A Governance-Integrated Architecture and Maturity Model for Robotic Process Automation in Higher Education Institutions

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ABSTRACT:
Higher Education Institutions (HEIs) are increasingly adopting automation technologies to support digital transformation and improve administrative efficiency. However, automation initiatives in universities are often implemented in isolated departmental contexts, limiting their scalability and institutional impact. Existing studies primarily focus on operational use cases and implementation challenges, while relatively little attention has been devoted to the architectural and organizational foundations required to support institution-wide automation. This study addresses this gap by proposing a governance-integrated architectural framework and a corresponding maturity model for institutional automation in higher education. Using a design science research approach, the study first conducts a cross-platform architectural analysis of leading Robotic Process Automation (RPA) ecosystems to identify recurring architectural invariants across contemporary automation platforms. These architectural invariants are subsequently abstracted into the Governance-Integrated RPA Architecture for Higher Education (GI-RPA-HE), a layered framework that integrates automation infrastructure with institutional governance, system interoperability, and analytical capabilities. The architecture also accommodates emerging AI-enabled and agentic automation capabilities. Building upon this architecture, the study further introduces the Automation Maturity Model for Higher Education Institutions (AMM-HEI), which conceptualizes the progressive development of institutional automation capabilities from isolated task automation toward AI-

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augmented and autonomous automation ecosystems. By linking maturity levels with architectural capabilities, the proposed framework provides both a conceptual foundation and a practical roadmap for universities seeking to scale automation initiatives as part of the digital transformation of higher education administration.

Keywords: Robotic Process Automation, Higher Education, Enterprise Architecture, Automation Maturity Model, Digital Transformation

1. Introduction

HEIs worldwide are experiencing an unprecedented wave of digital transformation. Increasing student populations, expanding regulatory requirements, growing demands for institutional accountability, and rising expectations regarding service quality have significantly increased the complexity of university administration (Baiyere et al., 2020; Bond et al., 2018). Modern universities must manage a diverse portfolio of administrative activities, including admissions processing, student records management, payroll administration, procurement operations, quality assurance, accreditation reporting, research administration, and institutional performance monitoring. These processes frequently span multiple organizational units and information systems, resulting in fragmented workflows, duplicated effort, and substantial administrative workload.

Digital transformation has therefore become a strategic priority for many universities seeking to improve operational efficiency, enhance institutional responsiveness, and support evidence-based decision-making. However, digital transformation extends beyond the adoption of new technologies. Prior research emphasizes that successful transformation requires the alignment of technological infrastructure, organizational processes, governance mechanisms, and institutional capabilities (Baiyere et al., 2020; Verhoef et al., 2021). In higher education environments, this challenge is particularly significant because universities typically operate through decentralized governance structures, heterogeneous information systems, and diverse stakeholder communities. As a result, technological initiatives that are implemented in isolation often struggle to achieve sustainable institution-wide impact.

Within this broader transformation context, automation technologies have attracted increasing attention as mechanisms for improving administrative performance and reducing routine workload. Among these technologies, RPA has emerged as one of the most widely adopted approaches for automating repetitive, rule-based, and high-volume digital processes (Lacity & Willcocks, 2016; Van der Aalst et al., 2018). By replicating human interactions with existing software applications, RPA enables organizations to automate workflows without extensive modifications to underlying systems. Consequently, RPA has been successfully applied across sectors such as finance, healthcare, telecommunications, public administration, and shared service operations.

The growing adoption of RPA has generated substantial evidence regarding its operational benefits. Existing studies report improvements in processing speed, accuracy, compliance, and service efficiency, while also highlighting reductions in operational costs and manual effort (Hofmann et al., 2020; Syed et al., 2020). More recently, universities have begun exploring automation technologies to support administrative functions such as student services, institutional reporting, information management, and workflow coordination. For example, Chu and Pham (2023) demonstrated the application of RPA in collecting and processing student feedback data, while Truong

et al. (2026) proposed an educational RPA platform integrating workflow orchestration and artificial intelligence capabilities. These studies suggest that automation can play an increasingly important role in supporting university administration and institutional modernization.

Despite these promising developments, automation adoption in higher education remains relatively fragmented. Many automation initiatives originate from local operational needs within individual departments and are implemented as isolated projects. Although such initiatives may generate immediate efficiency gains, they often remain disconnected from broader institutional strategies and governance structures. Consequently, universities frequently encounter challenges related to scalability, interoperability, accountability, and long-term sustainability. As automation portfolios expand, the absence of institutional coordination may result in duplicated development efforts, inconsistent implementation practices, and difficulties integrating automation across organizational boundaries.

These challenges reveal an important limitation in the existing literature. Current research on RPA has primarily focused on implementation experiences, adoption drivers, organizational challenges, and operational outcomes (Hofmann et al., 2020; Syed et al., 2020). While these studies provide valuable insights into automation deployment, considerably less attention has been devoted to understanding the architectural foundations that enable automation to function as an institution-wide capability. Contemporary automation ecosystems comprise multiple interdependent components, including development environments, execution agents, orchestration mechanisms, integration services, governance controls, and analytical capabilities. However, these components are typically described using vendor-specific terminology, making it difficult to identify generalized architectural patterns that can guide automation initiatives across different organizational contexts.

This limitation is particularly relevant for HEIs. Universities require automation infrastructures that not only support operational efficiency but also accommodate institutional governance, regulatory compliance, organizational diversity, and strategic transformation objectives. Existing vendor-centric architectures provide detailed technical capabilities, yet they rarely address the governance and coordination requirements characteristic of higher education environments. Consequently, universities lack a vendor-independent reference framework capable of guiding the design and governance of institution-wide automation ecosystems.

At the same time, the automation landscape is undergoing rapid transformation through advances in artificial intelligence (AI), large language models (LLMs), and autonomous software agents. Automation systems are increasingly capable of supporting process discovery, workflow generation, decision support, and natural-language interaction (Bommasani et al., 2021; Davenport & Ronanki, 2018). These developments are gradually shifting automation from predefined rule execution toward more adaptive and intelligent forms of process coordination. While such technologies create significant opportunities for universities, existing architectural frameworks provide limited guidance regarding how AI-enabled capabilities should be incorporated into institutional automation infrastructures.

Existing studies have examined RPA implementation, governance challenges, digital transformation, and AI-enabled automation from different perspectives. However, these research streams have largely evolved in parallel. As a result, no prior study has simultaneously addressed (1) the identification of architectural invariants across contemporary automation platforms, (2) the integration of governance and institutional requirements within a higher education automation architecture, and (3) the relationship between architectural capability development and automation maturity in universities. Consequently, universities continue to lack a coherent vendor-agnostic framework capable of linking automation infrastructure, institutional governance, and long-term capability development within a unified architectural perspective.

