

Phase-Dependent Drivers and Cumulative Institutional Impacts of Digital Transformation Adoption in Saudi Public Universities

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Abstract—Digital transformation (DX) adoption in Saudi public universities is shaped by centralised governance and national policy, notably Vision 2030, which existing Western models often fail to capture. This study examines and extends the Digital Transformation Adoption framework (DXA-SPU) through a sequential explanatory mixed-methods design, combining structural equation modelling of survey data with thematic analysis of interviews with senior IT leaders. Results reveal that adoption is governed by Phase-Dependent Drivers: national mandates and Strategy trigger the initial decision, while Collaboration and Coordination facilitate implementation. We further identify Cumulative Institutional Impacts, in which operational gains in Infrastructure and Efficiency precede later improvements in Teaching and Institutional Performance. Theoretically, the study reconceptualises governance structure as the determinant of factor timing; methodologically, it shows how explanatory mixed-methods resolve non-significant survey paths; practically, it offers university leaders a staged template for managing digital change. As a cross-sectional, single-country study, it invites longitudinal and comparative validation.

Index Terms—Digital transformation, Institutional impacts, Phase-Dependent Drivers, Cumulative Impacts, Mixed-Methods Research, Saudi public universities, TAM, TOE, Vision 2030, Institutional Performance, Thematic analysis.

I. INTRODUCTION

DIGITAL transformation (DX) is now a strategic issue in higher education. It is not only about new tools and technologies, but also about changes in how universities plan, deliver services, and organise work [1, 2, 3]. In Saudi Arabia, this shift is tied to Vision 2030 and the National Transformation Program [4, 5], which aim to modernise public services and strengthen the knowledge economy [6, 7]. Saudi public universities (SPUs) are central to that agenda, yet many still face challenges in readiness, governance, and strategic alignment despite major investment in digital infrastructure [8, 9].

Much of the literature on DX adoption in higher education draws on models developed in Western or private-sector set-

tings [10, 11]. Although useful, such work does not fully reflect the conditions in public universities operating under centralised governance and national policy direction. In the Saudi case, adoption decisions are shaped simultaneously by user perceptions, institutional hierarchy, and state regulation. This mix has received limited attention in the relevant literature.

The DXA-SPU framework was developed for this decision-making setting by combining the Technology Acceptance Model (TAM) and the Technology-Organisation-Environment (TOE) framework [11, 12]. Our earlier work tested this framework with survey data from 447 participants [13]. While 12 of the 14 hypotheses were supported, quantitative methods are inherently limited to identifying statistical associations. It cannot explain the institutional processes or the logic behind adoption decisions. Our earlier work also did not explore whether this non-significance reflected the faculty-dominated nature of its sample.

This paper addresses these gaps by introducing the concepts of Phase-Dependent Drivers and Cumulative Impacts. We demonstrate that the importance of adoption factors is not static throughout the project lifecycle. Instead, drivers such as collaboration shift from being non-significant during the initial decision phase to becoming critical during implementation.

This paper differs from our earlier work [13] in three concrete ways. First, it contributes new primary data: whereas [13] analysed survey responses from 447 participants (67.3% academic faculty), this study draws on original interviews with 11 senior IT leaders who direct institution-level adoption, a population absent from the prior study. Second, it advances new theoretical constructs, Phase-Dependent Drivers and Cumulative Institutional Impacts, that were neither proposed nor testable in the cross-sectional quantitative design. Third, it makes an explanatory contribution that the prior paper could not explicitly make at the statistical analysis stage. It resolves the two statistically non-significant survey paths (Collaboration and Coordination, Competitive Pressure) by showing they are not weak factors but factors that act at a later

project phase. In short, [13] established which factors correlate with adoption; this paper explains how and why they operate, and when each becomes influential.

The current study presents the qualitative phase of the research design. We interviewed top-level decision-makers to explain the mechanisms behind our previous statistical results. This study provides a dynamic framework for digital transformation in centralised governance settings.

Section II reviews related work and the framework. Section III outlines the method. Section IV presents the findings, recapping the quantitative results before the qualitative analysis. Section V discusses both strands together, and Section VI concludes.

II. LITERATURE REVIEW

Research on digital transformation in higher education has grown rapidly, but most studies still rely on surveys, structural models, or secondary data to identify factors influencing adoption [10]. Far fewer studies examine how adoption decisions are made inside universities. Where qualitative work exists, it often focuses on a single tool, such as an e-learning platform or learning management system, rather than a university-wide DX [14, 15]. As a result, existing research provides limited insight into the decision processes and institutional choices that underlie the statistical findings reported in quantitative studies.

