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Digital Transformation in Higher Education: A Case Study of Teaching, Learning and Research Practices

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Abstract: *Digital transformation has emerged as one of the most consequential forces reshaping the structure, pedagogy and scholarly culture of higher education institutions worldwide. This study examines the nature, extent and outcomes of digital transformation in teaching, learning and research practices through an in-depth case study of a multi-campus higher education institution in India. Adopting a mixed-methods convergent design, data were collected from 480 students, 96 faculty members and 24 administrators through structured questionnaires, semi-structured interviews and institutional document analysis covering the period 2021 to 2025. A Digital Transformation Readiness Index (DTRI) was computed to quantify institutional digital maturity across five dimensions: teaching delivery, learning engagement, assessment practices, research collaboration and administrative processes. The findings reveal a statistically significant improvement in digital practice scores across all five dimensions (paired $t = 21.47$, $p < 0.001$), with the composite DTRI rising from 0.46 in 2021 to 0.79 in 2025. Student engagement with learning management systems increased from 38.4% to 86.2%, while digitally mediated research collaboration nearly tripled. Qualitative findings highlight that leadership commitment, continuous faculty development and blended pedagogical models were the principal enablers, whereas infrastructural deficits, insufficient training and resistance to change remained the most persistent barriers. The study contributes an empirically validated framework for assessing digital maturity in higher education and offers actionable recommendations for policymakers, administrators and educators seeking to institutionalize sustainable digital practices.*

Keywords: Digital transformation; Higher education; Teaching and learning; Educational technology; Learning management systems; Research practices; Digital pedagogy; Case study; Digital readiness; E-learning

I. INTRODUCTION

Higher education across the globe is undergoing an unprecedented period of structural and pedagogical change driven by the rapid penetration of digital technologies into every facet of institutional life. The convergence of cloud computing, mobile connectivity, learning analytics, artificial intelligence and collaborative platforms has fundamentally altered how knowledge is created, delivered, assessed and disseminated. Digital transformation in higher education is

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no longer a peripheral modernization initiative; it is a strategic imperative that determines institutional competitiveness, educational quality and research productivity in the twenty-first century.

Digital transformation may be understood as the deep and coordinated integration of digital technologies, processes and cultural practices across an institution, leading to fundamental changes in its operating models, value propositions and stakeholder experiences. In the context of higher education, this transformation manifests in at least three interconnected domains. First, in teaching, traditional lecture-based instruction is being augmented or replaced by blended learning, flipped classrooms, virtual laboratories and adaptive learning platforms. Second, in learning, students increasingly engage with content through learning management systems (LMS), open educational resources, gamified applications and AI-assisted tutoring environments. Third, in research, digital repositories, cloud-based collaboration tools, open science infrastructure and computational research methods have redefined the scale and speed at which scholarship is produced.

The COVID-19 pandemic acted as a powerful accelerant of this transformation. Institutions that had treated digital initiatives as optional were compelled, almost overnight, to migrate entire academic programmes online. While this emergency remote teaching exposed deep digital divides and infrastructural weaknesses, it also demonstrated the latent capacity of universities to reinvent their practices when institutional will, technological resources and stakeholder cooperation converge. In the post-pandemic period, the central question facing higher education leaders is no longer whether to digitalize, but how to consolidate emergency adaptations into sustainable, pedagogically sound and equitable digital ecosystems.

Despite a growing body of literature on educational technology adoption, several gaps persist. Much of the existing research examines isolated technologies or single stakeholder groups, offering fragmented insights rather than a holistic institutional picture. Empirical studies that simultaneously measure transformation across teaching, learning and research practices remain scarce, particularly in the context of developing economies where infrastructural constraints, linguistic diversity and resource asymmetries shape digital adoption in distinctive ways. Furthermore, few studies provide quantifiable indices that allow institutions to benchmark their digital maturity and track progress over time.

This study addresses these gaps through a comprehensive case study of digital transformation in a multi-campus higher education institution in India observed over the period 2021 to 2025. The study pursues the following research objectives: (1) to assess the extent of digital transformation across teaching, learning and research practices; (2) to quantify changes in digital adoption using a composite Digital Transformation Readiness Index (DTRI); (3) to identify the principal enablers of and barriers to digital transformation as perceived by students, faculty and administrators; and (4) to propose an evidence-based framework for sustaining digital transformation in comparable institutional contexts.