To address these gaps, this study adopts a Design Science Research (DSR) approach to develop two

complementary research artifacts. The first artifact is the GI-RPA-HE, a vendor-agnostic reference architecture that integrates automation infrastructure with governance mechanisms, interoperability requirements, and analytical capabilities. The second artifact is the AMM-HEI, which conceptualizes automation development as a progressive institutional capability aligned with broader digital transformation objectives. Accordingly, the study addresses the following research questions:

- **RQ1**: What architectural invariants can be identified across leading RPA platforms?
- **RQ2**: How can these architectural components be abstracted into a vendor-agnostic reference architecture suitable for higher education institutions?
- **RQ3**: How can automation maturity in higher education institutions be conceptualized as a progressive institutional capability through a structured maturity model?

This study makes three primary contributions to the literature. First, it identifies and formalizes recurring architectural invariants across contemporary automation ecosystems through cross-platform architectural analysis. Second, it proposes a governance-integrated reference architecture that extends existing automation perspectives beyond operational deployment and explicitly addresses the institutional characteristics of higher education environments. Third, it introduces a maturity model that links architectural capabilities with the progressive development of institutional automation capacity. Collectively, these contributions provide both a conceptual foundation and a practical roadmap for universities seeking to develop scalable, sustainable, and strategically aligned automation ecosystems as part of broader digital transformation initiatives.

2. Literature Review

This study draws upon four complementary research streams: RPA, Enterprise Architecture (EA) and IT Governance, Digital Transformation in Higher Education, and AI-enabled Automation. Collectively, these streams highlight the need for a governance-integrated and vendor-agnostic framework capable of supporting institution-wide automation in higher education environments.

Table 1. Literature Synthesis and Research Gaps

Research Stream	Representative Studies	Main Focus	Limitation Relevant to This Study
RPA Research	(Lacity & Willcocks, 2016; Syed et al., 2020)	Automation benefits and adoption	Limited architectural perspective
EA & Governance	(Ross et al., 2006; Weill & Ross, 2004)	Strategic alignment and governance	Limited focus on automation ecosystems
Digital transformation	(Verhoef et al., 2021; Vial, 2019)	Organizational transformation	Rarely addresses automation architecture
Higher education digitalization	(Baiyere et al., 2020; Bond et al., 2018)	University digital transformation	Limited automation governance perspective
AI-enabled Automation	(Bommasani et al., 2021; Davenport & Ronanki, 2018)	Intelligent automation capabilities	Limited institutional architectural integration

Source: authors' synthesis based on prior literature.

Collectively, these limitations reveal the absence of a governance-integrated and vendor-agnostic architectural framework capable of linking automation infrastructure, institutional governance, and capability development in higher education environments.

2.1. Robotic Process Automation Research

RPA has emerged as a significant component of contemporary digital transformation initiatives. The technology enables organizations to automate repetitive, rule-based activities by replicating human interactions with existing software applications, thereby reducing the need for extensive modifications to underlying information systems (Van der Aalst et al., 2018). Because of its relatively low implementation complexity and compatibility with legacy systems, RPA has been widely adopted across sectors such as finance, healthcare, telecommunications, and public administration.

Early RPA research primarily emphasized operational benefits. Lacity and Willcocks (2016) argue that software robots can significantly improve service delivery by automating routine activities traditionally performed by human workers. Similarly, Aguirre and Rodriguez (2017) demonstrate that RPA can provide efficiency gains while requiring fewer organizational and technical changes than conventional enterprise system integration approaches. These studies established RPA as a practical mechanism for process automation and operational improvement.

As adoption expanded, researchers began examining RPA within broader organizational and strategic contexts. Van der Aalst et al. (2018) position RPA within a wider ecosystem of process technologies that includes business process management and process mining. From this perspective, automation is not an isolated technological solution but part of a larger process transformation capability. Subsequent studies have further highlighted challenges associated with large-scale automation initiatives, including governance, process standardization, organizational coordination, and integration with existing information systems (Hofmann et al., 2020; Syed et al., 2020).

More recently, the literature has explored the convergence of RPA with complementary technologies such as AI, process mining, and advanced analytics. These developments have expanded the scope of automation from deterministic task execution toward more adaptive and intelligent forms of process support (Davenport & Ronanki, 2018). As a result, automation is increasingly viewed as a strategic capability that contributes to broader digital transformation objectives rather than merely a tool for reducing manual effort.

Despite the growing maturity of RPA research, important limitations remain. Existing studies predominantly focus on implementation experiences, adoption challenges, and operational outcomes. Comparatively less attention has been devoted to examining the architectural structures that underpin contemporary automation ecosystems. In addition, commercial RPA platforms typically describe their architectures using proprietary terminology, making it difficult to identify generalized architectural patterns that transcend specific vendor implementations. Consequently, the literature provides limited guidance for organizations seeking to design vendor-agnostic automation infrastructures aligned with long-term institutional objectives.

These limitations are particularly significant in higher education environments, where automation initiatives must operate within complex governance structures and heterogeneous information system landscapes. Therefore, there remains a need for research that abstracts common architectural principles from contemporary automation platforms and reinterprets them within an institutional framework suitable for higher education.

2.2. Enterprise Architecture and IT Governance

EA provides a comprehensive framework for aligning organizational strategy, business processes, information systems, and technological infrastructure (Ross et al., 2006). Within complex organizations, EA serves as a mechanism for coordinating organizational capabilities and ensuring that technology investments support long-term strategic objectives. Rather than focusing solely on technical design, EA emphasizes the relationships among organizational structures, processes, information resources, and governance mechanisms.

The relevance of EA has increased significantly in the context of digital transformation. As organizations adopt new technologies and expand

their digital ecosystems, architectural coordination becomes essential for managing complexity, ensuring interoperability, and maintaining strategic alignment (Verhoef et al., 2021). Contemporary digital environments typically comprise multiple interconnected platforms, services, and data sources that must operate cohesively to support organizational objectives. Consequently, architecture has become a critical enabler of institutional agility and sustainable transformation.

Governance represents a complementary dimension of this architectural perspective. IT governance refers to the structures, policies, decision-making processes, and accountability mechanisms through which organizations direct and control the use of information technology resources (Weill & Ross, 2004). Effective governance ensures that technological initiatives remain aligned with organizational priorities while addressing concerns related to risk management, compliance, security, and performance monitoring.

Prior studies have demonstrated that governance plays a particularly important role in large-scale digital initiatives. Without appropriate governance mechanisms, technology adoption often becomes fragmented, resulting in duplicated investments, inconsistent implementation practices, and limited organizational value realization. Governance is therefore increasingly recognized as a critical success factor in digital transformation programs, particularly within organizations characterized by multiple stakeholders, distributed decision-making processes, and heterogeneous information systems.

These considerations are highly relevant to automation initiatives. Although many RPA projects originate as localized operational improvements, their organizational impact expands significantly as automation capabilities mature and become integrated across multiple departments and systems. As automation portfolios grow, institutions must address questions related to ownership, accountability, compliance, interoperability, performance measurement, and strategic coordination. Such concerns extend beyond the technical capabilities of automation platforms and require architectural and governance perspectives capable of supporting institution-wide adoption.

Despite the growing importance of governance and architecture in digital transformation research, relatively few studies have explicitly examined automation ecosystems through an EA lens. Existing automation literature predominantly focuses on implementation outcomes and technological capabilities, while governance considerations are often treated as secondary operational concerns. As a result, the literature provides limited guidance regarding how automation capabilities should be architecturally organized and governed as part of broader institutional transformation initiatives.