Governance structure is central to understanding adoption in this context. Institutional perspectives on technology adoption have long recognised that in public sector organisations, governance arrangements shape how technologies are adopted and enacted in practice. Fountain's technology enactment framework argues that institutional arrangements, including cognitive, cultural, and legal structures, determine how objective technologies become enacted differently across organisations [16]. Dunleavy's Digital Era Governance approach similarly argues that in public institutions, organisational structure and process change drive technology adoption, not the other way around [17]. TAM [12] and TOE [11], two widely applied adoption frameworks, were developed and tested in settings where organisations have broad independence in technology decisions. In that literature, collaboration and competitive pressure are often treated as direct drivers of adoption [18, 19]. Saudi public universities operate differently: Vision 2030 and the National Transformation Program shape strategy, funding, and performance expectations [6]. In this context, adoption decisions are influenced by compliance and top-down direction as much as by internal agreement or peer competition.

Studies in Saudi Arabia have examined attitudes to DX [8], requirements for transformation [9], organisational routines [20], data governance [21], the effect of COVID-19 on digital adoption [22], and the role of digital learning in sustainable development [23]. These studies are valuable, but most focus on one part of the problem at a time. They do not provide an integrated account of how organisational, technological, and environmental factors interact in DX adoption, nor do they

consider the impacts of DX. Our paper provides qualitative evidence on how these factors operate in practice and why some expected relationships do not hold in the Saudi governance setting.

Survey-based studies identify which factors correlate, but provide less insight into how decisions are made and why a factor that is salient in practice may not emerge as a direct statistical predictor [24]. For that reason, qualitative evidence is especially valuable when a study seeks to explain non-significant paths in an adoption model rather than confirm expected ones [24].

In this study of SPUs, where national programmes, ministerial direction, and institutional hierarchy shape major investment decisions, adoption cannot be understood solely in terms of individual perceptions. The decision to launch a digital initiative may be made at the top, while the coordination, local adjustments, and user acceptance occur later. Our study addresses this gap by showing how the same factor can have different effects at different stages of the adoption process.

Therefore, this study positions the qualitative phase as an analytical bridge rather than a supplement to the survey. As argued by [24], this approach uses qualitative data to explain and elaborate initial quantitative patterns, interpreting factors that are highly visible in practice yet emerged as weak statistical predictors.

A. The DXA-SPU Framework

The DXA-SPU framework combines TAM and TOE to examine DX adoption at the institutional level in SPUs [13]. TAM contributes to perceived ease of use and perceived usefulness [12]. TOE captures organisational, technological, and environmental conditions that shape adoption in public institutions. The framework includes 10 factors related to the intention to adopt DX (H1-H10) and 4 institutional outcome constructs (H11-H14). Full framework development is reported in [13].

The organisational context includes Effective Strategy (ES), Collaboration and Coordination (CC), and Funding and Resources (FR). The technological context covers Complexity (CX), Security (SC), Ease of Use (EU), and Usefulness (UF). The environmental context captures Regulatory Environment (RE), Competitive Pressure (CP), and Digital Upskilling (DU). The outcome side includes Institutional Performance (IP), Administrative Efficiency (AE), Technical Infrastructure (TI), and Teaching and Learning Effectiveness (TLE).

III. STUDY METHODOLOGY

This study employed a sequential explanatory mixed-methods design to bridge the gap between statistical outcomes and institutional reality [24]. The primary rationale for this design was to provide a deeper explanation of the "how" and "why" behind the results of the initial quantitative phase ($n=447$) [13]. Specifically, while the survey confirmed the majority of the hypothesised relationships, it could not explain why Collaboration and Coordination and Competitive Pressure were

non-significant in the Saudi context. By following the survey with qualitative interviews, this study explores whether these factors are truly secondary or if their influence is Phase-Dependent, shifting as a project moves from a top-down mandate to operational implementation.

Participant Selection and Sampling Logic

Purposive sampling was used to recruit 11 senior IT leaders across various Saudi Public Universities between June and September 2025. Purposive sampling is appropriate here because the study targets a specifically informed population, those who direct institution-level adoption, rather than a statistically representative one; this elite-informant logic is standard for the explanatory phase of a mixed-methods design. These participants were selected because they occupy a critical governance role, translating national strategic mandates into practical technology adoption. This selection also addresses a demographic limitation in the previous study phase, which relied heavily on academic faculty (67.3% of respondents). Unlike faculty, senior IT leaders are directly involved in system rollouts and manage the technical complexities that define the institutional adoption process. Each participant was required to have led a major digital transformation project within the last three years, ensuring the data reflects current institutional realities under the Saudi Vision 2030 framework.