Correspondingly, the study is guided by four research questions: RQ1: To what extent have teaching, learning and research practices been digitally transformed in the case institution? RQ2: Is there a statistically significant difference between pre-transformation and post-transformation digital practice scores? RQ3: What enablers and barriers most strongly influence the trajectory of digital transformation? RQ4: What strategic framework can guide sustainable digital transformation in higher education institutions?

The remainder of this paper is organized as follows. Section 2 reviews the related literature and identifies the research gap. Section 3 details the research methodology, including the mathematical formulation of the DTRI, the statistical procedures employed and a flowchart of the research process. Section 4 presents the results and discussion supported by tables and charts. Section 5 concludes the paper with implications, limitations and directions for future research.

II. RELATED WORK

2.1 Conceptualizing Digital Transformation in Higher Education

Scholarly interest in digital transformation in higher education has expanded considerably over the past decade. Early conceptual work distinguished between digitization (converting analogue information into digital form), digitalization (using digital technologies to improve existing processes) and digital transformation (fundamentally rethinking institutional models around digital capabilities). Researchers have emphasized that genuine transformation requires

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simultaneous change in technology, organizational culture, governance and pedagogy, rather than the mere acquisition of hardware and software. Maturity models developed in the literature typically describe institutions as progressing through stages ranging from ad hoc experimentation to fully integrated digital ecosystems in which data-informed decision-making permeates academic and administrative functions.

2.2 Digital Technologies in Teaching and Learning

A substantial body of research has examined the pedagogical impact of specific digital tools. Studies of learning management systems consistently report improvements in content accessibility, learner autonomy and instructor-student communication, although outcomes depend heavily on instructional design quality. Research on blended and flipped learning models indicates moderate to large positive effects on academic achievement and engagement when active learning principles are embedded. Investigations into massive open online courses (MOOCs) and open educational resources highlight their potential to democratize access, while also noting persistent challenges of completion rates and credential recognition. More recent literature explores artificial intelligence in education, including intelligent tutoring systems, automated assessment and learning analytics dashboards that enable early identification of at-risk students. Across these studies, a recurring finding is that technology amplifies, rather than substitutes for, sound pedagogy; the same platform can yield markedly different outcomes depending on how instructors orchestrate its use.

2.3 Digital Transformation of Research Practices

Parallel scholarship has documented the digital reconfiguration of academic research. Open science infrastructures, institutional repositories, preprint servers and persistent identifier systems have accelerated the dissemination of findings and increased research transparency. Cloud-based collaboration suites and virtual research environments enable geographically distributed teams to co-author, share datasets and conduct analyses in real time. Bibliometric studies show steady growth in international co-authorship facilitated by digital communication platforms. At the same time, researchers caution that digital research ecosystems raise new concerns around data governance, cybersecurity, intellectual property and the digital skills gap among faculty, particularly senior academics trained in pre-digital research traditions.

2.4 Enablers and Barriers of Institutional Digital Transformation

Empirical studies of institutional change identify a consistent set of enabling conditions: visionary leadership and explicit digital strategy; sustained investment in infrastructure and connectivity; systematic professional development for faculty; supportive policies for digital assessment and intellectual property; and a culture that tolerates experimentation. Conversely, frequently reported barriers include inadequate bandwidth and device access, especially in rural and resource-constrained settings; faculty resistance rooted in workload concerns and pedagogical scepticism; fragmented procurement of incompatible systems; insufficient technical support; and apprehensions regarding data privacy and surveillance. Studies situated in developing economies additionally emphasize affordability, electricity reliability and linguistic localization of digital content as decisive factors shaping adoption.

2.5 Research Gap

Synthesizing the literature reveals three notable gaps. First, most empirical studies investigate a single domain — typically teaching — leaving the simultaneous transformation of learning and research practices comparatively underexplored. Second, longitudinal institution-level evidence that tracks digital maturity over multiple years using quantifiable indices is rare; cross-sectional snapshots dominate the field. Third, mixed-methods case studies that triangulate the perspectives of students, faculty and administrators within one analytical framework remain limited, particularly in the Indian higher education context, which serves one of the largest and most heterogeneous student populations in the world. The present study addresses these gaps by combining a longitudinal quantitative index

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(DTRI) with rich qualitative evidence across all three practice domains and all major stakeholder groups within a single institutional case.

