

Digital Transformation in Saudi Public Universities: A Novel Framework for Adoption Drivers and Impact Analysis

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Abstract—Saudi Arabia’s Vision 2030 prioritises digital transformation (DX) to modernise higher education. However, despite significant investment, Saudi public universities (SPUs) face unique challenges in adoption due to a lack of context-specific frameworks. To address this gap, this study proposes and validates the novel DXA-SPU framework, an integrated model that combines the Technology Acceptance Model (TAM) and the Technology-Organisation-Environment (TOE) framework. The model was evaluated using survey data from 447 SPU participants, with hypothesised relationships analysed via Structural Equation Modelling (SEM). The results supported 12 of the 14 hypotheses. Perceived usefulness and the institutional skills gap emerged as the most significant drivers of adoption. In turn, DX adoption was strongly linked to enhanced institutional performance, administrative efficiency, technical infrastructure, and teaching effectiveness. The DXA-SPU framework offers a validated tool for university leaders to assess DX readiness and align strategic planning with Vision 2030 goals, providing actionable insights for policymakers.

Index Terms—Digital transformation, adoption frameworks, TAM, TOE, Saudi public universities, Vision 2030, SEM.

I. INTRODUCTION

DIGITAL transformation (DX) has become a top priority across various sectors, including higher education. In this context, it refers to the use of digital technologies to improve institutional operations, strategic planning and service quality [1], [2]. DX supports better performance in teaching, learning, research and administration [3], [4].

In Saudi Arabia, higher education is undergoing a significant transformation driven by national strategies, including Vision 2030 and the National Transformation Program (NTP). These initiatives aim to improve the quality and efficiency of public services, including universities, by promoting digital innovation [5]. The government's focus on digital initiatives underscores a national commitment to modernising higher education.

Despite strong governmental support and significant investment in digital infrastructure, the public sector still faces

challenges that hinder DX adoption [6]. This persistence of obstacles highlights the complexity of implementing DX in public sector institutions.

Research indicates that DX in the public sector is influenced by more than mere access to technology. Political, social and institutional factors also play a significant role [7]. However, most existing studies focus on Western countries or the private sector. As a result, there is limited understanding of how DX is adopted in public universities in Saudi Arabia. Thus, a context-specific framework is necessary to address the unique challenges of DX adoption in Saudi Public Universities (SPUs).

This study introduces the DXA-SPU framework, Digital Transformation Adoption in Saudi Public Universities, a framework that integrates the Technology Acceptance Model (TAM) and the Technology-Organisation-Environment (TOE) framework to explore and evaluate the factors influencing DX adoption and its institutional impacts. The research addresses the following questions:

1. What organisational, technological, and environmental factors influence DX adoption in SPUs?
2. How does DX adoption impact institutional outcomes, such as performance and efficiency?
3. How can a tailored framework support SPUs leaders in aligning DX with Vision 2030?

Using a mixed-methods approach, the study first employs Structural Equation Modelling (SEM) to test hypothesised relationships using survey data from university participants. This paper presents the quantitative results and the theoretical underpinnings of the framework.

II. LITERATURE REVIEW

Digital transformation has become a global imperative, compelling organisations to fundamentally rethink their operating models and value propositions. In the realm of higher education, this transformation is not merely about adopting technology but involves a profound cultural and strategic shift

that redefines teaching, research, and administrative processes [8]. The COVID-19 pandemic acted as an unprecedented accelerator, forcing higher education institutions (HEIs) worldwide into a period of "emergency remote teaching" and compelling a digital transition at a scale and pace previously unimagined [9], [10].

However, research shows that digitalisation in HEIs is often fragmented. [11] describe this as "dual digitalisation": the unintegrated, parallel development of top-down administrative systems (like Learning Management Systems, or LMS) and bottom-up, subject-specific digital tools used by academics. This fragmentation creates a disjointed experience, preventing the formation of a cohesive digital learning space. Consequently, technology use in HEIs often remains superficial, with LMS platforms frequently used as simple content repositories for administrative convenience rather than as tools for innovative education [12], [13]. Many universities launch digital initiatives as isolated projects without an overarching, integrated strategy, which limits their impact and return on investment [14].

In Saudi Arabia, DX is a cornerstone of the nation's strategic roadmap, Saudi Vision 2030, which aims to diversify the economy and build a thriving, knowledge-based society [15]. The government has invested heavily in establishing a sophisticated digital infrastructure and has launched initiatives like the "Future Gate" project to digitise curricula and empower learning [10], [15]. The pandemic response further highlighted this commitment, as the Ministry of Education rolled out platforms like "Madrasti" and provided extensive support to ensure educational continuity [15].

Despite this strong governmental support and investment, SPUs face a distinct set of challenges that hinder the successful adoption of DX. A primary obstacle lies in human and cul-

tural factors. [16] found that for instructors, the most significant barriers are attitudinal, including resistance to and fear of change, coupled with a lack of experience. This is compounded by a persistent digital skills gap among both faculty and students [17]. For DX to succeed, faculty require training that goes beyond mere tool usage to encompass new digital pedagogies, and the traditional reliance on rote learning must be replaced with methods that foster critical thinking and digital literacy [15].