This gap is particularly significant in HEIs, where automation initiatives must operate across diverse organizational units, support multiple stakeholder groups, and comply with complex institutional and regulatory requirements. Consequently, a governance-integrated architectural perspective provides an important theoretical foundation for understanding how automation can evolve from isolated technological projects into sustainable institutional capabilities.

2.3. Digital Transformation and Automation in Higher Education

Digital transformation has become a strategic priority for HEIs worldwide. Universities increasingly rely on digital technologies to improve operational efficiency, enhance service delivery, support data-driven decision-making, and respond to growing expectations from students, faculty members, regulatory agencies, and other stakeholders (Baiyere et al., 2020; Bond et al., 2018). Unlike traditional technology adoption initiatives that focus primarily on infrastructure modernization, digital transformation involves broader organizational changes affecting institutional processes, governance structures, and service models.

The higher education sector presents unique challenges for digital transformation. Universities typically operate through decentralized organizational structures in which academic departments, administrative offices, research units,

and support services maintain varying degrees of autonomy. At the same time, institutions must coordinate activities across a wide range of information systems, including student information systems, learning management systems, research management platforms, financial systems, human resource systems, and institutional reporting environments. This complexity often creates fragmented workflows, duplicated data processing activities, and administrative inefficiencies.

Consequently, universities have increasingly explored automation technologies as mechanisms for improving administrative effectiveness. Existing applications include student admissions processing, academic records management, institutional reporting, quality assurance activities, financial administration, procurement operations, and student service workflows. By automating repetitive and rule-based activities, institutions can reduce processing delays, improve consistency, and reallocate human resources toward higher-value activities requiring judgment, collaboration, and direct stakeholder engagement.

Recent studies demonstrate growing interest in applying RPA and related automation technologies within educational environments. Chu and Pham (2023) illustrate the use of automation technologies to support student feedback collection and analysis processes, while Truong et al. (2026) propose an intelligent educational automation platform integrating workflow orchestration and AI-enabled capabilities. These studies suggest that automation can contribute significantly to the modernization of university administration and support broader institutional transformation initiatives.

However, automation adoption within higher education remains uneven and frequently project-based. Many automation initiatives originate within individual departments seeking solutions to localized operational challenges. While such implementations may generate immediate efficiency gains, they often lack institutional coordination and strategic integration. As automation initiatives proliferate, universities may encounter challenges related to interoperability, governance, compliance, ownership, and long-term sustainability. These challenges become increasingly significant as institutions attempt to scale automation across organizational boundaries and integrate automation capabilities with existing digital ecosystems.

The literature therefore highlights an important tension within higher education digital transformation efforts. Although automation technologies offer substantial opportunities for improving administrative performance, sustainable institutional benefits depend on the ability to coordinate technological capabilities, governance mechanisms, and organizational objectives. This observation suggests that universities require architectural frameworks capable of supporting automation not merely as a collection of departmental tools, but as a coordinated institutional capability embedded within broader digital transformation strategies.

Accordingly, higher education provides a particularly relevant context for examining how automation architectures can be designed, governed, and matured over time. Understanding this relationship is essential for developing automation ecosystems that remain scalable, interoperable, and strategically aligned as institutions continue their digital transformation journeys.

2.4. AI-Enabled Automation and Emerging Automation Paradigms

Recent advances in AI are significantly reshaping the evolution of automation technologies. Traditional RPA systems primarily automate deterministic and rule-based activities through predefined workflows. While effective for structured processes, these systems often face limitations when dealing with unstructured information, contextual decision-making, and dynamic process environments.

The emergence of machine learning, natural language processing, and LLMs has expanded the scope of automation beyond routine task execution. AI-enabled automation systems increasingly support activities such as document understanding, information extraction, process discovery, decision support, and natural-language interaction (Bommasani et al., 2021; Davenport & Ronanki, 2018). These capabilities enable organizations to

automate more complex processes that previously required substantial human intervention.

More recently, the development of agent-based and AI-assisted automation approaches has further transformed the automation landscape. Rather than executing only predefined instructions, intelligent agents can assist in workflow generation, task coordination, information retrieval, and adaptive decision-making. As a result, automation is gradually evolving from static process execution toward more flexible and context-aware forms of organizational support.

These developments have important architectural implications. Contemporary automation ecosystems increasingly combine traditional RPA capabilities with AI services, analytics platforms, process mining tools, and intelligent decision-support mechanisms. Consequently, automation architectures must be capable of integrating heterogeneous technologies while maintaining governance, security, transparency, and operational control.

Despite the growing importance of AI-enabled automation, existing studies primarily focus on technological capabilities and implementation opportunities. Comparatively limited attention has been devoted to understanding how AI capabilities should be incorporated within institution-level automation architectures, particularly in environments characterized by complex governance requirements and multiple stakeholder groups. This limitation is especially relevant for higher education institutions, where emerging AI-enabled automation capabilities must operate within broader institutional frameworks for accountability, compliance, and strategic oversight.

Accordingly, the convergence of RPA, AI, analytics, and agent-based technologies reinforces the need for architectural models that can accommodate both current automation requirements and future developments in intelligent automation. Such considerations provide an important foundation for the governance-integrated architecture proposed in this study.

3. Research Methodology

This study adopts the DSR methodology proposed by Hevner et al. (2004) and further operationalized by Peffers et al. (2007). DSR is particularly appropriate for addressing organizational problems through the design and evaluation of purposeful artifacts. In contrast to explanatory research that seeks to describe or predict phenomena, DSR focuses on creating innovative solutions capable of addressing identified practical and theoretical challenges.

The motivation for this study arises from the absence of governance-integrated and vendor-agnostic automation frameworks capable of supporting institution-wide automation initiatives in higher education institutions. As identified in the literature review, existing studies have primarily examined automation implementation, adoption challenges, and operational outcomes, while providing limited guidance regarding the architectural organization and capability development of automation ecosystems in university environments. To address this gap, the study develops two complementary artifacts: (1) the GI-RPA-HE and (2) the AMM-HEI.

The research process consisted of four major phases: literature synthesis, industrial benchmarking, architectural abstraction, and artifact construction. Literature synthesis established the theoretical foundations of the study by examining prior research on RPA, EA, IT governance, digital transformation in higher education, and AI-enabled automation. Building upon this foundation, a benchmarking analysis of contemporary automation platforms was conducted to identify recurring architectural characteristics and implementation patterns. The resulting findings were subsequently abstracted into a vendor-agnostic architectural framework and a maturity model tailored to the higher education context.

3.1 Industrial Benchmarking and Data Sources

To investigate the architectural foundations of contemporary automation ecosystems, an industrial benchmarking study was conducted across six representative automation platforms: UiPath, Automation Anywhere, Microsoft Power

Automate, Robocorp, akaBot, and n8n. These platforms were selected through purposive sampling because they collectively represent diverse segments of the automation market, including enterprise-grade commercial platforms, cloud-based automation ecosystems, regional enterprise solutions, and open-source automation environments. This diversity increases the likelihood of identifying architectural characteristics that transcend individual vendor implementations.