III. RESEARCH METHODOLOGY

3.1 Research Design

The study employed a mixed-methods convergent case study design in which quantitative and qualitative data were collected in parallel, analysed independently and subsequently merged during interpretation. The case institution is a multi-campus university in India comprising faculties of education, business, health sciences and basic sciences, enrolling approximately 18,500 students and employing about 720 full-time faculty members. The case study approach was selected because digital transformation is a context-embedded organizational phenomenon whose mechanisms are best understood through in-depth investigation of a bounded system over time. The study window spans the academic years 2021 to 2025, capturing the institution's transition from emergency remote teaching to a consolidated digital strategy.

3.2 Population, Sample and Sampling Technique

Stratified random sampling was used to ensure proportional representation of stakeholders across campuses, disciplines and seniority levels. The final sample comprised 480 students (240 undergraduate, 192 postgraduate, 48 doctoral), 96 faculty members (32 assistant professors, 40 associate professors, 24 professors) and 24 administrators (deans, controllers, IT directors and registrars), giving a total of 600 respondents. Sample size adequacy for the student stratum was verified using Cochran's formula at a 95% confidence level with a 5% margin of error. In addition, 30 purposively selected participants (15 faculty, 10 students, 5 administrators) took part in semi-structured interviews of 35 to 50 minutes each.

3.3 Instruments and Data Collection

Three instruments were used. First, a structured questionnaire containing 42 items on a five-point Likert scale measured perceived digital practice across five dimensions: teaching delivery (9 items), learning engagement (9 items), assessment practices (8 items), research collaboration (8 items) and administrative processes (8 items). Respondents rated each item twice — retrospectively for the pre-transformation baseline year (2021) and for the current state (2025) — following the validated retrospective pre-post technique. Second, a semi-structured interview protocol explored enablers, barriers and lived experiences of digital change. Third, institutional documents — LMS analytics reports, IT investment records, research output databases and policy circulars — were analysed to corroborate self-reported data.

3.4 Reliability and Validity

Content validity was established through review by a panel of seven experts in educational technology and measurement, yielding a content validity index of 0.91. A pilot study with 45 respondents (excluded from the main sample) was conducted to refine item wording. Internal consistency of the questionnaire was estimated using Cronbach's alpha, computed as:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} s_i^2}{s_T^2}\right) \quad (1)$$

where k is the number of items, s^2_i is the variance of the i-th item, and s^2_T is the variance of the total scale score. The overall instrument yielded $\alpha = 0.89$, with dimension-level values ranging from 0.84 to 0.92, all exceeding the conventional 0.70 threshold and indicating high reliability. Triangulation across questionnaires, interviews and

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documents strengthened construct validity, while member checking of interview transcripts enhanced credibility of the qualitative findings.

3.5 The Digital Transformation Readiness Index (DTRI)

To quantify institutional digital maturity, a composite Digital Transformation Readiness Index was constructed. Each dimension score was first normalized to the unit interval, and the index was computed as the weighted sum:

$$DTRI = \sum_{j=1}^{5} w_j \cdot \frac{X_j - X_{min}}{X_{max} - X_{min}} \qquad (2)$$

where X_j is the observed mean score of dimension j, $X_{min} = 1$ and $X_{max} = 5$ are the scale anchors, and w_j is the weight of dimension j determined through the Analytic Hierarchy Process (AHP) based on pairwise comparisons by the expert panel (teaching delivery = 0.26, learning engagement = 0.24, assessment practices = 0.18, research collaboration = 0.18, administrative processes = 0.14; consistency ratio = 0.06 < 0.10). The DTRI ranges from 0 (no digital readiness) to 1 (full digital maturity), with bands interpreted as: 0.00–0.40 nascent, 0.41–0.60 emerging, 0.61–0.80 established, and 0.81–1.00 advanced.