From an organisational perspective, rigid institutional routines can inhibit the flexibility needed for transformation [18]. Successful DX requires clear leadership, a supportive organisational culture, a well-defined strategy, and adequate resources, factors often identified as lacking or underdeveloped in HEIs [17], [19]. Technically, while the national infrastructure is robust, challenges remain in ensuring reliable access for all, managing the explosion of institutional data through effective data governance, and addressing cybersecurity and privacy concerns [16], [20].

This complex landscape demonstrates that generic DX models are insufficient. There is a clear need for a context-specific framework tailored to the unique regulatory, cultural, and institutional conditions of SPUs. Such a framework must address the multifaceted challenges of human readiness, organisational agility, and strategic alignment with Vision 2030. This study proposes and validates the DXA-SPU framework to support SPUs' leadership in the strategic implementation of their university's DX.

III. HYPOTHESES AND STUDY FRAMEWORK

This study proposes the DXA-SPU framework to investigate the adoption of DX in SPUs, as illustrated in Fig. 1. The framework integrates two established models: the TAM and TOE frameworks. Together, they offer a combined view of

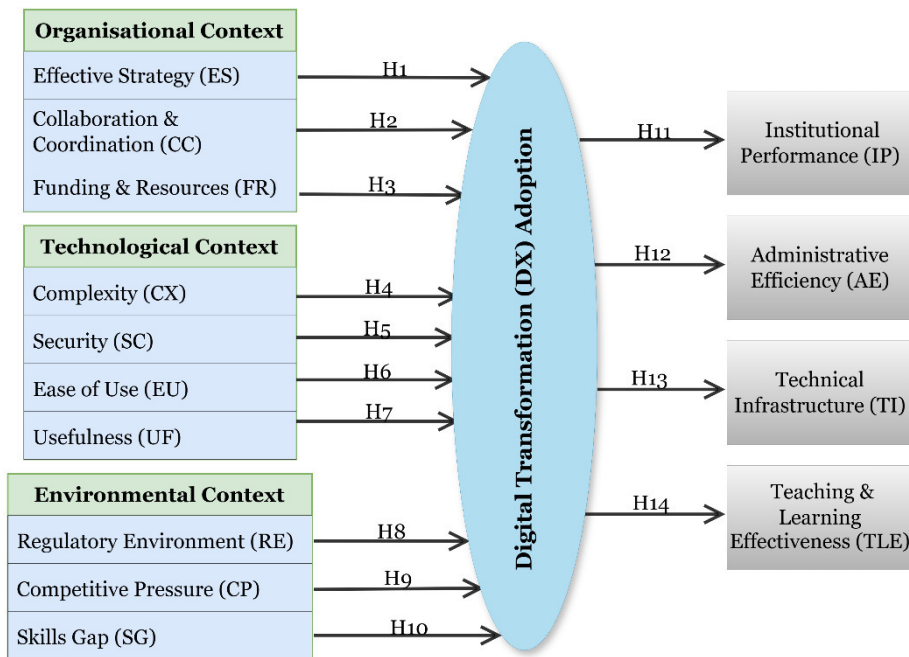


Fig. 1 The Initial Framework for DXA-SPU

individual and institutional influences on technology adoption. The aim is to identify the key factors shaping adoption and evaluate how DX is expected to impact university operations and performance.

A. Technology Acceptance Model (TAM)

The TAM posits that individuals are more likely to adopt a technology if they perceive it as useful and easy to use [21]. These core constructs, perceived usefulness and perceived ease of use, are central to predicting technology adoption behaviour. In this context, Saudi public university faculty, administrators and staff may support DX if it helps them work more efficiently and is accessible without added complexity.

However, TAM primarily focuses on individual-level perceptions and does not account for the broader institutional or environmental factors critical for analysing DX in universities. To address this, TAM is extended in this study to link the intention to adopt DX directly with perceived institutional impacts, such as performance and administrative efficiency, consistent with TAM's original structure connecting intention, behaviour, and outcomes [21]. The study examines whether this intention is associated with positive perceptions of institutional outcomes (H11-H14), using survey data to assess these links.

B. Technology-Organisation-Environment (TOE) Framework

The TOE framework provides a broader view of technology adoption by including factors from three domains [22] (see Table I):

Technological context: Characteristics of the technology itself, such as system complexity, ease of use and security.

Organisational context: Internal features of the institution, including leadership, planning, available resources and coordination across departments.

Environmental context: External influences like government policy (e.g., Vision 2030), regulatory pressures and competition from other universities.

The TOE complements the TAM by addressing the broader institutional and external conditions that affect adoption. Such perspectives are essential in public universities, where DX is shaped not only by individual preferences but also by policy, leadership, and organisational readiness.

C. DXA-SPU Framework Overview

Both the TAM and TOE frameworks are widely used for technology adoption. However, their application in isolation often falls short in complex environments like Saudi Public Universities [8].