The benchmarking dataset consisted of publicly available technical documentation, platform reference architectures, developer guides, solution white papers, product specifications, and official technical resources published by platform vendors. These materials were selected because they provide detailed descriptions of platform components, orchestration mechanisms, execution environments, integration services, governance capabilities, analytics functions, and emerging AI-enabled features. The objective of the benchmarking process was not to evaluate platform performance, but rather to identify recurring architectural structures shared across contemporary automation ecosystems.

3.2 Architectural Analysis and Invariant Identification

The benchmarking analysis followed a structured qualitative abstraction procedure designed to identify architectural invariants across platforms.

In the first stage, architectural components were systematically extracted from the documentation associated with each platform. Components related to automation development, orchestration, execution, integration, governance, analytics, process intelligence, and AI-enabled services were identified and cataloged.

In the second stage, extracted components were grouped according to their functional roles within the automation ecosystem. This step reduced inconsistencies arising from vendor-specific terminology and enabled comparison at the capability level rather than the product-feature level.

In the third stage, cross-platform comparisons were conducted to identify recurring functional patterns. Components performing equivalent functions across multiple platforms were analyzed to determine shared architectural characteristics regardless of implementation differences.

In the fourth stage, recurring patterns were synthesized into architectural invariants. Within the context of this study, architectural invariants refer to functional capabilities that consistently appear across contemporary automation ecosystems and therefore represent foundational building blocks of automation architecture.

Finally, the identified invariants were abstracted into higher-level architectural layers suitable for institutional deployment within higher education environments. Additional governance, interoperability, and strategic alignment considerations derived from the literature were incorporated to ensure that the resulting architecture addressed the organizational requirements of universities rather than merely reproducing vendor-specific technical structures.

3.3 Artifact Construction

The first artifact, the GI-RPA-HE, was constructed by synthesizing the identified architectural invariants with theoretical concepts derived from EA, IT governance, and higher education digital transformation literature. The resulting architecture organizes automation capabilities into a coherent set of interrelated layers encompassing strategic alignment, process intelligence, automation development, orchestration and execution, integration, governance and compliance, analytics, and AI-enabled services.

The second artifact, the AMM-HEI, was developed as an extension of the proposed architecture. Rather than conceptualizing maturity solely in terms of technology adoption, the model views automation maturity as the progressive institutionalization of architectural capabilities. Maturity levels were therefore defined according to the extent to which architectural layers become integrated, governed, and embedded within institutional processes. This approach establishes an explicit relationship between architectural capability development and organizational automation maturity.

Together, the two artifacts provide complementary perspectives on institutional automation. The GI-RPA-HE architecture defines the structural components required for sustainable automation ecosystems, while the AMM-HEI maturity model provides a developmental pathway through which HEIs may progressively expand and institutionalize those capabilities over time. Consistent with the ex-ante evaluation perspective in DSR, the proposed artifacts were assessed through three complementary criteria: (1) theoretical grounding in the literature on RPA, EA, IT governance, and digital transformation; (2) cross-platform architectural consistency derived from industrial benchmarking; and (3) institutional relevance to the governance and operational requirements of HEIs. This evaluation approach aims to ensure the internal coherence, conceptual validity, and practical applicability of the proposed architecture and maturity model.

4. Industrial Architecture Benchmarking and Invariant Extraction

4.1. Cross-Platform Architectural Convergence

To address RQ1, this study conducted a structured comparative analysis of publicly available architectural descriptions and technical documentation from leading RPA platforms, including UiPath, Automation Anywhere, Microsoft Power Automate, Robocorp, akaBot, and n8n. The purpose of this benchmarking was not to evaluate vendor performance but to identify recurring structural components across heterogeneous implementation ecosystems.

Although these platforms differ in deployment models (cloud-native, hybrid, or open-source), programming paradigms (low-code versus script-based), and integration capabilities, prior studies have observed that modern RPA ecosystems tend to converge around a common set of architectural components enabling scalable automation deployment (Lacity & Willcocks, 2016; Syed et al., 2020). Each platform separates development functionality from runtime execution, introduces a centralized orchestration mechanism for lifecycle management, provides credential and access control mechanisms, supports integration through API connectors, and offers monitoring or analytics modules.

This convergence suggests that modern RPA platforms have evolved toward a shared architectural grammar, where core functional components remain consistent despite differences in implementation technologies and vendor ecosystems. Rather than being proprietary innovations, these components represent functional necessities for scalable automation deployment. From an EA perspective, such recurring elements can be interpreted as architectural invariants, which may be understood as structural primitives that persist across technological variations (Bharadwaj et al., 2013; Ross et al., 2006).

The abstraction process therefore begins by identifying these invariants independent of vendor-specific terminology. For example, while one platform may refer to its orchestration component as a "Control Room" and another as an "Orchestrator," both perform centralized scheduling, bot lifecycle management, and monitoring functions. Similarly, development environments labeled "Studio," "Designer," or "Bot Creator" share the common function of defining process automation logic separate from runtime execution. To formalize this convergence, Table 2 synthesizes the structural components observed across platforms and maps them to generalized functional roles.

Table 2. Cross-Platform Architectural Invariants Identified from Contemporary Automation Platforms

Functional Role	Typical Vendor Terminology	Presence Across Platforms	Abstracted Function
Bot Development Environment	Studio, Designer, Bot Creator	Across all analyzed platforms	Definition and configuration of automation logic
Runtime Execution Engine	Robot, Bot Runner, Agent	Across all analyzed platforms	Execution of automated workflows
Orchestration Layer	Control Room, Orchestrator	Across all analyzed platforms	Scheduling, monitoring, lifecycle governance
Credential Management	Vault, Secure Store	Across most platforms	Secure storage of authentication data
Integration Connectors	APIs, Connectors	Across all analyzed platforms	Interoperability with external systems
Monitoring & Analytics	Insights, Dashboard	Across most platforms	Performance tracking and reporting

ource: authors' synthesis based on industrial RPA platforms.

The convergence illustrated in Table 2 indicates that vendor ecosystems differ primarily at implementation depth rather than structural architecture. This finding directly addresses RQ1: architectural invariants can indeed be identified across leading platforms, and these invariants can be abstracted into vendor-agnostic functional layers. However, industrial convergence alone does not guarantee institutional suitability. Vendor architectures are optimized for enterprise efficiency rather than sector-specific governance complexity. Consequently, abstraction must extend beyond invariant identification toward institutional adaptation.

4.2. From Vendor Components to Functional Layers

Having identified cross-platform invariants, the next analytical step involves reorganizing them into functional layers consistent with EA principles. EA theory emphasizes separation of concerns across strategic, business, application, and technology domains (Bharadwaj et al., 2013; Matt et al., 2015; Ross et al., 2006). Applying this logic to RPA requires grouping vendor components according to their architectural function rather than their proprietary labels.