Data Collection and Ethical Procedures

The qualitative data were gathered through semi-structured interviews lasting 45 to 60 minutes. These sessions were conducted either in person or via Zoom, recorded, and transcribed verbatim for analysis. The 39-question interview guide was mapped directly to the DXA-SPU framework constructs, such as Perceived Usefulness, Security, and Complexity, distributing roughly two to three open questions across each of the fifteen constructs rather than over-burdening any single theme. This alignment allowed the qualitative evidence to be correlated directly with the survey variables while still permitting an open-ended exploration of unexpected results.

Ethical approval for this study was obtained from the University of Sussex Sciences and Technology Cross-Schools Research Ethics Committee (ref ER/SA2142/3). All participants provided informed consent and were de-identified using codes P1–P11 to ensure institutional confidentiality.

Thematic Analysis and Trustworthiness

To ensure a rigorous analytical process, the interview data were processed through a multi-stage thematic analysis in NVivo [25]. The coding strategy was both deductive and inductive: an *a priori* codebook ensured alignment with the DXA-SPU constructs, while open coding allowed for the emergence of "temporal sequence" and "cumulative impact" patterns. To enhance interpretative consistency, a peer-checking process was implemented where a second researcher reviewed a subset of the transcripts. Thematic saturation was assessed iteratively throughout the process. The later interviews confirmed and elaborated on patterns already established in the earlier ones rather than introducing new thematic

categories, indicating that saturation had been reached within the sample.

IV. FINDINGS

This section summarises the quantitative results [13]. Table I reproduces the structural model results from that prior work; these values are not re-estimated here. They are presented solely to make the sequential design transparent and to identify the patterns, particularly the non-significant paths for Collaboration and Coordination (H2) and Competitive Pressure (H9), that the qualitative phase was designed to explain.

Eight out of ten hypotheses related to DX Adoption were supported. Perceived Usefulness had the largest effect ($\beta = .272$, $p < 0.001$), followed by Digital Upskilling ($\beta = .239$, $p < 0.001$), Funding and Resources ($\beta = .184$, $p = 0.002$), Complexity ($\beta = .181$, $p < 0.001$), Security ($\beta = .131$, $p = 0.003$), Effective Strategy ($\beta = .121$, $p = 0.001$), Ease of Use ($\beta = .103$, $p = 0.047$), and Regulatory Environment ($\beta = .091$, $p = 0.009$). Two hypotheses were not supported: Collaboration and Coordination (H2: $\beta = -0.009$, $p = .773$) and Competitive Pressure (H9: $\beta = .100$, $p = 0.068$). All four Impact hypotheses (H11 to H14) were strongly supported, with Administrative Efficiency showing the largest coefficient ($\beta = .753$, $p < 0.001$), followed by Technical Infrastructure ($\beta = .683$, $p < 0.001$), Teaching and Learning Effectiveness ($\beta = .639$, $p < 0.001$), and Institutional Performance ($\beta = .629$, $p < 0.001$). Table I summarises these results.

TABLE I.
SUMMARY OF HYPOTHESIS TESTING RESULTS

H	Path	β	S.E.	C.R.	P	Result
H1	DX $\leftarrow$ ES	.121	.037	3.256	.001	Supported
H2	DX $\leftarrow$ CC	-.009	.031	-.288	.773	Not Supported
H3	DX $\leftarrow$ FR	.184	.059	3.099	.002	Supported
H4	DX $\leftarrow$ CX	.181	.054	3.364	***	Supported
H5	DX $\leftarrow$ SC	.131	.044	2.995	.003	Supported
H6	DX $\leftarrow$ EU	.103	.052	1.983	.047	Supported
H7	DX $\leftarrow$ UF	.272	.049	5.539	***	Supported
H8	DX $\leftarrow$ RE	.091	.035	2.613	.009	Supported
H9	DX $\leftarrow$ CP	.100	.055	1.822	.068	Not Supported
H10	DX $\leftarrow$ DU	.239	.052	4.601	***	Supported
H11	IP $\leftarrow$ DX	.629	.043	14.491	***	Supported
H12	AE $\leftarrow$ DX	.753	.047	16.004	***	Supported
H13	TI $\leftarrow$ DX	.683	.046	14.990	***	Supported
H14	TLE $\leftarrow$ DX	.639	.049	13.165	***	Supported

Note: *** = significance at the 0.001 level. Source: [13].

The non-significance of Collaboration and Coordination and Competitive Pressure is notable, as our interviewees identified both as essential drivers in practice, a visibility also reported in [20, 26]. Therefore, the qualitative analysis addresses this gap by examining decision-making processes, implementation conditions, and participants' interpretations of DX's institutional impacts.

This section presents the findings from the thematic analysis of interviews with 11 senior IT leaders across Saudi public universities. The analysis was framework-guided, using the DXA-SPU constructs to organise and interpret the interview evidence. At the same time, broader patterns emerged from participants' interpretations of how digital transformation is decided, implemented, and experienced in their institutions.