TAM emphasises individual perceptions. This focus implies that it does not fully capture external forces, such as governmental policies or funding structures, that profoundly influence the adoption of DX in public institutions. Conversely, TOE addresses broader organisational and environmental factors. For example, it has been applied in specific regional contexts like Vietnam's creative industries [23]. However, TOE

TABLE I.
DXA-SPU HYPOTHESES GROUPING SUMMARY

Group	Hypotheses	Focus
Organisational Context	H1-H4	Internal institutional factors: effective strategy, collaboration & coordination, funding & resources.
Technological Context	H5-H8	Technology-related factors: complexity, ease of use, usefulness and security.
Environmental Context	H9-H10	External influences: regulatory environment, competitive pressure, and skills gap
Impacts of DX Adoption	H11-H14	Institutional outcomes: institutional performance, administrative efficiency, technical infrastructure and teaching & learning effectiveness.

has been criticised for overlooking the crucial role of individual user perceptions and behavioural intention. These factors are strongly emphasised in technology acceptance models like TAM. They are also critical in digital learning adoption [24].

In universities, both levels are paramount. Faculty and staff exhibit varying levels of digital readiness and literacy. Institutional change is significantly shaped by national agendas like Vision 2030 [15], [25].

Recognising these limitations, the DXA-SPU framework integrates the strengths of both TAM and TOE. This provides a more comprehensive understanding of DX in this unique context. Various technology adoption models have been applied in sectors like e-learning, healthcare, and public administration. However, these models often suit general contexts or developed nations. They overlook the specific interplay of national policies and centralised governance in Saudi public education [15], [19], [20].

Critically, previous Saudi-focused studies have often been limited to specific applications, such as online learning or cloud systems. They often neglect holistic DX or key factors such as skills gaps. In contrast, the DXA-SPU framework explicitly incorporates constructs like 'Skills Gap' and 'Regulatory Environment'. These constructs are tailored to address the evolving digital literacy needs and policy alignment challenges in the Saudi higher education landscape. By integrat-

ing user and institutional perspectives, and explicitly accounting for regulatory pressures, funding dependencies, and digital skills deficiencies prevalent in Saudi Arabia, this framework offers a more effective approach for studying DX adoption in SPUs.

The DXA-SPU framework is designed to identify factors influencing DX adoption and evaluate its institutional impacts in SPUs. It integrates TAM to assess user perceptions and behavioural intention, and TOE to capture technological, organisational, and environmental influences.

Key constructs include ease of use, strategic alignment, and regulatory support, while outcome areas include institutional performance, administrative efficiency, technical infrastructure, and teaching effectiveness.

While this section outlines the structure and provides a detailed breakdown of hypotheses, constructs appear in later sections. Validation is performed using SEM.

D. Development of Hypotheses

Based on the TAM and TOE frameworks, the following hypotheses have been developed to explore the relationships between these factors and DX adoption in SPUs:

Organisational Context

The successful implementation of DX within a university is contingent upon key internal factors. These factors include an effective institutional strategy, robust inter-departmental collaboration, and the allocation of adequate resources.

a) Effective Strategy (ES)

A well-defined DX strategy ensures that technological initiatives are aligned with institutional goals and educational priorities. DX is not merely a standalone IT project but a cross-functional initiative that must integrate academic, administrative, and technological planning [26]. Multiple forms of strategy, including IT, change management and business strategy, must be synchronised to support successful digital initiatives [27]. When strategic alignment is lacking, institutions face fragmented efforts, inefficiencies and resistance to change [28]. In the context of higher education, a clear DX strategy enhances coordination, promotes long-term adaptability, and increases the likelihood of adoption success.

H1: *An effective DX strategy positively influences the intention to adopt DX in SPUs.*

b) Collaboration and Coordination (CC)

Collaboration among stakeholders, faculty, administrators and students is essential for the successful adoption of DX in universities. Research shows that engaging academic users helps ensure technologies are meaningfully integrated into teaching and learning [29]. Collaboration improves feedback, enhances digital literacy, and supports access to appropriate tools, which are often barriers to DX adoption [30]. Coordinated efforts across departments and governance levels also promote shared ownership of digital strategies and smooth implementation [31]. A collaborative environment increases acceptance and strengthens institutional readiness for DX.

H2: *Strong collaboration and coordination among stakeholders positively influence the intention to adopt DX in SPUs.*

c) Funding and Resources (FR)

Successful DX depends on access to sufficient financial, technical and human resources. Investments in infrastructure, software and skilled personnel form the foundation for sustainable implementation [32]. When funding is limited, institutions may struggle to upgrade systems or provide staff training, which delays adoption [33]. Training programs and digital tools also require ongoing investment to remain effective, making resource availability a long-term concern [34]. Thus, ensuring adequate support for DX projects is crucial to facilitating adoption across the university.

H3: *Sufficient funding and resources positively influence the intention to adopt DX in SPUs.*

Technological Context

Beyond organisational considerations, the intrinsic characteristics of the technology itself are instrumental to the success of DX. The adoption of these new digital tools is directly influenced by their complexity and security, as well as their perceived usefulness and ease of use.

a) Complexity (CX)

Technological complexity is a significant barrier to DX, especially when modern systems must integrate with legacy infrastructure. Incompatibility between platforms can lead to data silos, operational disruptions and increased transition costs [36]. Complex implementation processes can disrupt workflows and reduce staff willingness to adopt new tools [37]. Without clear integration pathways, institutions may face delays, increased risks and unmet goals. Reducing complexity helps build user confidence and simplifies institutional decision-making.