Development environments and execution engines are conceptually distinct from orchestration layers, which in turn differ from integration mechanisms and governance controls. While vendor documentation often presents these elements as features within a single platform ecosystem, abstraction reveals a layered structure that separates design-time, run-time, coordination, and oversight functions. As shown in Figure 1, vendor-specific components are reorganized into functional invariants, which subsequently inform the development of institutional architectural layers. This abstraction step ensures that the resulting architecture is not a reproduction of any single vendor ecosystem but rather a generalized reference model.

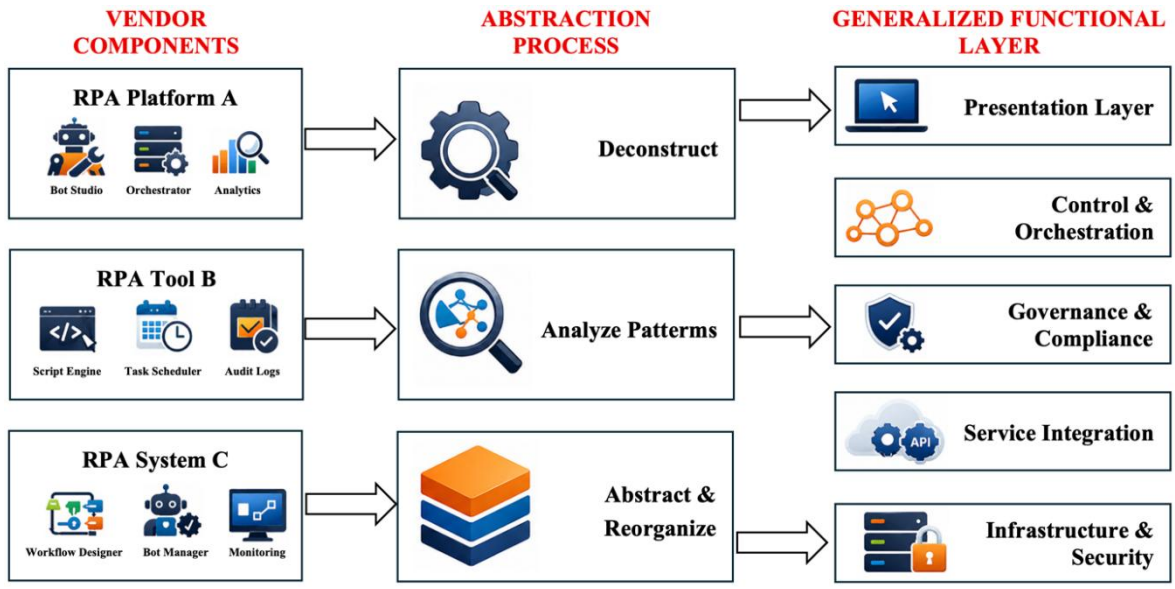

Figure 1. Abstraction process from vendor-specific components to generalized functional layers.

Source: authors' synthesis based on industrial RPA platforms.

4.3. Limitations of Vendor-Centric Architectures in Higher Education

Industrial RPA architectures provide strong technical capabilities. However, they rarely model institutional governance requirements characteristic of higher education environments. Vendor documentation typically embeds governance within administrative modules, focusing on role-based access control and credential security. However, universities require additional layers of strategic oversight and compliance traceability.

Therefore, while industrial benchmarking confirms the existence of cross-platform architectural invariants, these vendor-derived structures remain insufficient for modeling the governance complexity of higher education environments. Consequently, a higher level of architectural abstraction is required to integrate automation infrastructures with institutional governance mechanisms. This requirement motivates the development of the GI-RPA-HE architecture, presented in the following section.

4.4. Architectural Abstraction Principles

While the benchmarking analysis identified a set of recurring technological invariants across contemporary automation platforms, institutional automation in higher education requires a broader architectural perspective than vendor ecosystems typically provide. Enterprise automation platforms are primarily designed to support operational efficiency and technical deployment. In contrast, universities must also address strategic alignment, institutional governance, regulatory compliance, and long-term capability development.

Consequently, the abstraction process was guided by two complementary principles. First, technological invariants extracted from industrial platforms were preserved as the operational foundation of the architecture. These invariants include automation development, orchestration, execution, integration, and monitoring capabilities. Second, additional architectural layers were incorporated based on insights from EA, IT governance, and digital transformation literature to address organizational requirements that are not explicitly represented within vendor-centric platforms.

Through this abstraction process, operational capabilities identified during benchmarking were reorganized into higher-level architectural layers suitable for institutional deployment. Strategic alignment and governance mechanisms were introduced to ensure institutional coordination and accountability, while process intelligence and analytics capabilities were incorporated to support continuous improvement and organizational learning. The resulting architecture therefore extends beyond technological infrastructure and conceptualizes automation as an institution-wide

capability embedded within broader digital transformation initiatives.

The architectural abstraction developed in this section provides the conceptual bridge between the cross-platform invariants identified in RQ1 and the governance-integrated institutional architecture proposed in response to RQ2.

5. The Governance-Integrated RPA Architecture for Higher Education (GI-RPA-HE)

Building upon the architectural invariants identified in Section 4, the GI-RPA-HE architecture reorganizes automation capabilities into a governance-integrated institutional framework comprising seven interrelated layers. Grounded in EA principles, the framework extends vendor-centric automation ecosystems by incorporating strategic alignment, governance, interoperability, analytics, and institutional capability development requirements specific to HEIs.

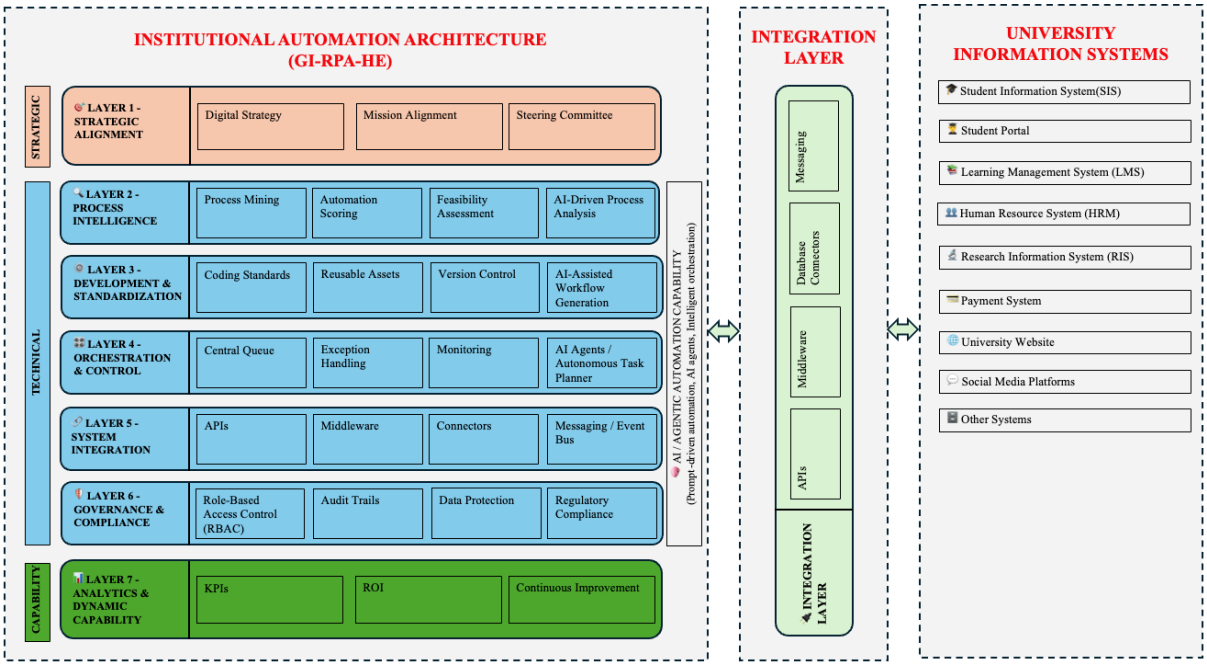

Figure 2. The GI-RPA-HE architecture and its interaction with institutional information systems

Source: authors' own design.

