge asset management, digital infrastructure integration, strategic collaboration, and adaptive quality assurance. As illustrated in Figure 2, the homepage of S-EMS serves as the institutional entry point, providing a centralized gateway for accessing institutional data across all participating PTN-BH. Instead of maintaining isolated databases at faculty or administrative levels, the platform consolidates institutional information into a unified digital environment. This centralized architecture directly addresses one of the major empirical findings of this study: the fragmentation of academic, research, financial, and quality-assurance information systems. By integrating these heterogeneous data sources, S-EMS enables institutional leaders to access comprehensive strategic information from a single interface, thereby reducing duplication of administrative processes and improving organizational transparency.

Figure 3 further illustrates the S-EMS dashboard interface, in which institutional indicators are visualized via real-time monitoring panels. Unlike conventional quality assurance systems that primarily generate descriptive reports after periodic evaluations, the dashboard supports continuous monitoring of key institutional indicators, including academic performance, research productivity, digital assets, and governance outcomes. This finding extends previous studies on learning analytics and higher education information systems by demonstrating that dashboard technologies should function not merely as reporting tools but as strategic decision-support mechanisms capable of generating institutional intelligence. Consequently, quality assurance becomes an ongoing governance process rather than a cyclical accreditation activity.

The multi-institution interface presented in Figure 4 reflects another significant contribution of the proposed framework. The platform simultaneously accommodates the digital profiles of all 22 PTN-BH while preserving their institutional uniqueness. The empirical findings revealed substantial differences among universities regarding strategic priorities, research strengths, digital maturity, and governance practices. Rather than imposing a standardized governance model, S-EMS accommodates these contextual differences within an integrated digital ecosystem. This adaptive architecture enables benchmarking among universities while allowing each institution to maintain its distinctive competitive advantages. Such flexibility strengthens institutional agility, a capability considered essential for universities operating in increasingly volatile and uncertain environments. More importantly, Figure 5 illustrates how institutional information is transformed into integrated digital mapping modules. Each university profile combines organizational information, human resources, publications, digital mapping components, and system integration within a single interface. This configuration operationalizes the Knowledge-Based View by treating institutional knowledge as an integrated strategic asset rather than dispersed administrative records. Instead of storing information independently across organizational units, S-EMS orchestrates multiple institutional resources into interconnected knowledge assets that continuously support evidence-based governance.

The conceptual relationship among these components is summarized in Figure 6, which presents the S-EMS governance model for enhancing university quality. The model demonstrates that fragmented quality systems, characterized by bureaucratic procedures, inconsistent governance, and isolated information resources, are transformed into holistic quality improvement through five interconnected dimensions: digital integration, global orientation, research downstreaming, quality assurance, and institutional intelligence. Digital integration serves as the enabling infrastructure connecting institutional databases, while a global orientation strengthens international collaboration and research competitiveness. Research downstreaming ensures that knowledge generated by universities produces measurable societal and industrial impacts, whereas adaptive quality assurance promotes transparent, sustainable, and continuous governance. Collectively, these dimensions establish an institutional ecosystem that supports sustainable competitive advantage through data-driven strategic decision-making.

These findings further reinforce the theoretical foundations of the Knowledge-Based View and Dynamic Capability Theory. Through integrated knowledge assets, cloud-based orchestration, and adaptive governance dashboards, S-EMS enables universities to continuously sense institutional changes, reconfigure strategic resources, and respond proactively to environmental uncertainty. Consequently, institutional quality evolves from compliance-oriented assessment toward prescriptive quality governance, positioning quality assurance as a dynamic capability that continuously generates sustainable competitive advantage in the VUCA era.

4. CONCLUSION

This study concludes that the main determinant of sustainable competitive advantage (SCA) in Indonesian State Universities with Legal Entities (PTN-BH) lies in their strategic capacity to move from compliance-oriented governance to impact-based and data-driven digital governance. Through cross-zone qualitative analysis of 22 PTN-BH, the study identified persistent systemic fragmentation and cultural resistance as critical inhibitors of institutional agility. In response, the proposed Smart-EduVerse Management System (S-EMS) serves as an integrated, prescriptive digital framework that transforms fragmented institutional data into strategic intelligence. It embodies a comprehensive approach to real-time decision-making, enabling higher education institutions (HEIs) to

achieve adaptive, transparent, and sustainable governance. By embedding prescriptive data mapping, integrated knowledge assets, and adaptive governance mechanisms, S-EMS provides a conceptual roadmap for colleges to improve their organizational resilience in the VUCA era. Ultimately, S-EMS reframes quality assurance not as a bureaucratic process but as a strategic investment for long-term institutional sustainability.