Thematic analysis of the interviews produced four themes: (1) Institutional Alignment and Support, (2) Trusted and Effortless Experience, (3) External Mandates and Pressures, and (4) Operational and Educational Gains.

A. Institutional Alignment and Support

Interviewees described digital transformation as gaining momentum when it was tied to institutional priorities and national goals. For participants, Strategy functioned as the primary mechanism for translating national objectives into specific projects. For instance, P5 noted that Strategy supported data-driven decision-making and a digital culture, while P10 viewed it as a path to leadership in e-learning. In these accounts, Strategy was more than a formal statement; it was the tool used to turn national goals into institutional priorities: *"Our digital transformation strategy is not just about technology; it is deeply connected with the national goals of Saudi Vision 2030. We are focused on using technology to create tangible benefits for our society."* (P1)

When asked why Collaboration and Coordination did not emerge as a significant driver in the earlier survey, P1 explained: *"This perception is likely because the core decision to start a digital transformation project is a strategic, top-down decision from our top leadership. This is especially true when it is connected to a national plan like Saudi Vision 2030."* (P1)

The practical value of Collaboration and Coordination is most significant after a project has moved from approval to execution. This distinction between strategic adoption and operational implementation is reinforced by how universities manage Collaboration and Coordination, as stated by P1. While coordination through steering committees and routine feedback channels, such as Blackboard and internal service platforms, is evident in daily service improvements, it rarely influences the initial decision to adopt a major digital initiative. For instance, P11 described a campus-wide scheduling project, in which disagreements were managed through centralised tracking and early stakeholder engagement rather than broad consultation. When internal disagreements over priorities occur, institutions rely on such central project management to ensure execution without reopening the adoption decision. Consequently, Collaboration and Coordination function as an implementation-stage facilitator rather than a strategic trigger, explaining the non-significance of H2.

Funding was treated as essential, but mostly as a question of pace and scale. P3 explained how endowment companies add to government funding, including a programme that offers up to 50,000 riyals for medium-sized research projects.

P4 described cost-control strategies, such as outsourcing non-critical services. Interviewees did not present funding as the sole factor determining whether DX would be adopted. They described it as the factor that shaped what could be done, how fast, and at what scale.

B. Trusted and Effortless Experience

The technological side of DX was described in practical terms. Interviewees focused on trust, ease of use, and clear value. They also returned repeatedly to one problem: new systems must work with old ones.

Legacy systems integration was the most common implementation problem. P1 said, *"The primary difficulty is integrating new, modern tools with our existing legacy platforms."* P5 linked poor compatibility to delays, errors, and lower confidence in new systems. P2 added that upgrades require careful planning so that integration and security are managed together. Universities responded with pilot testing, phased rollouts, and close work with vendors. P11 gave a concrete example: an AI-based attendance system failed to sync with biometric devices, so the university restored manual tracking while the vendor developed a patch. This episode showed the importance of pre-deployment testing and backup procedures.

Security was treated as a threshold issue that participants (P1, P9) directly linked to institutional trust and operational reliability. Beyond technical protocols, such as pre-approval security checks and incident response procedures, the interviews revealed that Security is intrinsically connected to Complexity. This is demonstrated by the practice of pausing deployments or reverting to stable versions to prevent service disruption when integration fails. Consequently, in a centralised environment, Security is not merely an isolated technical requirement but a continuous process of managing the Complexity inherent in integrated systems.

Ease of use was discussed less as convenience and more as inclusion. P3 stressed user-friendly design and guides for systems such as Blackboard and a university communication platform, adding, *"Ease of use is crucial."* P10 said the goal was to make systems simple enough for everyone to benefit. When systems are hard to use, less confident staff often return to manual work, which limits wider adoption.

Usefulness was the clearest reason for support. P5 said, *"I think they are extremely useful. Our research shows a direct and positive impact. For efficiency, data-driven decision-making has the highest correlation with continuous improvement."* Participants linked usefulness to things they had seen directly, such as faster administration and better teaching decisions. This underpins Perceived Usefulness (H7) as the strongest predictor of adoption intention.

C. External Mandates and Pressures

Environmental conditions also mattered, but not in the same way. Interviewees spoke about regulation, competition, and skills, each working at a different point in the process.

The Regulatory Environment was described less as a checklist and more as a basis for institutional confidence and

legitimacy. Alignment with Saudi Vision 2030, the Digital Government Authority, and national cybersecurity standards (P4, P9) allows senior leaders to justify investment and defend decisions internally. In this sense, regulation does not constrain action; instead, it reduces uncertainty by providing a formal basis for institutional and political alignment. This explains why Regulatory Environment emerged as a significant driver.

