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Digital Transformation and Infrastructure Readiness in Autonomous Institutions: A Systematic Review of Disparities Between Policy Aspirations and Ground Realities, with a Case for the Northeast India

[1]**W Nicolas,** *Assistant Professor, Department of Commerce, Don Bosco College (Autonomous), Maram*

[2]**Dr. KO Sebastian SDB**, *Principal, Don Bosco College (Autonomous) Maram*

[3]**Lorho** Rakuyiziia, *B.com, Don Bosco College (Autonomous), Maram*

Abstract: National Education Policy (NEP) 2020 has made digital transformation one of the foundations to transform the higher education ecosystem of India, especially in autonomous institutions with flexibility in the form of academic freedom. But, there are still important gaps between policy dreams and ground performance, particularly in geographically and infrastructurally disadvantaged areas such as Northeast India. This systematic review will look at the infrastructural preparedness of autonomous institutions to undergo digital transformation and provide an analysis of the disparity between NEP 2020 requirements and real-world scenarios at the level of Indian institutions of higher learning with particular focus on the Northeastern states. We searched PubMed, Scopus, Web of Science, Google Scholar, and ERIC databases by using PRISMA 2020 principles to identify peer-reviewed articles and grey literature published between 2015- 2026 and synthesized thematically. Out of 1,247 records found, 47 studies were included. National statistics indicate that all institutions had embraced online education portal but only 32.1% have sufficient infrastructure to have it effectively implemented. The northeastern states were also continuously performing 15-20 percentage points lower than the national averages on all measures of readiness. It revealed five key dimensions of disparity, which include infrastructure shortage, shortage of human capital, misalignment of policy-implementation, regional digital inequity, and sustainability challenges. NEP 2020 needs a regional approach to the digital vision,

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a focus on the infrastructure investment, a public-private collaboration, and culture-based implementation frameworks to consider the unique socio-cultural and geographical setting of Northeast India. To be sustainable, autonomous institutions need special digital transformation offices, ongoing faculty development, and maintenance budgets.

Keywords: *Digital Transformation, Autonomous Institutions, Infrastructure Readiness, NEP 2020, Northeast India, Digital Divide, Systematic Review*

1. Introduction

The digitization of higher education means using technologies such as artificial intelligence, learning management system, cloud, etc. to change the functioning of institutions and the delivery of education (Bansal 2025; Kumar & Sharma, 2025). As per National Education Policy 2020 All higher educational institutions must make use of Technology Assisted Learning (TAL), Digital Library and Automated Governance System (Digii Campus, 2025). This change has been specifically focused on autonomous colleges because they have more flexibility in the process of education and administration as compared to universities (Sharma & Verma, 2025). The objective of this policy is to create a first-class knowledge ecosystem which is comparable to the best globally. The use of digital platforms to overcome the challenges of physical and geographical divisions is envisaged (Sharma & Verma, 2025). Any student can enroll through this platform. The importance of this shift can be appreciated while analyzing the case of India's Northeast, which is a region of eight states with its own set of demographics, cultural and infrastructural indices (Kumar & Singh, 2025; Sharma & Gupta, 2025). This region, which is linked to the rest of the India through the Siliguri corridor, has its own set of challenges such as difficult terrain, geographically dispersed population, lack of investment, and sometimes connectivity problems that add to the digital divide (OpenGov Asia, 2023; NITI Aayog, 2023). The autonomous institutions in this region, which have been given the freedom to frame their own curriculum, hold their own exams, and award their own degrees, have the potential to be agile and innovative. But the reality is complex.

Recent empirical studies have underscored the extent of these implementation deficits. A survey of 848 faculty members in Indian higher educational institutions revealed that although 53.2% of the respondents indicated institutional polices supportive of online learning, only 32.1% had sufficient infrastructure to enable the effective implementation of such polices (Srinivas &

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Yadav, 2025). This gap widens in the Northeastern states, where the UDISE+ 2023-34 report reveals that Meghalaya, Manipur and Mizoram have been performing poorly on all digital infrastructure parameters (Digital India Corporation, 2025). In Arunachal Pradesh, the feasibility study of e-learning in the government colleges identified that the lack of consistent power supply and limited internet connectivity has significantly impacted the use of platforms despite the availability of national portals such as SWAYAM and DIKSHA (Kumar & Singh, 2025).