Strategic Alignment Layer

The Strategic Alignment Layer serves as the governance foundation of the architecture. Its primary purpose is to ensure that automation initiatives remain aligned with institutional objectives, digital transformation priorities, and organizational strategies. In higher education environments, automation projects frequently emerge from local administrative needs and may become fragmented without institutional coordination. This layer therefore provides mechanisms for strategic oversight, prioritization, and resource allocation. Typical components include digital transformation strategies, institutional steering committees, and decision-making structures responsible for guiding automation investments. By embedding strategic alignment within the architecture, automation is positioned not merely as a technical initiative but as a strategic institutional capability. Whereas the Governance and Compliance Layer focuses on operational accountability and regulatory requirements, the Strategic Alignment Layer focuses on ensuring that automation activities contribute to long-term institutional goals.

Process Intelligence Layer

The Process Intelligence Layer supports the identification and evaluation of automation opportunities within institutional workflows. Extending the benchmarking-derived architecture,

this layer incorporates process discovery, process mining, and automation assessment capabilities commonly discussed in business process management and digital transformation research. By analyzing workflow data and operational processes, institutions can identify repetitive, rule-based activities suitable for automation and prioritize initiatives according to expected value and feasibility. Emerging AI techniques may further enhance this capability through automated process analysis and opportunity detection. Consequently, automation decisions become evidence-based rather than driven by ad-hoc experimentation.

Development and Standardization Layer

The Development and Standardization Layer provides the environment through which automation solutions are designed, configured, and maintained. It encompasses workflow development tools, reusable automation components, coding standards, documentation practices, and lifecycle management procedures. In HEIs, automation initiatives often emerge across multiple departments, creating risks of duplication and inconsistent implementation. This layer promotes standardization by encouraging common development practices and reusable design patterns. As a result, automation solutions can be developed more efficiently, maintained more effectively, and scaled across institutional contexts while reducing technical complexity and governance risks.

Orchestration and Control Layer

The Orchestration and Control Layer coordinates the execution, scheduling, monitoring, and management of automation processes. It serves as the operational core of the automation ecosystem by ensuring that workflows are executed reliably and according to predefined business rules. Key capabilities include workload management, process scheduling, exception handling, and resource allocation. Within higher education environments, this layer enables institutions to manage automation activities across multiple administrative units while maintaining operational consistency and service continuity. By centralizing automation control, institutions can improve scalability, visibility, and operational resilience.

System Integration Layer

The System Integration Layer enables automation services to interact with the diverse information systems that characterize modern university environments. Typical integrations include student information systems, learning management systems, financial systems, human resource platforms, and institutional reporting tools. Because HEIs often operate heterogeneous digital ecosystems, interoperability becomes a critical requirement for sustainable automation. This layer provides the interfaces and connectivity mechanisms necessary for data exchange and process coordination across systems. Consequently, automation initiatives can operate as institution-wide capabilities rather than isolated departmental solutions.

Governance and Compliance Layer

The Governance and Compliance Layer ensures that automation initiatives operate within institutional policies, regulatory requirements, and risk management frameworks. Core responsibilities include access control, auditability, security management, compliance monitoring, and accountability mechanisms. Universities must frequently manage sensitive information while complying with internal policies and external regulations. Consequently, governance cannot be treated as a secondary consideration but must be embedded directly within the automation architecture. This layer provides the oversight necessary to ensure that automation activities remain secure, transparent, and institutionally accountable.

Analytics and Dynamic Capability Layer

The Analytics and Dynamic Capability Layer supports performance measurement, organizational learning, and continuous improvement. Through operational metrics, dashboards, and analytical insights, institutions can evaluate the effectiveness of automation initiatives and identify opportunities for optimization. Beyond monitoring performance, this layer enables universities to adapt automation capabilities in response to changing institutional priorities and operational conditions. Drawing on the concept of dynamic capabilities, the layer supports the continuous evolution of automation

ecosystems and helps ensure that automation investments remain relevant and strategically valuable over time.

AI-Enabled and Agentic Automation Capability

Unlike the seven architectural layers, AI-Enabled and Agentic Automation Capability is conceptualized as a cross-cutting capability that operates across multiple layers of the architecture. Recent advances in AI, LLMs, and autonomous agents have expanded the scope of automation beyond rule-based task execution. These technologies can support process discovery, decision assistance, workflow generation, and adaptive process optimization. Rather than functioning as an independent layer, AI capabilities enhance existing architectural components by increasing flexibility, responsiveness, and decision-support capacity. This design allows the architecture to accommodate emerging forms of intelligent automation while preserving governance, transparency, and institutional control.

Collectively, the seven architectural layers transform vendor-specific automation capabilities into a governance-integrated institutional framework capable of supporting large-scale automation initiatives in higher education environments. By combining technological infrastructure, governance mechanisms, interoperability capabilities, analytics, and AI-enabled services within a unified architectural perspective, the GI-RPA-HE architecture addresses RQ2 and provides a vendor-agnostic foundation for the institutionalization of automation as part of broader digital transformation strategies.

6. Automation Maturity Model for Higher Education Institutions (AMM-HEI)

While the GI-RPA-HE architecture defines the structural foundation of institutional automation infrastructures, universities typically adopt automation technologies gradually rather than implementing a complete architecture at once (Syed et al., 2020). To capture this evolutionary process, this study proposes the AMM-HEI maturity model. The AMM-HEI conceptualizes institutional automation as a progressive capability that develops through multiple stages. Maturity models are widely used in information systems research to describe the gradual evolution of organizational capabilities and to provide guidance for technology adoption and governance development (Becker et al., 2009; Mettler, 2011). In the context of automation, maturity models help organizations understand how isolated automation initiatives can evolve into strategically aligned institutional automation ecosystems. The proposed AMM-HEI model defines five maturity levels, representing a progression from ad-hoc automation experiments to fully autonomous institutional automation environments. Each maturity level corresponds to the progressive activation of architectural layers within the GI-RPA-HE framework. As institutions advance through maturity levels, additional architectural layers become institutionalized, enabling increasingly sophisticated automation capabilities. Figure 3 illustrates the proposed maturity model.