In contrast, Competitive Pressure was described as a secondary influence rather than a primary trigger for adoption. While participants like P7 noted it as a factor in specific AI and data science investments, most institutions monitor peers primarily through rankings and networks to shape their positioning once a project is underway. While the two forces are present simultaneously, they operate at different points: Regulatory Environment triggers the initial strategic decision, whereas Competitive Pressure influences how universities advance their endeavours.

While Digital Upskilling emerged as a strong predictor in the survey, the interviews show it is a manageable impediment rather than a constant barrier. Participants (P2, P6) described how universities mitigate this gap through key user testing, targeted workshops, and phased platform introductions. This clarifies the quantitative significance of Digital Upskilling: the primary challenge was not an inherent lack of capacity but rather weak support structures that hindered the pace of adoption. When these support systems are visible and integrated into routine practices, adoption accelerates.

D. Operational and Educational Gains

When discussing systems already in use, interviewees spoke less about adoption and more about what they believed had changed. Two patterns emerged from the interviews. First, participants often described outcomes as becoming easier to observe once systems had stabilised and routine use had increased. Second, they indicated that gains in one area could support gains in others.

Institutional Performance was framed as the cumulative, symbolic outcome of Digital Transformation, shifting the focus from internal efficiency to institutional reputation. Participants (P1, P5) indicated that while automation and infrastructure investment drive service quality, the broader value of Institutional Performance lies in building trust and signalling capability to national stakeholders. By reducing service interruptions and enhancing transparency, universities demonstrate that they are modern, responsive, and well-governed. This underpins H11: Institutional Performance aggregates administrative and technical gains into a broader signal of institutional standing.

Administrative Efficiency (H12) was identified as the most immediate and visible outcome of digital transformation. Participants provided concrete evidence of improved systems that resolved long-standing operational bottlenecks. One notable example provided by P11 illustrates this impact: *"One notable example is the implementation of a unified student*

portal, which centralises academic records, course registration, and fee payments. This reduced student complaints by 40% and minimised administrative bottlenecks." (P11)

Beyond the student portal, participants (P5, P6) noted that cloud platforms and infrastructure upgrades significantly raised service quality in libraries and administrative units. In the interviews, Technical Infrastructure emerged as the foundational layer on which the other three impacts rest, rather than as one impact among equals; P5 noted that network and server investment "creates the foundation for all of our digital transformation projects to succeed." Administrative Efficiency is the first gain to become visible; automation affects daily operations immediately, but it rests on the infrastructure foundation rather than preceding it.

Technical Infrastructure (H13) was described as both a starting point and a reinforcing outcome of Digital Transformation. Participants (P5, P8) noted a cyclical relationship in which adoption programmes justify investment in networks, which in turn lower the cost and difficulty of subsequent innovation. For example, the transition to AI-based tools and virtual classrooms on Blackboard Ultra (P8) was only possible because of prior investments in bandwidth and server nodes. This suggests that Technical Infrastructure is a cumulative asset that builds institutional capacity for future digital shifts.

Teaching and Learning Effectiveness (H14) represents a broad academic shift that integrates digital tools into the core curriculum. Participants (P6-8, P11) highlighted that the value of Digital Transformation in this area extends beyond simply moving content online. It involves providing students with flexible access to materials through virtual labs and aligning programmes more closely with labour market expectations in fields like AI and data science. In these accounts, AI-based plagiarism tools and blended delivery models (P11) strengthen academic integrity and student engagement.

The qualitative evidence suggests that these four outcome areas do not become visible at the same speed. Technical Infrastructure forms the foundational layer. Administrative Efficiency is typically the first gain to become *visible* because automation affects daily operations immediately. Teaching and Learning Effectiveness takes longer as it depends on changes in staff practice and student uptake. Finally, Institutional Performance serves as the cumulative result of these prior successes. While the survey data showed support for H11 through H14 simultaneously, the real-world benefits are interpreted as accumulating progressively over time.

In summary, these qualitative findings provide a multi-layered view of Digital Transformation that extends beyond the statistical associations reported in [13]. The interview data capture the transition from strategic triggers, such as national mandates, to the practical realities of infrastructure and cumulative impact. By providing the institutional logic behind the quantitative patterns, these operational experiences establish the evidentiary basis for the Phase-Dependent DXA-SPU framework discussed in the following section.

V. DISCUSSION

To provide a comprehensive examination of digital transformation in Saudi public universities, this section integrates the structural model results from [13] with qualitative insights. The analysis employs a phase-dependent perspective to clarify how the influence of adoption drivers shifts across the institutional lifecycle. Moving beyond isolated statistical patterns, this synthesis explains the underlying organisational mechanisms and their longitudinal institutional impacts. The updated DXA-SPU framework, reflecting these findings, is presented in Fig. 1.