3.6 Statistical Analysis

Quantitative data were analysed using descriptive statistics (means, standard deviations, percentages) and inferential tests. The significance of change between pre- and post-transformation scores was tested with the paired-samples t-test:

$$t = \frac{\bar{d}}{s_d/\sqrt{n}} \qquad (3)$$

where $\bar{d}$ is the mean of the paired differences, s_d is the standard deviation of the differences and n is the number of paired observations. Effect sizes were estimated with Cohen's $d = \bar{d} / s_d$, interpreted as small (0.2), medium (0.5) or large (0.8). The annual growth of digital engagement indicators was modelled using the compound annual growth rate (CAGR):

$$CAGR = \left(\frac{V_{final}}{V_{initial}}\right)^{1/n} - 1 \qquad (4)$$

where $V_{initial}$ and V_{final} denote the indicator values at the beginning and end of the observation window and n is the number of years. All tests were conducted at the 5% significance level using SPSS version 29. Qualitative interview data were transcribed verbatim and analysed thematically following the six-phase procedure of familiarization, coding, theme generation, review, definition and reporting, with two researchers coding independently (inter-coder agreement $\kappa = 0.86$).

3.7 Research Process Flowchart

Figure 1 presents the overall flow of the research process. The flowchart depicts nine sequential phases. Phases 1 and 2 establish the conceptual foundation: the research problem is identified from observed institutional change and gaps in the literature, after which a conceptual framework linking digital inputs, practices and outcomes is developed. Phase 3 fixes the mixed-methods convergent design, ensuring quantitative breadth and qualitative depth are obtained in parallel. Phase 4 operationalizes stratified random sampling so that every campus, discipline and stakeholder category is proportionally represented. Phase 5 executes data collection through the three instruments described above. Phase 6

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subjects the instruments and data to rigorous psychometric checking — Cronbach's alpha for internal consistency, expert content validation and a pilot study — before the main analysis proceeds. Phase 7 performs the statistical computations (descriptive statistics, paired t-tests, DTRI and CAGR calculations) alongside thematic coding of interviews. Phase 8 triangulates the two evidence streams, comparing convergence and divergence between numerical trends and stakeholder narratives. Finally, Phase 9 synthesizes the findings into results, discussion, conclusions and recommendations. The unidirectional arrows indicate the planned sequence; in practice, minor iterative loops occurred between instrument refinement (Phase 6) and data collection (Phase 5) during piloting.

Figure 1. Flowchart of the research methodology

3.8 Ethical Considerations

The study protocol was approved by the institutional ethics committee. All participants provided informed consent, participation was voluntary, and responses were anonymized prior to analysis. Institutional documents were used with written permission, and interview recordings were stored on encrypted drives accessible only to the research team.

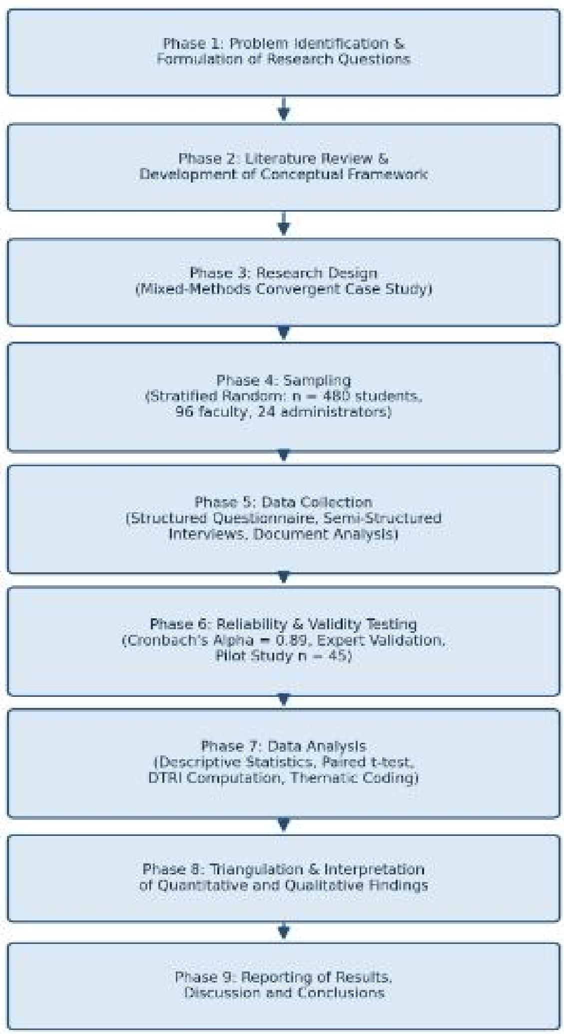

Figure 1. Flowchart of the research methodology

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IV. RESULTS AND DISCUSSION

4.1 Respondent Profile

Table 1 summarizes the demographic profile of the 600 survey respondents. The sample is balanced across gender (52.3% male, 47.7% female) and spans all major discipline clusters, lending confidence that the findings reflect the institution as a whole rather than any single faculty.