H4: *Lower complexity in integrating digital technologies with existing systems and processes positively influences the intention to adopt DX in SPUs.*

b) Security (SC)

As universities become more reliant on digital platforms, concerns over cybersecurity and data protection have grown. The use of cloud services, online portals, and connected devices introduces multiple risks, including data breaches and ransomware attacks [38]. Without strong security measures, universities may face legal, operational and reputational consequences [39]. A secure digital environment builds trust among users and reduces resistance to adopting new digital technologies. Therefore, confidence in data security is a critical enabler of DX adoption.

H5: *A higher level of digital security positively influences the intention to adopt DX in SPUs.*

c) *Ease of Use (EU)*

According to TAM, ease of use is a core predictor of technology adoption [21]. When digital tools are perceived as intuitive and user-friendly, individuals are more likely to explore and apply them in their work. Ease of use also influences trust and satisfaction, both of which contribute to long-term engagement [40]. In the context of higher education, simple interfaces reduce learning curves for faculty and staff and encourage quicker adoption.

H6: *The perceived ease of use of DX solutions positively influences the intention to adopt DX in SPUs.*

d) *Usefulness (UF)*

Perceived usefulness is among the strongest predictors of technology adoption in the TAM framework. In higher education, digital tools are more likely to be adopted if users believe they improve teaching, learning and administrative efficiency [41]. Technologies that support personalised instruction and streamline processes are especially valued, as they contribute to both student outcomes and institutional performance [42]. When users recognise the practical benefits of DX, they are more motivated to support its adoption.

H7: *The perceived usefulness of DX positively influences the intention to adopt DX in SPUs.*

Environmental Context

The external environment, heavily influenced by government directives such as Vision 2030, is a primary driver of DX in SPUs. National policies create a direct regulatory pressure for modernisation, while competitive dynamics between institutions also foster innovation. At the same time, the evolving Saudi labour market demands graduates with advanced digital skills. This pressure for skilled graduates, combined with the need for internal faculty and staff to be digitally competent, creates a significant challenge for universities to address the overall skills gap.

a) *Regulatory Environment (RE)*

The regulatory environment plays a vital role in enabling or restricting DX in public institutions. In Saudi Arabia, higher education policies and budgetary frameworks strongly influence the scope and pace of DX adoption. Supportive government policies, such as Vision 2030, encourage investment in digital tools, infrastructure and human capital [43]. Effective regulation helps create the conditions for innovation, whereas rigid or unclear policies can limit institutional flexibility [23]. A favourable regulatory climate increases confidence and motivates universities to invest in digital initiatives.

H8: *A flexible and supportive regulatory environment positively influences the intention to adopt DX in SPUs.*

b) *Competitive Pressure (CP)*

Competitive pressure is a key external factor that drives innovation in higher education. When universities compete for rankings, visibility or recognition, they are more likely to adopt advanced digital tools to enhance teaching, research and administration [44]. Institutions that seek to differentiate

themselves invest more in technology, which can improve student outcomes and faculty productivity [45]. In Saudi Arabia, competition among public universities creates momentum for DX, pushing institutions to modernise quickly to remain relevant.

H9: *Higher competitive pressure among universities positively influences the intention to adopt DX in SPUs.*

c) *Skills Gap (SG)*

A major challenge facing DX in higher education is the skills gap among students, faculty and staff. As digital tools become central to education and work, institutions must address deficits in both technical and soft skills to ensure readiness for transformation [46]. Employers increasingly expect digital fluency, critical thinking and adaptability, which are not always part of traditional curricula [47].

Universities that align their teaching and training with evolving workforce needs will be better positioned to adopt digital technologies successfully. Addressing the skills gap enhances both institutional effectiveness and graduate preparedness [48], [49]. Thus, bridging this gap is essential to ensuring DX efforts can be successfully implemented and sustained.

H10: *Addressing digital skills gaps positively influences the intention to adopt DX in SPUs.*

E. The Impact of DXA on SPUs

This study extends the TAM to link the intention to adopt DX with its perceived impacts on university outcomes. These impacts are framed as expected outcomes within a mixed-methods approach, where the quantitative phase tests the hypothesised relationships using survey data.

The hypotheses aim to investigate how various technological, organisational and environmental factors influence the intention to adopt DX, and how this intention relates to outcomes such as institutional performance, administrative efficiency, technical infrastructure and teaching and learning effectiveness.

The DXA-SPU framework, by combining the TAM and TOE, offers a robust model for understanding the drivers of DX in SPUs. It captures both individual perceptions and broader institutional dynamics, making it a comprehensive tool for analysing adoption behaviour and its anticipated impacts. These hypotheses were tested to assess the relationships between influencing factors, adoption intentions and institutional outcomes, which are described below.