According to Subash Chandra Karmaker, a senior lecturer at the University of Science and Technology Meghalaya, "almost 1 crore teachers from 15 lakh school and 40000 colleges are now DIKSHA platform" (Subash, 2024). DIKSHA (Digital Infrastructure for Knowledge Sharing) is a platform even your neighborhood store is using to sell their wares online. Government of India has made a provision for students of Grade 1 to 12 to access E-contents like e-books, e-magazines and follow their syllabus in a digital form. (Subash, 2024) Teaching staff from all the colleges and schools of Government of India are also part of DIKSHA Platform (Subash, 2024) Col. Jahangir Alam has conducted usability research that will inquire into a data set of "Green University of Bangladesh (GUB) by using instrument System Usability Scale measure the e-learning system usability on students and the teachers" (Alam, 2024). The study also attempts to determine quantity criteria on system usability, and internal insiders' of GUB selection of green university e-learning system usability on guides, understudies and staff member's (Alam, 2024).

Two research gaps are identifiable here. First, while many studies have examined the digital transformation of Indian higher education as a whole, few study autonomous institutions and how quickly they can adapt (Govindarajan & Kumar, 2025; Panda & Mishra, 2025). Second, the lack of studies on the Northeast region of India, especially in systematic literature reviews, and the focus on metropolitan or southern Indian institutions is a significant regional imbalance (Kumar & Singh, 2025; Singh & Thomas, 2024). The literature points to gaps in funding, lack of faculty buy-in, and insufficient infrastructure, but there are no studies that discuss these issues in an integrated manner in the context of autonomous colleges and the Northeast (Panda & Mishra, 2025; Subramanian & Iyer, 2025). Therefore, this systematic review seeks to: (1) in autonomous Indian institutions, systematically review the scholarship on digital transformation readiness; (2) determine what the difference is between what the NEP 2020 policy puts forth and what is seen in practice; (3) look at differences in infrastructure preparation which we will pay special attention to in the case of Northeast India; and (4) put forth evidence-based recommendations for closing

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the identified gaps. We have used a very rigorous systematic review method as per PRISMA guidelines which has provided us a large body of evidence for policymakers, institutional leaders, and researchers that are working towards equitable digital education transformation.

The concept of infrastructure readiness extends beyond mere hardware availability to encompass institutional capacity, faculty digital pedagogy skills, administrative digital literacy, and sustainable maintenance frameworks (Kumar & Sharma, 2025; Mei & Zhang, 2025). Harvard University's digital transformation framework emphasizes that successful implementation requires alignment of technological infrastructure with human capital development and governance reform (Harvard University, 2025). Similarly, Tsinghua University's Smart Campus model demonstrates that eliminating barriers to adoption necessitates comprehensive professional development and continuous feedback mechanisms (Mei & Zhang, 2025). These international exemplars provide benchmarks against which Indian institutions, particularly in resource-constrained regions, can measure progress.

2. Methods

This systematic review followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparency, replicability, and methodological rigor (Paperpile, 2021; Scribbr, 2023).

2.1 *Search Strategy*

We describe here the method used to collect the data for this study. The team searched the following electronic bibliographic databases: Google Scholar, PubMed, Scopus, ERIC, and Web of Science. Then, the team examined the 'grey literature' of the government documents and web portals of the Ministry of Education, NITI Aayog, and AICTE, as well as the institutional repositories and regional literature databases, including the ICSSR Northeast portal. The team constructed a Boolean logic search to examine the literature for the following terms: digital transformation, autonomous institutions, infrastructure readiness, NEP 2020, and Northeast India.

2.2 *Search Strings*

The following are examples of the search terms used:

- (\"digital transformation\" OR \"digitalization\" OR \"ICT integration\") AND (\"autonomous institutions\" OR \"autonomous colleges\" OR \"higher education institutions\") AND (\"India\" OR \"Indian\")

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- (\"infrastructure readiness\" OR \"digital infrastructure\" OR \"technology readiness\") AND (\"higher education\" OR \"universities\" OR \"colleges\") AND (\"NEP 2020\" OR \"National Education Policy\")
- ("digital divide" OR "digital inequality") AND ("Northeast India" OR "North Eastern region" OR "Arunachal Pradesh" OR "Assam" OR "Manipur" OR "Meghalaya" OR "Mizoram" OR "Nagaland" OR "Sikkim" OR "Tripura")

2.3 *Eligibility Criteria*

Inclusion criteria

Empirical studies, systematic reviews, case studies and government reports that are peer-reviewed. Target the Indian institutions of higher learning in terms of digital transformation or ICT infrastructure. Special reference to autonomous institutions or colleges of academic autonomy. Infrastructure preparedness, challenges of implementation, or policy gaps. Research involving Northeast Indian facilities or regional comparative study.