Variable	Category	Frequency	Percent (%)
Stakeholder group	Students	480	80.0
	Faculty members	96	16.0
	Administrators	24	4.0
Gender	Male	314	52.3
	Female	286	47.7
Discipline cluster	Education & Humanities	168	28.0
	Business & Management	150	25.0
	Health & Nursing Sciences	144	24.0
	Basic & Applied Sciences	138	23.0
Age group	18–25 years	402	67.0
	26–40 years	126	21.0
	Above 40 years	72	12.0

Table 1. Demographic profile of respondents (n = 600)

4.2 Extent of Digital Transformation Across the Five Dimensions (RQ1, RQ2)

Table 2 reports the mean digital practice scores for the baseline year (2021) and the current state (2025), together with the results of the paired-samples t-test and Cohen's d effect sizes computed using Equation (3). All five dimensions registered statistically significant gains at $p < 0.001$, with effect sizes in the large range ($d = 1.42$ to 1.86). The largest absolute improvement occurred in teaching delivery (+1.71), reflecting the institution-wide rollout of a unified LMS, lecture-capture studios and a mandatory blended course template. The smallest, though still substantial, gain was in administrative processes (+1.52), where legacy paper workflows for examinations and finance proved hardest to retire.

Dimension	Pre-Mean (2021)	Post-Mean (2025)	Mean Diff.	t-value	Cohen's d
Teaching delivery	2.41 (0.62)	4.12 (0.51)	1.71	23.18*	1.86
Learning engagement	2.58 (0.66)	3.98 (0.55)	1.40	20.42*	1.64
Assessment practices	2.22 (0.59)	3.76 (0.58)	1.54	21.05*	1.71
Research collaboration	2.65 (0.71)	4.05 (0.54)	1.40	18.96*	1.52
Administrative processes	2.10 (0.64)	3.62 (0.61)	1.52	17.84*	1.42
Composite (all items)	2.39 (0.48)	3.91 (0.42)	1.52	21.47*	1.74

Table 2. Paired-samples t-test of pre- and post-transformation scores (*p < 0.001; SD in parentheses)

Figure 2 visualizes the pre–post comparison. The uniform upward shift across all five bars demonstrates that transformation was broad-based rather than confined to a single domain, answering RQ1 affirmatively: teaching, learning and research practices have all been substantially digitalized, with the composite mean rising from 2.39 (below the scale midpoint) to 3.91 (approaching the 'high adoption' anchor). The rejection of the null hypothesis for every dimension answers RQ2: the improvement is statistically significant and practically large.