A. Organisational Context

In the centralised Saudi governance model, Strategy and Funding serve as the primary organisational drivers of adoption. The strong statistical support for Strategy (H1) ($\beta = .121$, $p = .001$) confirms that a clear roadmap is essential for building institutional commitment. Qualitative evidence clarifies that Strategy is not merely a symbolic policy but a mechanism for translating national goals, such as Saudi Vision 2030, into sequenced institutional projects. This aligns with [27], which argues that strategic alignment is a prerequisite for bridging the gap between high-level policy and practical modernisation. Similarly, Funding (H3) ($\beta = .184$, $p = .002$) acts as the critical "safety net" for technical risk-taking. With the Saudi higher education market projected to reach \$317 million by 2025 [27], financial readiness remains the most significant precursor to large-scale action.

In contrast, the rejection of Collaboration and Coordination (H2) ($\beta = -0.009$, $p = .773$) highlights the "top-down" nature of this environment. While inter-departmental cooperation is highly valued during implementation, it does not drive the initial decision to adopt. As noted by [28], hierarchical legacies in Saudi institutions often create friction that delays collective efforts, meaning momentum is generated by mandate rather than horizontal consensus. These results indicate that Digital

Transformation adoption in Saudi public universities is governed by hierarchical triggers, specifically Strategy and Funding, while Collaboration and Coordination functions as an implementation-stage facilitator rather than a strategic trigger. This confirms that the institutional governance structure dictates the timing of factor influence, with top-down mandates preceding bottom-up coordination, providing a necessary correction to Western models that often assume collaborative drivers are present from the beginning.

B. Technological Context

Technological adoption depends on a delicate balance between the perceived value of a tool and the technical barriers to its entry. Perceived Usefulness (H7) ($\beta = .272$, $p < 0.001$) emerged as the strongest predictor in the model, as users view digital tools as fundamental utilities for institutional readiness in an increasingly AI-literate global landscape [29]. However, this utility is contingent upon the mitigation of technical risks, specifically Complexity (H4) ($\beta = .181$, $p < 0.001$) and Security (H5) ($\beta = .131$, $p = .003$). Participants noted that integrating legacy systems with cloud platforms remains a primary hurdle, a perspective supported by [30], which identifies the simplification of traditional constraints as a requirement for institutional agility.

Security has transitioned from a technical requirement into a "threshold issue" for institutional trust. Alignment with national personal data protection laws is now critical to the user trust required for university-wide e-governance adoption [31]. While Perceived Ease of Use (H6) ($\beta = .103$, $p = .047$) was a significant predictor, its modest impact indicates it is an "enabler" rather than a primary driver. As argued in [30], while user-friendly design and training are essential for driving digital performance, users are willing to navigate greater complexity if the system's functional value and security are clearly established.

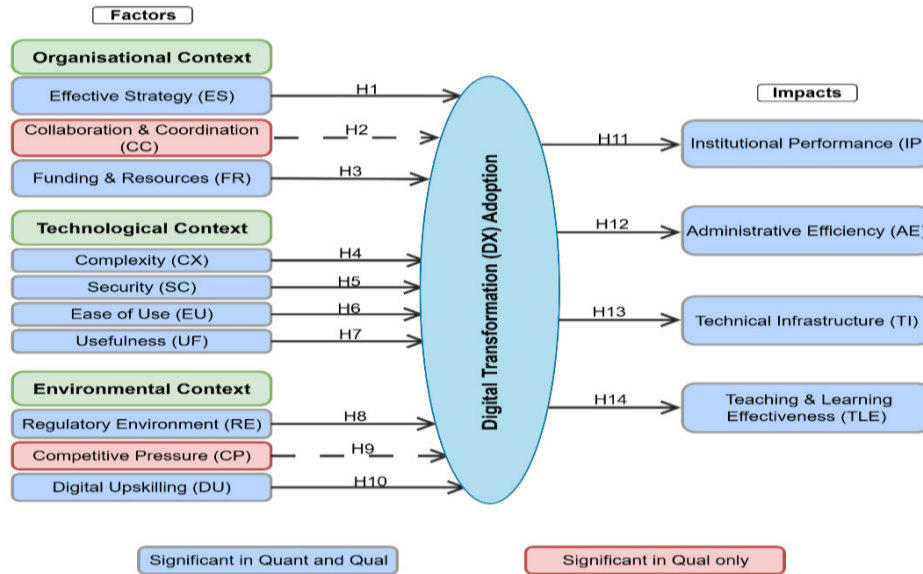


Fig. 1. The Validated and Updated DXA-SPU Framework

These findings suggest that technological adoption depends on a balance between perceived value (UF) and the mitigation of technical risk (CX, SC). Strategic commitment is highest when operational benefits are clear and technical barriers to entry are minimised.