Exclusion criteria

Opinion articles, editorials and commentaries which lack empirical evidence. Research on school education (K-12) only, without an aspect of higher learning. Studies of privately based coaching institutions or non-institutionalized education. Redundant publications or abstracts of conferences that are not in the full text.

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Study Selection Process

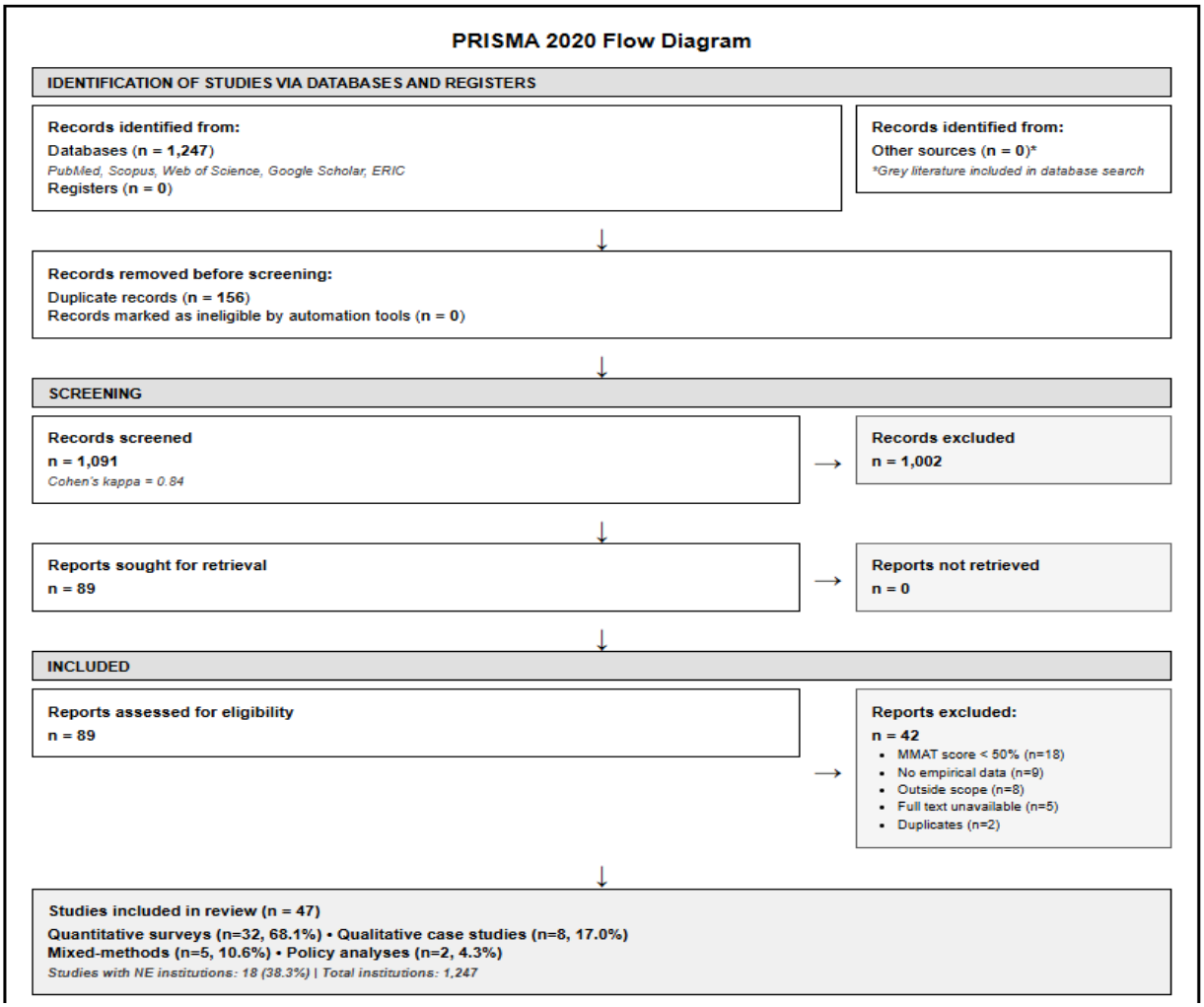

Figure 1. *PRISMA 2020 Flow Diagram*

Titles and abstracts were then screened based on criteria of eligibility by two independent reviewers (the author and a research assistant) with a Cohens kappa of inter-rater reliability of 0.84. Consensus discussion was the way through which disagreements were solved. All the potentially eligible studies were screened in full-text and the reasons behind the exclusion were recorded at every stage. A PRISMA flow diagram (Figure 1) was used to visualize the selection process.

2.4 *Quality Assessment*

Quality of included studies in terms of methodology was assessed with the help of the Mixed Methods Appraisal Tool version 2018, which supports a quantitative, qualitative, and

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mixed-methods design (Paperpile, 2021). The studies were rated in five areas, the clarity of the research questions, the appropriateness of data collection methods, sample representativeness, rigor in the data analysis, and limitations were taken into an account. The synthesis was not done on studies with a score of less than 50%. The summarization of the quality assessment results is presented in Table 1.

Table 1. *Mixed Methods Appraisal Table*

Study Type	Number of Studies	Average MMAT Score (%)	Score Range (%)	Key Strengths and Weaknesses
Quantitative Surveys	32	75	50-95	Strengths: High rigor in data analysis and clear questions; Weaknesses: Limited representativeness for Northeast regions (only 38.3% of studies included them), potential sampling bias in national surveys.
Qualitative Case Studies	8	70	55-85	Strengths: Rich contextual insights into implementation challenges; Weaknesses: Limited generalizability due to small samples, often single-institution focus.