Beyond summarizing the findings, this study contributes theoretically by integrating the Knowledge-Based View, Dynamic Capabilities, Strategic Agility, and Cloud Computing into a unified cloud-based governance framework for higher education. This integration extends existing digital governance literature by demonstrating how cloud-enabled knowledge management and adaptive governance can collectively strengthen Sustainable Competitive Advantage. Practically, the proposed S-EMS provides higher education leaders and policymakers with a strategic framework for integrating institutional data, improving evidence-based decision-making, reducing system fragmentation, and strengthening adaptive quality governance across universities. This study is subject to several limitations. First, the empirical investigation was limited to 22 Indonesian PTN-BH, which may restrict the generalizability of the findings to other types of higher education institutions with different governance structures and levels of digital maturity. Second, the proposed S-EMS remains a conceptual architecture derived from empirical needs assessment and has not yet been implemented or experimentally validated in institutional settings.

Future research should focus on implementing and validating the proposed S-EMS architecture through pilot implementation, longitudinal evaluation, and multi-institutional assessment across diverse higher education contexts. Empirical studies are needed to examine the effectiveness of S-EMS in improving institutional performance, governance agility, decision-making quality, and sustainable competitive advantage using quantitative or mixed-method approaches. Future studies are also encouraged to evaluate system usability, organizational acceptance, interoperability with existing university information systems, and the scalability of cloud-based implementation across different institutional environments. Future work may also extend the framework by integrating emerging technologies such as artificial intelligence, learning analytics, predictive and prescriptive analytics, digital twins, and generative AI to enhance institutional intelligence and automated strategic recommendations. Comparative studies involving universities from different countries and governance systems are likewise recommended to assess the generalizability, scalability, and adaptability of the S-EMS framework as a digital governance model for higher education in an increasingly dynamic global environment.

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6. DECLARATIONS

AI USAGE STATEMENT

The authors declare that Artificial Intelligence (AI) assisted tools were used solely to support language editing, grammar refinement, and improvement of manuscript readability during the preparation of this article. All conceptual development, research design, data collection, data analysis, interpretation of findings, and final manuscript content were performed and critically reviewed by the authors. The authors take full responsibility for the accuracy, originality, and integrity of the published work.

AUTHOR CONTIBUTION

Rochmawati served as the principal investigator and corresponding author, leading the study's conceptualization, designing the overall research framework, supervising the development of the Cloud-Based Smart-EduVerse Management System (S-EMS) architecture, coordinating research activities, interpreting the findings, and overseeing the preparation and revision of the manuscript for publication. Anik Nur Handayani contributed to the research methodology, provided academic supervision throughout the study, validated the research design and analytical procedures, critically reviewed the interpretation of the results, and participated in revising the manuscript to enhance its scientific quality. Tran Thi Hao contributed as an international researcher by providing expert perspectives on higher education digital transformation, validating the proposed S-EMS architecture in an international context, reviewing the research methodology, and offering critical feedback to strengthen the discussion and global relevance of the study. Soubin Sisavath contributed as an international researcher by conducting comparative analysis of higher education quality management practices,

evaluating the proposed digital quality mapping framework, interpreting research findings from an international perspective, and critically reviewing the manuscript to improve its academic rigor. Moch Haris Purwanto assisted in data collection from participating universities, data organization and preprocessing, literature compilation, preparation of supporting research materials, and preliminary analysis of the research findings. Nailah Aliya Putri Antero contributed to data collection and validation, preparation of research instruments, visualization and graphical presentation of the Smart-EduVerse Management System (S-EMS) architecture, manuscript editing, reference management, and formatting the article in accordance with the target journal's author guidelines. All authors participated in reviewing the manuscript, approved the final version for publication, and agreed to be accountable for the accuracy, integrity, and originality of the work.

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COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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