Institutional Performance (IP)

Digital transformation plays a growing role in enhancing institutional performance across universities globally, including Saudi public institutions. Studies in Saudi Arabia confirm that DX can improve efficiency, leadership, research productivity and stakeholder engagement. For example, [50] shows that DX supports academic and financial performance and promotes sustainability through digital learning. Reference [18] highlights the role of internal processes and routines in

shaping transformation outcomes, while [51] connects leadership styles to DX success. Data governance, as emphasised by [20], is also essential for institutional performance. Moreover, as in [19], the study links DX to broader social and academic outcomes, including student engagement and well-being. Collectively, these studies indicate that DX contributes to performance through operational, human and technological improvements.

H11: *Adopting DX in SPUs is expected to positively enhance institutional performance.*

Administrative Efficiency (AE)

Digital transformation supports more efficient university operations by streamlining workflows, integrating digital tools, and enhancing stakeholder engagement. Research from Saudi universities shows that knowledge management systems and cloud-based solutions can enhance administrative agility and service quality [53], [54]. DX allows institutions to reduce technical errors, improve decision-making, and strengthen accountability through real-time data access [55], [56]. Studies by [57], [58] show that user engagement, trust and service efficiency improve when universities adopt digital public administration tools. These technologies also enable the modernisation of resource management and coordination, which is essential for competitiveness and institutional effectiveness.

H12: *Adopting DX in SPUs is expected to positively enhance administrative efficiency.*

Technical Infrastructure (TI)

The shift toward DX has accelerated infrastructure development in SPUs. Institutions have expanded their Information and Communication Technology (ICT) capabilities, especially in response to the COVID-19 pandemic, which underscored the need for resilient e-learning platforms and remote service access [59], [60]. Hence, robust infrastructure is critical for sustaining digital tools across academic and administrative systems [45], [61]. Moreover, Supportive ICT policies and resource availability influence the digital readiness of universities and their ability to scale technologies effectively [62]. Therefore, investing in reliable and flexible infrastructure is essential for enabling long-term transformation.

H13: *Adopting DX in SPUs is expected to positively enhance technical infrastructure.*

Teaching and Learning Effectiveness (TLE)

Digital transformation significantly shapes the effectiveness of teaching and learning in higher education. In SPUs, DX enables more interactive, student-centred learning environments, especially through online platforms and blended learning methods [63]. Investments in digital hardware, content and staff training have improved e-learning quality and digital literacy [64]. Studies also show that DX positively influences student engagement, professional development and learning continuity during crises [65]. While DX introduces new challenges, such as digital well-being and emotional adjustment, its benefits in learning outcomes and instructional quality are well-documented [66]. Overall, DX supports a more flexible, engaging and effective teaching and learning

environment that meets evolving student and institutional needs.

H14: *Adopting DX in SPUs is expected to positively enhance teaching and learning effectiveness.*

IV. STUDY METHODOLOGY

A. Approach and Sample

This study uses a mixed-methods approach to evaluate the DXA-SPU framework. The quantitative phase tests relationships using survey data, while a subsequent qualitative phase is planned to explore contextual interpretations through interviews with IT managers.

The survey focused on three groups within SPUs: faculty members, who include academic teaching and research staff; administrators, who hold strategic or managerial positions with university-wide decision-making authority; and staff, which encompasses all other non-faculty employees, including support and technical personnel. A stratified sampling strategy was applied to ensure role-based representation. According to the General Authority for Statistics, the target population comprises approximately 134,000 members [67], [68]. Using a 95% confidence level and 5% margin of error, the minimum required sample size was 384. In 2024, the survey link was distributed to a random sample, yielding 447 valid responses, exceeding the threshold for robust analysis.

B. Survey Implementation

The primary objective of the survey was to examine the relationships between the DXA-SPU framework constructs and the intention to adopt DX in SPUs. The questionnaire consisted of three parts: Part I (7 questions) gathered demographic and contextual data, Part II (40 questions) assessed ten influencing factors (e.g., Collaboration and Coordination, Ease of Use), and Part III (16 questions) evaluated four impact constructs (e.g., Teaching and Learning Effectiveness). Each construct was measured with five Likert-scale questions to support reliable statistical analysis. The survey instrument is accessible for review online at [Survey for SPU].

A pilot study was conducted prior to the main survey to test the clarity and reliability of the questionnaire. The pilot involved a small group of university stakeholders, targeting 20 responses, with 25 responses received. Feedback led to minor adjustments in wording and layout to enhance clarity, but no substantive changes to the questions were required.

The main survey was conducted from August 15 to November 15, 2024, using an online survey platform. The instrument was developed in English and translated into Arabic to accommodate participant preferences. Over 700 questionnaires were randomly distributed to faculty, administrative, and staff members across SPUs. Of these, 551 questionnaires were completed, but only 447 (81%) responses were accurate and suitable for analysis, while 104 (19%) were deemed invalid.

Participants were informed of the study's purpose, and confidentiality was assured prior to participation. Ethical ap-

proval was obtained from the university research ethics committee, and informed consent was secured from all participants. No personal identifiers were collected, and data were securely stored for academic research purposes only.

The quantitative data were analysed using SEM with IBM AMOS 29, incorporating Confirmatory Factor Analysis (CFA) to evaluate the measurement model. Internal consistency was assessed using Cronbach's Alpha, convergent validity using Composite Reliability (CR) and Average Variance Extracted (AVE), and discriminant validity using Maximum Shared Variance (MSV). Model fit was evaluated through indices such as χ^2/df (CMIN/DF), Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardised Root Mean Square Residual (SRMR).