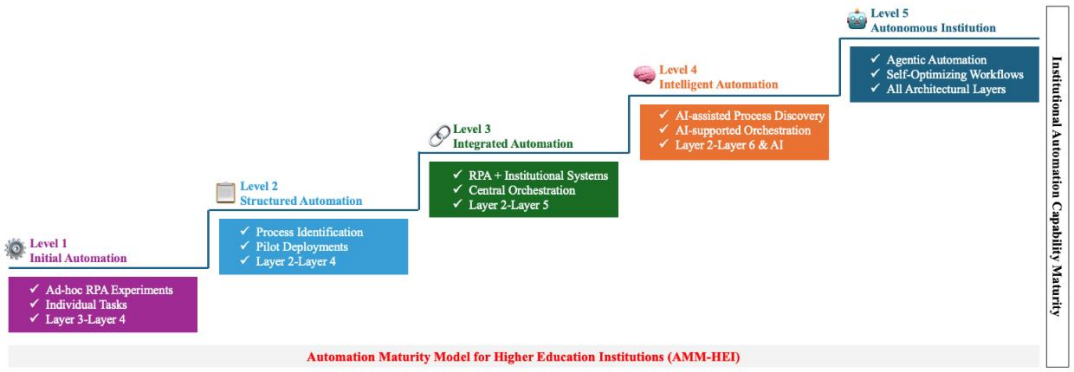

Figure 3. The AMM-HEI maturity model illustrating the progressive institutionalization of RPA and AI-enabled automation capabilities.

Source: proposed by the authors.

Level 1: Initial Automation

The first maturity level represents the earliest stage of automation adoption, characterized by isolated and experimental automation initiatives. At this stage, automation efforts typically focus on individual tasks performed within administrative processes. These initiatives are often initiated by individual departments seeking to reduce repetitive manual work. Automation implementations at this level are primarily based on simple RPA scripts that interact with user interfaces to execute repetitive tasks. Governance mechanisms and strategic coordination are typically absent, and automation activities remain localized within individual operational units. From an architectural perspective, this stage primarily activates the Development and Orchestration layers (Layer 3-Layer 4) of the GI-RPA-HE architecture. Automation scripts can be developed and executed, but broader institutional integration and governance structures are not yet established.

Level 2: Structured Automation

At the second maturity level, automation initiatives become more organized and systematic. Institutions begin to identify automation opportunities intentionally, often through structured assessments of administrative workflows. Automation projects at this stage may include pilot deployments targeting repetitive administrative processes such as data entry, report generation, or information synchronization across systems. Although automation initiatives remain relatively localized, institutions begin to develop basic governance practices for managing automation projects. Architecturally, this stage introduces the Process Intelligence Layer (Layer 2) alongside the development and orchestration capabilities already present. Institutions begin to analyze workflows systematically and identify suitable candidates for automation. As a result, the active architectural scope expands to Layer 2 through Layer 4.

Level 3: Integrated Automation

The third maturity level represents the transition from isolated automation projects to institutionally integrated automation infrastructures. Automation workflows increasingly interact with institutional information systems, enabling cross-system process execution. At this stage, universities integrate automation workflows with core enterprise systems such as student information systems, learning management systems, financial systems, and research management platforms. Centralized orchestration mechanisms are typically introduced to coordinate automation activities across multiple processes and departments. Within the GI-RPA-HE architecture, this level activates the System Integration Layer (Layer 5) in addition to the previously established layers. Automation workflows can now interact with institutional systems through APIs, connectors, middleware services, and event-driven messaging infrastructures. Consequently, automation capabilities expand to Layer 2 through Layer 5.

Level 4: Intelligent Automation

The fourth maturity level represents the emergence of AI-augmented automation infrastructures. At this stage, automation systems incorporate AI technologies that enhance process discovery, decision support, and orchestration mechanisms. AI can support the identification of automation opportunities through data-driven process analysis, while intelligent orchestration mechanisms can dynamically allocate automation tasks and optimize workflow execution. AI technologies may also assist in generating automation workflows through natural language interfaces or machine learning models. From an architectural perspective, this stage activates the Governance and Compliance Layer (Layer 6) in addition to the existing technical infrastructure. Institutions establish stronger governance mechanisms such as audit trails, regulatory compliance monitoring, and data protection policies to ensure responsible automation deployment. As illustrated in Figure 3, the operational scope of automation infrastructures expands to Layer 2 through Layer 6, augmented by AI capabilities. At this stage, enterprise-wide governance structures become formalized, although automation remains primarily focused on operational optimization rather than institution-wide strategic transformation. Automation initiatives are increasingly evaluated according to institutional priorities, risk management

requirements, and compliance obligations rather than purely operational considerations.

Level 5: Autonomous Institution

At the highest maturity level, strategic alignment becomes fully institutionalized and embedded within university decision-making processes. Automation evolves from a collection of operational tools into a strategic institutional capability that supports governance, service delivery, and continuous organizational improvement. Rather than focusing solely on task automation, institutions at this stage leverage automation as an integral component of their broader digital transformation strategy. Automation infrastructures are deeply integrated across administrative functions, enabling coordinated process execution, data sharing, and decision support throughout the institution. AI-enabled services and autonomous software agents increasingly support workflow coordination, exception handling, predictive analysis, and adaptive process optimization. Through continuous interaction with institutional systems and operational data, automation capabilities become more responsive to changing organizational requirements and environmental conditions. From an architectural perspective, this maturity level activates all layers of the GI-RPA-HE framework, including the Strategic Alignment Layer (Layer 1) and the Analytics and Dynamic Capability Layer (Layer 7). Strategic alignment ensures that automation investments remain connected to institutional priorities, while advanced analytics provide evidence for performance evaluation, resource allocation, and continuous improvement. Governance, interoperability, analytics, and AI-enabled capabilities operate as a unified ecosystem rather than as separate technological functions. In such environments, automation infrastructures evolve into adaptive socio-technical systems that support institutional learning, strategic agility, and long-term capability development. Consequently, automation becomes a sustainable institutional resource that enables universities to continuously enhance administrative effectiveness while responding proactively to emerging opportunities and challenges associated with digital transformation.

Table 3. Characteristics of AMM-HEI Maturity Levels and Corresponding Architectural Activation

Level	Institutional Characteristic	Governance Integration	Architectural Activation
Level 1 - Initial Automation	Ad-hoc RPA experiments focused on individual administrative tasks	No formal governance; automation initiated locally	**Layer 3-Layer 4** (Development and Orchestration)
Level 2 - Structured Automation	Systematic identification of automation opportunities and pilot deployments	Basic coordination and development standards	**Layer 2-Layer 4** (Process Intelligence, Development, Orchestration)
Level 3 - Integrated Automation	Automation workflows integrated with institutional information systems	Emerging governance coordination across departments	**Layer 2-Layer 5** (Integration with SIS, LMS, etc.)
Level 4 - Intelligent Automation	AI-assisted process discovery and orchestration capabilities	Formal governance, compliance monitoring, and auditability	**Layer 2-Layer 6 + AI capabilities**
Level 5 - Autonomous Institution	Institution-wide intelligent automation characterized by strategic alignment, agentic capabilities, and continuous optimization	Strategic automation governance integrated with institutional decision-making	**All architectural layers operational (Layer 1-Layer 7)**

Source: authors' synthesis.