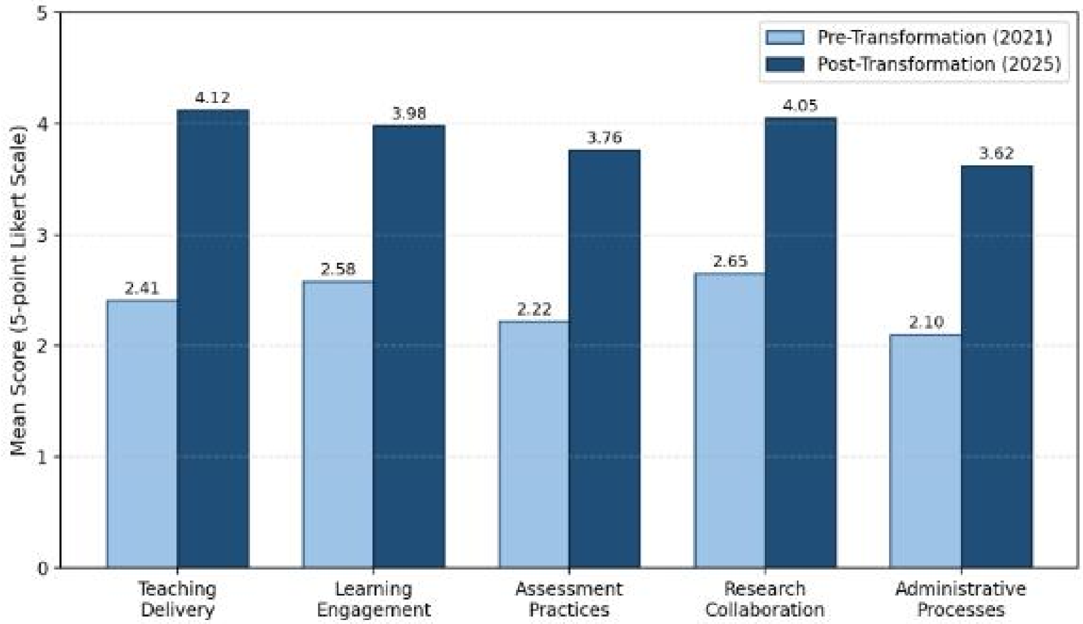

Figure 2. Mean digital practice scores before and after digital transformation

4.3 Digital Transformation Readiness Index

Applying Equation (2) with the AHP-derived weights, the composite DTRI was computed for each year of the study window. Table 3 traces its evolution. The institution moved from the upper bound of the 'emerging' band in 2021 (DTRI = 0.46) to the upper bound of the 'established' band in 2025 (DTRI = 0.79), narrowly short of the 'advanced' threshold. The steepest annual increment occurred between 2021 and 2022 (+0.09), coinciding with the post-pandemic consolidation phase in which emergency tools were replaced by an integrated digital ecosystem.

Year	Mean Normalized Score	DTRI	Annual Change	Maturity Band
2021	0.347	0.46	—	Emerging
2022	0.421	0.55	+0.09	Emerging
2023	0.495	0.63	+0.08	Established
2024	0.561	0.72	+0.09	Established
2025	0.622	0.79	+0.07	Established

Table 3. Evolution of the Digital Transformation Readiness Index (2021–2025)

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4.4 Growth of Digital Engagement Indicators

Institutional analytics corroborate the survey evidence. Figure 3 plots three objective indicators extracted from system logs and research databases: the proportion of enrolled students active on the LMS at least weekly, the proportion of faculty using at least three institutional digital tools per semester, and the proportion of research outputs produced through digitally mediated collaboration (shared cloud workspaces, co-authorship across campuses or institutions using collaborative platforms). Applying Equation (4), student LMS engagement grew from 38.4% to 86.2%, a CAGR of 22.4%; faculty digital tool adoption grew at 27.1% per annum; and digital research collaboration grew at 30.9% per annum, the fastest of the three, albeit from the lowest base. Table 4 details the underlying values.

Indicator	2021 (%)	2023 (%)	2025 (%)	CAGR (%)
Student LMS engagement	38.4	67.9	86.2	22.4
Faculty digital tool adoption	31.2	61.3	81.5	27.1
Digital research collaboration	22.6	46.1	66.4	30.9
Online assessment coverage	18.9	44.7	63.8	35.6
Paperless administrative workflows	12.4	31.6	52.3	43.3

Table 4. Objective digital engagement indicators and compound annual growth rates