V. STUDY RESULTS

A. Data Collection and Screening

Table II. details the demographic profile of the respondents, which shows a diverse group from SPUs. Most participants were female (53.2%), while males made up 45.4%. A small number (1.3%) preferred not to state their gender. The largest age group was 31-45 years (73.2%), followed by those aged 18-30 (19.7%).

Regarding education, 49.7% held a master's degree and 36.2% held a doctorate. This suggests that most respondents were well educated. Regarding their roles, 67.3% were faculty members, 16.8% were staff, and 15.9% worked in administration. Almost half (49.0%) had over ten years of experience at their university. Others had 5-10 years (27.0%) or 1-4 years (21.0%) of experience.

A majority (66.7%) were aware of national DX programs such as the Vision 2030 NTP. Similarly, 69.1% were familiar with their university's DX efforts.

Many participants viewed DX as effective. Approximately 34.7% reported that it was very effective, and 29.5% considered it moderately effective. Satisfaction levels were also high. Around 41.9% were somewhat satisfied, while 12.0% were extremely satisfied.

Overall, the respondents were experienced, informed, and qualified to provide feedback on the adoption of DX.

Data screening confirmed the dataset's suitability for analysis. The Z-score analysis revealed no significant outliers, and the skewness and kurtosis values fell within ± 2.0 , indicating normality. Missing values were below 10%, requiring no imputation [69]. These checks validated the integrity of the dataset for SEM analysis.

B. Measurement Model Assessment

Confirmatory Factor Analysis was used to assess the validity and reliability of the measurement model. All standardised factor loadings exceeded 0.50, indicating that the items aligned with their respective constructs.

Table III shows that internal consistency was verified using Cronbach's Alpha and CR, with all values above the 0.70

TABLE II.
DEMOGRAPHIC STATISTICS FOR THE PARTICIPANTS

Gender	N	%
Male	203	45.4%
Female	238	53.2%
Prefer not to say	6	1.3%
Age	N	%
18 - 30	88	19.7%
31 - 45	327	73.2%
46 - 60	28	6.3%
60+	4	0.9%
Position	N	%
Administrator	71	15.9%
Faculty	301	67.3%
Staff	75	16.8%
Years of Experience	N	%
1-4	94	21.0%
5-10	121	27.0%
10+	221	49.0%
Education Level	N	%
Diploma	13	2.9%
Bachelor	50	11.2%
Master	222	49.7%
Doctorate	162	36.2%
DX Impact	N	%
Not effective at all	40	8.9%
Slightly effective	68	15.2%
Moderately effective	132	29.5%
Very effective	155	34.7%
Extremely effective	52	11.6%
DX Awareness	N	%
Yes	309	69.1%
No	138	30.9%
Approach Satisfaction	N	%
Extremely	19	4.3%
Somewhat	71	16.1%
Neither satisfied nor dissatisfied	72	16.4%
Somewhat satisfied	184	41.2%
Extremely satisfied	54	12.1%

threshold. Convergent validity was supported through AVE, with values exceeding 0.50. Discriminant validity was established as all constructs showed AVE values greater than the MSV.

Model fit indices also indicated an acceptable model fit:

- $\chi^2/\text{df} = 1.445$
- CFI = 0.968

TABLE III.
CONSTRUCT VALIDITY AND RELIABILITY

Constructs	Cronbach (above 0.7)	CR	AVE	MSV
ES	.952	0.952	0.833	0.130
CC	.923	0.923	0.751	0.045
FR	.816	0.817	0.528	0.123
CX	.872	0.877	0.643	0.130
SC	.902	0.903	0.701	0.102
EU	.910	0.910	0.717	0.264
UF	.914	0.915	0.730	0.308
RE	.938	0.939	0.793	0.088
CP	.907	0.907	0.709	0.278
SG	.931	0.931	0.772	0.306
IP	.918	0.918	0.737	0.585
AE	.925	0.925	0.755	0.555
TI	.920	0.921	0.744	0.585
TLE	.916	0.919	0.741	0.575
ES	.952	0.952	0.833	0.130

- RMSEA = 0.032
- NFI = 0.902

These results indicate that the measurement model is robust and well-constructed.

C. Structural Model Assessment

The structural model tested the hypothesised relationships between the factors influencing the intention to adopt DX and the perceived impacts of adoption. Path coefficients and significance levels were estimated using SEM.

Table IV presents the results of the structural model. Among the adoption factors (H1-H10), *Effective Strategy (ES)* showed a significant positive effect on DX adoption ($\beta = 0.121$, $p = 0.001$). However, *Collaboration and Coordination (CC)* showed no significant effect on DX adoption ($\beta = -0.009$, $p = 0.773$). This unexpected result may stem from limited cross-departmental structures in SPUs, as bureaucratic silos could hinder collaborative efforts [70]. In addition, the measurement of the CC construct might not fully reflect the dynamics among stakeholders. This indicates that future studies may benefit from developing more refined survey items.