Table 3 summarizes the characteristics of each maturity level and its corresponding architectural activation. Collectively, the maturity model addresses RQ3 by conceptualizing automation as a progressive institutional capability that evolves from isolated automation initiatives toward strategically aligned and intelligent automation ecosystems.

7. Discussion

The purpose of this study was to investigate how automation can be conceptualized and governed as an institutional capability within higher education environments. Through the development of the GI-RPA-HE architecture and the AMM-HEI maturity model, the findings extend existing automation research beyond implementation-focused perspectives and contribute to ongoing discussions concerning EA, institutional governance, and digital transformation in universities.

The industrial benchmarking conducted in this research demonstrates that contemporary automation platforms exhibit a considerable degree of architectural convergence. Despite differences in vendor ecosystems, deployment models, and implementation approaches, most platforms contain recurring components related to automation development, workflow execution, orchestration, integration, governance, and monitoring. This convergence suggests that scalable automation infrastructures are built upon a common set of architectural principles rather than proprietary technological innovations alone. By abstracting these recurring components into vendor-agnostic functional layers, the proposed architecture provides a conceptual foundation that can guide automation initiatives independently of specific technology providers. Theoretically, this finding extends existing automation research by repositioning automation architecture as an institutional capability rather than a collection of implementation technologies.

From an EA perspective, the findings reinforce the importance of aligning automation initiatives with broader institutional objectives. Universities are characterized by complex organizational structures, multiple stakeholder groups, decentralized decision-making processes, and heterogeneous information systems. Within such environments, automation initiatives frequently emerge as localized responses to operational challenges. Although these initiatives may generate immediate benefits at the departmental level, their institutional impact is often limited when they are implemented without coordination, governance, or integration with wider digital transformation strategies. The GI-RPA-HE architecture addresses this challenge by embedding automation within a governance-oriented architectural framework that connects strategic objectives, process analysis, technology infrastructure, and continuous capability development.

The proposed maturity model further extends existing discussions on automation adoption by conceptualizing automation as an evolving institutional capability rather than a collection of isolated projects. The AMM-HEI model illustrates how universities can progressively expand their automation capabilities through the activation of additional architectural layers. Early stages focus primarily on automating repetitive administrative tasks, while later stages emphasize system integration, governance mechanisms, intelligent decision support, and organizational learning. This progression reflects the reality that successful digital transformation requires the co-evolution of technology, governance, and organizational capabilities. Consequently, the maturity model provides a roadmap that may assist university leaders in planning automation initiatives and evaluating their institutional readiness for more advanced forms of automation.

The findings also have important implications for higher education administration. By supporting process standardization, interoperability, and governance integration, the proposed architecture enables universities to coordinate automation initiatives across organizational units and information systems. Consequently, automation can contribute not only to efficiency improvement but also to institutional coordination, transparency, and service quality enhancement.

In the broader context of digital transformation, the architecture highlights the increasing importance of interoperability and governance. As universities continue to expand their digital ecosystems through student information systems, learning management systems, research management platforms, and cloud-based services, the ability to coordinate processes across these environments becomes increasingly critical. The integration layer proposed in the GI-RPA-HE architecture provides a conceptual mechanism through which automation can bridge fragmented systems and support more seamless administrative workflows. At the same time, the governance layer emphasizes the need for accountability, compliance, security, and strategic oversight, ensuring that automation initiatives remain aligned with institutional priorities and regulatory requirements.

Another important contribution of the study is the integration of AI-enabled and agentic automation capabilities within the proposed architecture. Rather than treating AI as a separate technological component, the framework conceptualizes AI as a cross-cutting capability that enhances process discovery, orchestration, analytics, and decision support. This perspective reflects the ongoing evolution of automation from rule-based task execution toward more adaptive and intelligent forms of institutional support, while maintaining governance and organizational control.

The proposed framework therefore contributes to a broader understanding of digital transformation in higher education. Digital transformation is often interpreted primarily as the adoption of new technologies. However, the findings of this study suggest that sustainable transformation requires a combination of technological infrastructure, governance mechanisms, organizational capabilities, and continuous institutional learning. Automation becomes most valuable when it is embedded within a coherent institutional architecture that supports strategic objectives and enables ongoing capability development. From this perspective, automation represents not merely a technological innovation but a foundational component of modern university administration.

Despite these contributions, several limitations should be acknowledged. First, both the GI-RPA-HE architecture and the AMM-HEI maturity model are conceptual artifacts derived from literature synthesis and industrial benchmarking rather than empirical implementation studies. Although this approach is consistent with DSR, future research should evaluate the applicability of the proposed framework through case studies, expert assessments, and longitudinal investigations of automation initiatives within higher education institutions. Second, the benchmarking analysis focused on widely adopted automation platforms and may not fully capture emerging developments in AI-native automation environments. As automation technologies continue to evolve, new architectural patterns may emerge that require refinement of the proposed framework.

Overall, the findings suggest that automation should be understood not merely as a technological tool for improving administrative efficiency, but as an institutional capability requiring governance, interoperability, and continuous organizational development. By linking architectural design with capability maturity, the proposed framework offers a foundation for universities seeking to develop scalable, sustainable, and strategically aligned automation ecosystems as part of their broader digital transformation efforts.

8. Conclusion and Future Research

This study addressed the challenge of conceptualizing automation as an institutional capability within higher education environments. While automation technologies are increasingly adopted to improve administrative efficiency, existing implementations often remain fragmented and disconnected from broader governance and digital transformation initiatives. To address this limitation, the study employed a DSR approach to develop two complementary artifacts: the GI-RPA-HE and the AMM-HEI.

The study contributes to the literature in three ways. First, it identifies and formalizes architectural invariants shared across contemporary automation platforms through cross-platform benchmarking. Second, it proposes a governance-integrated and

vendor-agnostic reference architecture that connects automation infrastructure with strategic alignment, interoperability, governance, analytics, and institutional capability development. Third, it introduces a maturity model that conceptualizes automation as a progressive organizational capability evolving from isolated automation initiatives toward intelligent and strategically aligned automation ecosystems.

From a practical perspective, the proposed framework provides university leaders and digital transformation practitioners with a structured reference for designing, governing, and scaling automation initiatives. By linking architectural capabilities with maturity development, the framework offers a roadmap for institutionalizing automation as part of broader higher education digital transformation strategies.

The study remains subject to several limitations. Both artifacts are conceptual and derived from literature synthesis and industrial benchmarking rather than empirical implementation. Future research should therefore evaluate the framework through case studies, expert validation, and longitudinal investigations in diverse higher education contexts. Further research may also examine how emerging AI-native and agentic automation technologies influence the evolution of institutional automation architectures and maturity pathways.

Overall, the study argues that sustainable automation in higher education depends not only on technological deployment but also on the integration of governance, interoperability, and organizational capability development. By integrating architectural design, governance principles, and capability maturity into a unified framework, the study contributes to a more comprehensive understanding of how automation can support the digital transformation of higher education administration.

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