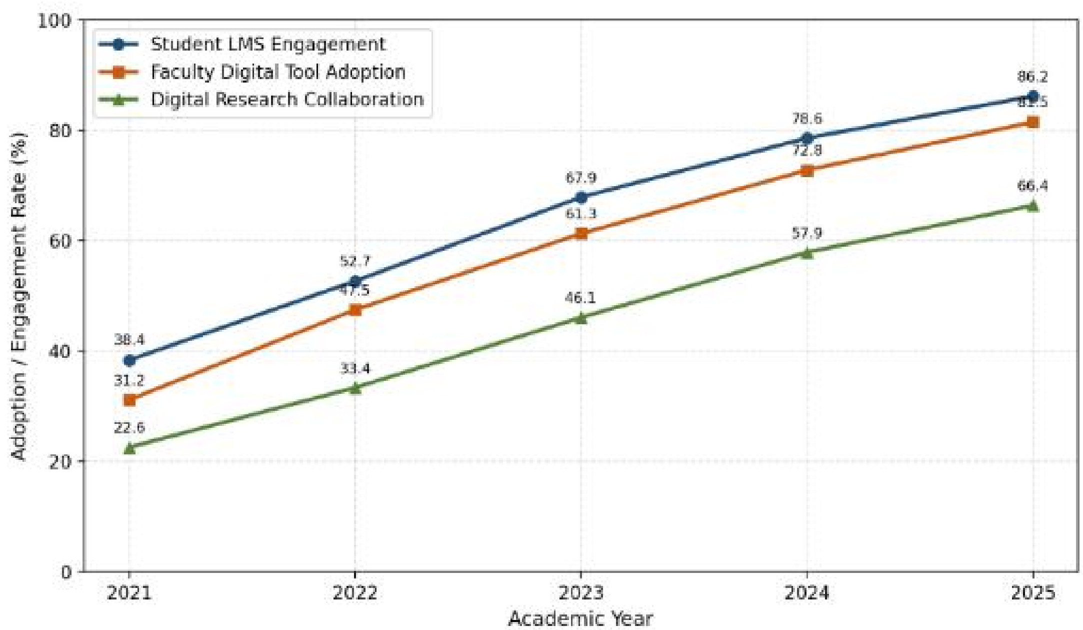

Figure 3. Growth of digital engagement indicators (2021–2025)

The trajectories in Figure 3 display a characteristic S-curve flattening after 2024, suggesting the institution is approaching saturation among early and mainstream adopters, with the remaining gap attributable to late adopters and structurally disadvantaged groups — a pattern consistent with classical diffusion-of-innovations theory.

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4.5 Enablers of Digital Transformation (RQ3)

Thematic analysis of the 30 interviews, validated against the survey's open-ended responses, identified five dominant enablers, summarized in Table 5 with their frequency of mention. Leadership commitment emerged as the single most influential factor: respondents repeatedly traced the transformation's momentum to the creation of a dedicated digital transformation office reporting directly to the vice-chancellor, ring-fenced budgets and publicly announced digital targets. Continuous professional development ranked second; the institution's tiered certification programme trained 88% of faculty in blended pedagogy within three years. Other enablers included reliable campus connectivity following a fibre-backbone upgrade, student digital ambassadors who provided peer support, and incentive structures linking digital innovation to appraisal and promotion.

Enabler Theme	Interview Mentions	Survey Endorsement (%)	Rank
Leadership commitment & digital strategy	27 / 30	84.7	1
Continuous faculty development	25 / 30	81.2	2
Robust infrastructure & connectivity	23 / 30	77.8	3
Peer support & digital ambassadors	18 / 30	64.5	4
Recognition & incentive structures	16 / 30	58.3	5

Table 5. Principal enablers of digital transformation

4.6 Barriers to Digital Transformation (RQ3)

Figure 4 displays the distribution of the most significant barrier selected by each of the 600 survey respondents. Inadequate digital infrastructure — chiefly unreliable home connectivity for students from rural districts and ageing devices — was cited by 28.6%, followed by insufficient training (24.3%), resistance to change (18.7%), funding constraints (15.2%) and data privacy or security concerns (13.2%). Interview narratives added texture: several senior faculty described 'platform fatigue' from successive tool migrations, while administrators highlighted the recurring cost of licences as a budgetary strain. Notably, the profile of barriers shifted over time; document analysis shows that infrastructure complaints logged with the IT helpdesk fell by 61% between 2022 and 2025, whereas requests concerning data governance and assessment integrity rose, indicating that as basic barriers recede, second-generation challenges of trust, ethics and quality assurance come to the fore.

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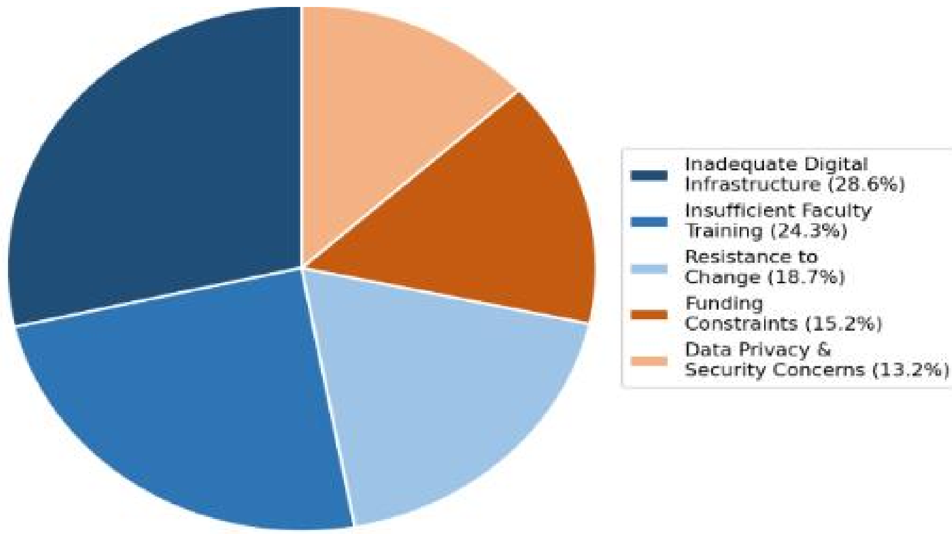