Moreover, *Complexity (CX)* had a significant positive effect ($\beta = 0.181$, $p < 0.001$), suggesting that manageable complexity supports adoption. *Funding and Resources (FR)* was also significant ($\beta = 0.184$, $p = 0.002$), showing the importance of institutional support. *Security (SC)* ($\beta = 0.131$, $p = 0.003$) and *Ease of Use (EU)* ($\beta = 0.103$, $p = 0.047$) both had significant positive impacts. *Usefulness (UF)* was the strongest predictor ($\beta = 0.272$, $p < 0.001$), highlighting its significant role. *Regulatory Environment (RE)* was also significant ($\beta = 0.091$, $p = 0.009$).

TABLE IV.
RESULTS OF ANALYSIS OF HYPOTHESIS PATH FOR THE
DXA-SUPS FRAMEWORK

Hypothesis	Structural Relation	Regression Weight	Standard Error (S.E.)	Critical Ratio (C.R.)	P Value
H1	DX $\leftarrow$ ES	.121	.037	3.256	.001
H2	DX $\leftarrow$ CC	-.009	.031	-.288	.773
H3	DX $\leftarrow$ FR	.184	.059	3.099	.002
H4	DX $\leftarrow$ CX	.181	.054	3.364	***
H5	DX $\leftarrow$ SC	.131	.044	2.995	.003
H6	DX $\leftarrow$ EU	.103	.052	1.983	.047
H7	DX $\leftarrow$ UF	.272	.049	5.539	***
H8	DX $\leftarrow$ RE	.091	.035	2.613	.009
H9	DX $\leftarrow$ CP	.100	.055	1.822	.068
H10	DX $\leftarrow$ SG	.239	.052	4.601	***
H11	IP $\leftarrow$ DX	.629	.043	14.491	***
H12	AE $\leftarrow$ DX	.753	.047	16.004	***
H13	TI $\leftarrow$ DX	.683	.046	14.990	***
H14	TLE $\leftarrow$ DX	.639	.049	13.165	***

NOTE: ("***"=SIGNIFICANCE AT THE 0.001 LEVEL")

Likewise, *Competitive Pressure (CP)* approached significance ($\beta = 0.100$, $p = 0.068$). While not statistically significant at the conventional 0.05 level, this finding suggests a marginal influence. The *Skills Gap (SG)* showed a strong positive effect ($\beta = 0.239$, $p < 0.001$), underscoring the role of digital competencies.

All four impact hypotheses (H11-H14) were supported. *Institutional Performance (IP)* was significantly predicted by DX adoption ($\beta = 0.629$, $p < 0.001$), followed by strong effects on *Administrative Efficiency (AE)* ($\beta = 0.753$, $p < 0.001$), *Technical Infrastructure (TI)* ($\beta = 0.683$, $p < 0.001$), and *Teaching and Learning Effectiveness (TLE)* ($\beta = 0.639$, $p < 0.001$). These findings suggest that DX adoption is associated with broad and substantial institutional benefits.

Overall, twelve out of fourteen hypotheses were supported. The results empirically support the DXA-SPU framework, demonstrating its relevance to SPUs.

D. Summary of Findings

The results of the quantitative analysis provide strong empirical support for the DXA-SPU framework. Perceived usefulness, skills gap and complexity emerged as the most influential factors, while collaboration and coordination, and competitive pressure did not show a significant effect in this context.

The extension of the TAM was also empirically supported, as the intention to adopt DX was found to significantly impact all four key outcome areas: institutional performance, administrative efficiency, technical infrastructure and teaching and learning effectiveness. Among these, administrative efficiency showed the strongest relationship, suggesting that DX is especially effective in enhancing internal operational processes.

These findings not only reinforce the relevance of the TAM and TOE in higher education settings but also highlight the strategic role of DX in improving institutional outcomes.

VI. DISCUSSION

The results support the relationships proposed by the DXA-SPU framework, demonstrating how organisational, technological, and environmental factors influence adoption (see Fig. 2). This outcome strengthens the theoretical validity of integrating TAM and TOE for analysing DX adoption.

These findings extend the applicability of TAM and TOE in higher education settings, providing empirical support for the framework's multidimensional design. Such validation offers practical and theoretical contributions, particularly in non-Western, public-sector contexts, such as Saudi Arabia.

In the organisational context, effective strategy and funding and resources significantly influenced adoption, consistent with prior research emphasising the importance of institutional planning and leadership commitment [71], [72]. However, the factor of collaboration and coordination was not supported, indicating that cross-departmental integration may not yet be strong or institutionalised enough to shape adoption behaviours. This suggests an opportunity for organisational development initiatives that promote structured collaboration and digital governance.

Within the technological dimension, perceived usefulness and ease of use emerged as strong predictors of adoption intention, reinforcing the applicability of the TAM in the higher education context. The finding that lower system complexity positively influences adoption underscores the need for intuitive, interoperable digital systems that minimise disruption during adoption. The significance of security also reflects increasing institutional awareness of data protection and privacy challenges in digital environments [73].