C. Environmental Context

The Regulatory Environment (H8) ($\beta = .091, p = .009$) provides the legal "backbone" of the framework, with the National Transformation Program (NTP) serving as the enabling force that legitimises digital initiatives. Recent 2025 legislation and support policies specifically designed to stimulate innovation within public institutions [32] provide the confidence universities need to pursue modernisation. This mandate-driven logic clarifies why Competitive Pressure (H9) ($\beta = .100, p = 0.068$) was not statistically significant. In a centralised system, market rivalry primarily influences institutional positioning and branding after the infrastructure is established, rather than triggering the core decision to adopt [26].

Furthermore, the strong support for the Digital Upskilling (H10) ($\beta = .239, p < 0.001$) indicates that adoption is fundamentally motivated by the desire to align educational outputs with labour market needs. The strategic priorities identified in [33] emphasise that Saudi universities are under increasing pressure to align digital transformation with student employability and the human capability requirements of Vision 2030. These findings reveal that environmental drivers are not merely external pressures but are strategic imperatives tied to national socioeconomic goals.

D. Institutional Outcome Impacts

The findings are compatible with a provisional cumulative sequence rather than a set of parallel benefits. Because the design is cross-sectional, this ordering rests on the convergence of the qualitative accounts and the pattern of effect magnitudes and is advanced as an interpretation rather than a tested causal sequence. Foundational operational successes create the conditions for subsequent academic and reputational shifts.

Foundational Gains: Technical Infrastructure and Administrative Efficiency

The chain begins with Technical Infrastructure (H13: $\beta = .683, p < 0.001$), the foundation on which the other impacts depend; Administrative Efficiency (H12: $\beta = .753, p < 0.001$) is the first and largest gain built on that foundation. Although Administrative Efficiency carries the higher path coefficient, Technical Infrastructure remains foundational—a foundation is judged by what it enables, not by the size of its own association with adoption. These results suggest that the primary "quick wins" of adoption are located in the university's back-office operations.

By automating routine tasks and reducing manual errors, digital tools have considerably improved administrative performance across Saudi institutions [34]. This operational streamlining is supported by rapid modernisation of hardware and software, as reflected at the national level, where Saudi

Arabia's digital experience maturity reached 86.71% in 2025 [35]. The high impact coefficients for these factors reveal that while a project may be triggered by national policy, its first visible institutional footprint rests on creating a robust, AI-ready technical foundation that simplifies the bureaucratic experience for staff and students.

Intermediate Gains: Educational Transformation

Once the infrastructure has stabilised, the impact of Digital Transformation shifts towards Teaching and Learning Effectiveness (H14) ($\beta = .639, p < 0.001$). The qualitative evidence clarifies that academic shifts are not immediate; they depend on the prior successful adoption of infrastructure and a coherent digital strategy to enable personalised, flexible learning pathways. As noted in [29], the 2025 AI curriculum rollouts and digital educational shifts in Saudi Arabia are now beginning to transform classroom quality, but only in environments where the "technical friction" has already been minimised. This indicates that Teaching and Learning Effectiveness is a mediated outcome; it requires a period of institutional "settling" in which staff and students move beyond basic system use to meaningful digital engagement.

Long-Term Outcome: Cumulative Institutional Performance

The final stage of this sequence is Institutional Performance (H11: $\beta = .629, p < 0.001$). While highly significant, its slightly lower coefficient compared to Administrative Efficiency suggests that performance gains are a delayed, cumulative effect. This aligns with the analysis of institutional maturity at King Khalid University, which posits that performance quality is the final result of successfully stabilising the underlying technical and administrative ecosystem [36]. In the Saudi context, Institutional Performance is not merely an internal metric but a symbolic signal of institutional standing. It combines gains in operational efficiency and pedagogical excellence to build the reputation and trust needed to meet the rising expectations of national stakeholders.

This provisional cumulative sequence reveals that digital transformation is a sustained commitment, with outcome measures responding to adoption at different rates. The chain begins with Technical Infrastructure (capacity), which enables Administrative Efficiency (automation); these operational gains together facilitate Teaching and Learning Effectiveness (educational quality). These successes culminate in marked improvement in overall Institutional Performance, which ultimately contributes to the high-level socioeconomic goals of Saudi Vision 2030. This sequential logic provides university leadership with a realistic framework for managing expectations, suggesting that the most profound academic and reputational benefits will only emerge after the foundational operational gains have been closed.

E. Contributions and Implications

Before detailing these contributions, we state explicitly how they extend [13]. The earlier paper validated the DXA-SPU framework statistically but treated all adoption factors and all institutional impacts as simultaneous, undifferentiated effects. The present study replaces that static picture with a

dynamic conceptual vision, extended by phase-dependent drivers on the input side and cumulative impacts on the outcome side, grounded in evidence that the survey could not provide.