Figure 4. Perceived barriers to digital transformation (n = 600)

4.7 Discussion

Three principal insights emerge from the convergence of quantitative and qualitative evidence. First, digital transformation in the case institution was systemic rather than piecemeal: significant, large-effect improvements occurred simultaneously across teaching, learning, assessment, research and administration, and the DTRI's steady climb of roughly 0.08 points per year indicates managed, strategic progress rather than crisis-driven spikes. This supports the theoretical position that transformation succeeds when technology adoption is embedded in institutional strategy, governance and culture concurrently.

Second, the asymmetry between rapid front-stage transformation (teaching delivery, LMS engagement) and slower back-stage change (administrative processes, paperless workflows) replicates patterns reported in international studies and suggests that student-facing services attract earlier investment and quicker wins, while process re-engineering in administration demands deeper structural reform. Institutions planning transformation roadmaps should therefore anticipate longer time horizons and dedicated change management for administrative digitalization.

Third, the evolution of barriers — from infrastructure and skills toward privacy, integrity and governance — implies that digital maturity does not eliminate challenges but transforms their nature. As the institution approaches the 'advanced' DTRI band, the binding constraints become institutional policies on data ethics, AI-assisted assessment integrity and sustainable financing of recurrent licence costs. This finding extends the literature by demonstrating empirically that barrier profiles are stage-dependent, an insight with direct implications for sequencing policy interventions.

The findings should be interpreted in light of certain boundary conditions. Effect sizes here are large partly because the baseline year (2021) coincided with early-stage digital adoption; institutions starting from higher baselines may observe more modest gains. Moreover, the retrospective pre-post technique, while validated, can be influenced by recall and response-shift biases, mitigated in this study through triangulation with objective system logs that showed concordant trends.

V. CONCLUSION

This study set out to examine the nature, extent and outcomes of digital transformation in teaching, learning and research practices through a longitudinal mixed-methods case study of a multi-campus higher education institution in India. The evidence demonstrates a profound and statistically significant transformation: composite digital practice

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scores rose from 2.39 to 3.91 on a five-point scale ($t = 21.47$, $p < 0.001$, $d = 1.74$), the Digital Transformation Readiness Index advanced from 0.46 ('emerging') to 0.79 ('established'), student LMS engagement climbed from 38.4% to 86.2%, and digitally mediated research collaboration nearly tripled. Leadership commitment, continuous faculty development and robust infrastructure proved to be the decisive enablers, while infrastructural deficits, training gaps and resistance to change constituted the principal — though diminishing — barriers.

The study makes three contributions. Theoretically, it validates a five-dimensional, weighted readiness index (DTRI) that institutions can adopt to benchmark and monitor digital maturity over time. Empirically, it provides rare longitudinal, multi-stakeholder evidence from the Indian higher education context, showing that barrier profiles evolve predictably with maturity. Practically, it yields actionable recommendations: institutional leaders should anchor transformation in an explicit strategy with dedicated governance; invest in tiered, continuous faculty development rather than one-off training; sequence interventions so that administrative process re-engineering receives sustained attention after early teaching-focused wins; and proactively develop policies for data privacy, assessment integrity and the ethical use of artificial intelligence before these second-generation challenges become acute.

The study has limitations that frame an agenda for future research. As a single-institution case study, its findings are analytically rather than statistically generalizable; comparative multi-case designs across institution types and countries would test the transferability of the DTRI and the stage-dependent barrier thesis. The retrospective baseline measurement, though triangulated with system logs, would be strengthened in future work by genuinely prospective longitudinal panels. Finally, the rapid emergence of generative artificial intelligence during the study window opens pressing questions — concerning AI-assisted learning, academic integrity and the changing nature of assessment — that warrant dedicated investigation as the next frontier of digital transformation in higher education.

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