Regarding environmental influences, the regulatory environment demonstrated statistical significance, reaffirming that national policies, especially those tied to Vision 2030, are powerful motivators for DX in SPU. In contrast, competitive pressure approached significance but was not statistically supported at the conventional level. While some literature suggests that competitive dynamics drive innovation, the insignificant finding in this specific context may imply that, for SPUs operating under strong governmental directives, top-down policy mandates (such as Vision 2030) currently exert a more direct and statistically dominant influence on DX adoption than inter-university competition. Meanwhile, the influence of the skills gap confirms that digital readiness

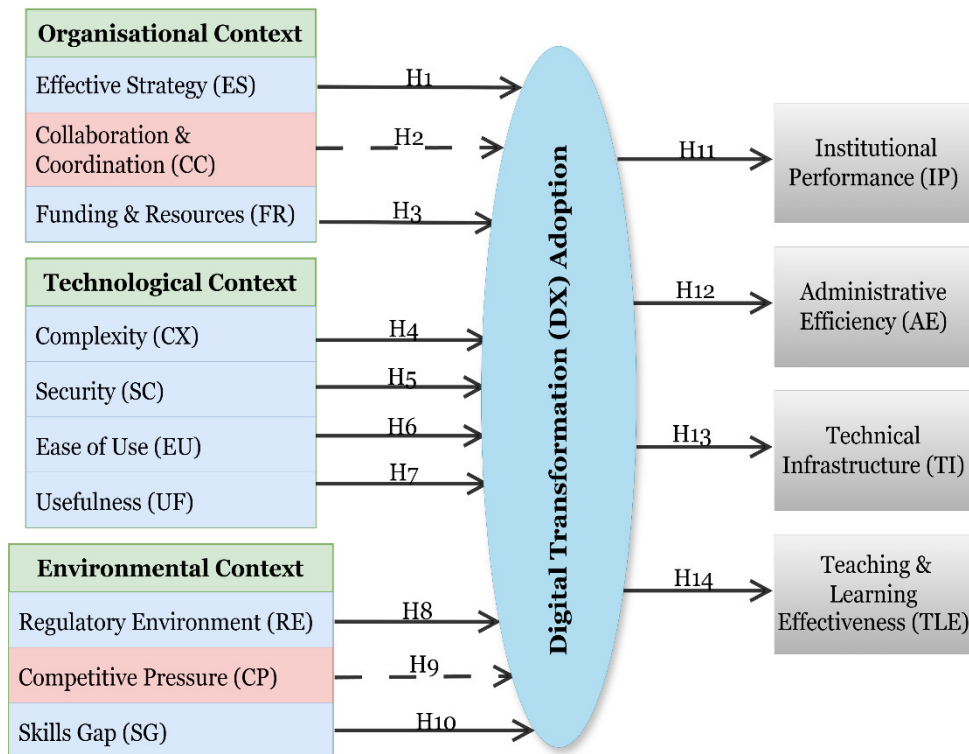


Fig. 2 Fig. 2 The Revised Version of the Comprehensive Framework for DXA-SPU

among staff and students remains a challenge, despite strategic alignment at the policy level [74].

The extended TAM results confirm that adoption intention is strongly associated with multiple institutional outcomes. These include improvements in operational efficiency, infrastructure resilience, and academic delivery, reinforcing the strategic significance of DX adoption in the SPU context.

Overall, these results underscore that successful DX adoption depends not only on the availability of technology but also on strategic planning, institutional preparedness and alignment with national reform agendas.

VII. CONCLUSION

This study provides empirical support for the novel DXA-SPU framework, integrating the TAM and TOE frameworks to examine DXA in SPUs. Survey data from 447 participants supported 12 of 14 hypotheses, identifying perceived usefulness, ease of use, regulatory alignment, and skills gap as key adoption drivers. DX adoption significantly enhances institutional performance, administrative efficiency, technical infrastructure, and teaching effectiveness, aligning with Vision 2030's educational reform goals.

The non-significant collaboration and coordination (CC) and competitive pressure (CP) hypotheses suggest a need for stronger interdepartmental mechanisms, such as cross-departmental task forces, to foster stakeholder engagement. Collectively, they indicate that internal organisational factors or top-down strategic mandates may currently be more critical drivers of DX adoption in this context.

The DXA-SPU framework offers significant contributions to both theory and practice. Theoretically, it adapts and combines the TAM and TOE frameworks to specifically address the unique context of SPUs, reflecting their national goals, institutional structures, and digital priorities. Practically, it provides an empirically supported tool for SPUs leaders to assess DX readiness and align their strategies with Vision 2030.

This study is based on self-reported perceptions, offering valuable insights into behavioural intention but not fully capturing actual adoption. Although the sample size was statistically sufficient, it may not fully represent the full diversity of stakeholder perspectives across all SPUs. To address these limitations, the following research phase will involve completing the qualitative phase by October 2025, with interviews of 10-15 IT managers to validate the findings and explore implementation dynamics.

While this framework was designed and validated in the context of SPUs, it may also be applicable in similar contexts in other countries. Moreover, a comparative analysis of the results with findings from other cultures would be a particularly valuable extension to assess the framework's broader applicability. Such research could further support the development of effective DX strategies and inform national education policy planning initiatives.

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