This study makes three connected contributions. Theoretically, it advances a stage-based account of adoption in centralised public universities. Whereas quantitative applications of TAM and TOE typically model organisational, technological, and environmental factors as simultaneous direct predictors [11, 12], our findings indicate that Strategy, Regulatory Alignment, and Perceived Usefulness shape the decision to adopt, while Collaboration and Coordination and Competitive Pressure operate primarily at the implementation and positioning stages [3, 13]. This distinction helps explain why factors highly visible in practice may not emerge as direct statistical predictors in cross-sectional data [20, 26]. The framework's outcome side is equally stage-dependent: rather than emerging together, institutional impacts follow a provisional cumulative sequence: Technical Infrastructure forms the foundation, Administrative Efficiency is the first and most visible gain built on it, Teaching and Learning Effectiveness follows, and Institutional Performance accumulates last. These compounding impacts extend to graduate readiness and the broader national knowledge economy [6, 7].

Methodologically, the study demonstrates that a sequential explanatory design can serve an analytical rather than merely descriptive function [24]: the non-significance of H2 and H9 was only resolvable through the qualitative strand, which revealed the centralised governance logic behind them. Interviewing senior decision-makers, rather than end users, is therefore especially suited to explaining the governance processes that shape institutional adoption.

Practically, the findings offer university leaders a staged template. National policy direction creates the legitimacy needed to initiate transformation; leaders should then make system value visible, treat security as an enabling condition rather than a post-adoption concern, support staff through phased rollouts, and plan resourcing across the full adoption cycle [13]. Because benefits accrue progressively, from the Technical Infrastructure foundation through Administrative Efficiency and Teaching and Learning Effectiveness to Institutional Performance, investment must be sustained across successive cycles rather than expected to deliver uniformly or immediately. These contributions invite extension to comparable governance contexts, such as Gulf Cooperation Council university systems, and to decentralised or private settings, to test whether the phase-dependent drivers and cumulative impacts identified here generalise [3, 13].

VI. CONCLUSION, LIMITATIONS AND FUTURE WORK

This study provides a contextually grounded examination of Digital Transformation in Saudi public universities by integrating quantitative validation [13] with qualitative institutional evidence. By bridging the gap between the statistical results of the DXA-SPU framework ($n=447$) and the operational experiences of senior IT leaders ($n=11$), the research

clarifies that adoption in this setting is a Phase-Dependent process. The findings demonstrate that while national mandates and institutional Strategy trigger the initial decision to adopt, factors such as Collaboration and Coordination and Competitive Pressure emerge as vital facilitators during the implementation and positioning stages. Furthermore, the study establishes that the resulting benefits accumulate in a specific temporal sequence, from the Technical Infrastructure foundation through Administrative Efficiency and Teaching and Learning Effectiveness to Institutional Performance. This longitudinal perspective confirms that digital change is a sustained commitment that ultimately strengthens graduate labour market readiness and contributes to Saudi Arabia's national knowledge economy. Whereas our previous paper [13] reported that 12 of 14 hypothesised relationships held, the present study explains why the two exceptions occurred and the order in which the four institutional benefits materialise, thereby moving the framework from a validated static model to a dynamic, phase-aware conceptual vision.

Limitations and Future Directions

Despite these insights, several limitations provide opportunities for further research. The primary constraint is the cross-sectional design, which captured institutional perceptions at specific points in time between 2024 and 2025. Because Digital Transformation is an ongoing process, a temporal snapshot cannot fully capture the "intention-behaviour gap," in which strong adoption intentions do not always translate into actual usage [37, 38]. Future research should employ longitudinal designs to track institutions over several years, providing objective evidence of how adoption decisions evolve into long-term implementation. Furthermore, while the qualitative phase targeted strategic decision-makers to address the initial survey's faculty-heavy composition, students' and administrative personnel's perspectives remain underrepresented. Future studies should adopt stratified, multi-stakeholder sampling to capture the diverse experiences of the entire university community.

The geographical and institutional scope of this study also suggests areas for expansion. The findings are specific to the centralised governance of Saudi public universities during a unique period of national transformation under Saudi Vision 2030. Consequently, the non-significance of factors such as Competitive Pressure may not hold for private universities or decentralised international systems. Comparative studies across the Gulf Cooperation Council (GCC) region or between public and private sectors would clarify which aspects of the DXA-SPU framework are universal and which are context-specific. Finally, as the current outcome measures are perceptual, future investigations should link survey data with objective institutional records, such as administrative processing times or research outputs, to strengthen the evidence base for the framework's impact on institutional excellence.

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