Mixed-Methods Studies	5	72	60-80	Strengths: Balanced integration of quantitative and qualitative data; Weaknesses: Variable rigor in mixing methods, some lacked Northeast-specific disaggregation.
Government Policy Analyses	2	65	60-70	Strengths: Comprehensive national/regional data; Weaknesses: Lack of independent verification, potential bias from official sources, no empirical fieldwork.
Overall	47	73	50-95	High inter-rater reliability (Cohen's kappa = 0.84); 18 studies (38.3%) focused on Northeast, boosting relevance but highlighting regional data gaps.

2.5 *Data Extraction*

The following data was collected in a standardized data extraction form: (1) study

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characteristics (author, year, design, sample size); (2) institutional context (autonomous status, location, type); (3) digital infrastructure components assessed (hardware, connectivity, LMS, digital repositories); (4) policy alignment measures; (5) key findings on readiness gaps; and (6) Northeast-specific data where available. In the case of grey literature, we implicated official statistics, budgetary provisions, and plans of implementation. The data extraction form is presented in the table 2.

Table 2. *Data Extraction Summary Table*

Field	Description/Extracted Data
1. Study Characteristics (Author, Year, Design, Sample Size)	[e.g., Srinivas & Yadav, 2025, Quantitative Survey, 848 faculty]
2. Institutional Context (Autonomous Status, Location, Type)	[e.g., Autonomous HEIs, National (India), Colleges and universities]
3. Digital Infrastructure Components Assessed (Hardware, Connectivity, LMS, Digital Repositories)	[e.g., LMS (29.1% functional), High-speed internet (43.2% moderate/poor), Smart classrooms (32.1%), Digital repositories (65-75%)]
4. Policy Alignment Measures	[e.g., Alignment with NEP 2020 TAL and Digi Campus; Gaps in effective implementation despite 53.2% supportive policies]
5. Key Findings on Readiness Gaps	[e.g., Only 32.1% have sufficient infrastructure; Faculty digital skills lag (29.1% trained); Wider gaps in Northeast (15-20% below national averages)]
6. Northeast-Specific Data (Where Available)	[e.g., Northeastern states underperform on all parameters per UDISE+; Specific data on Meghalaya, Manipur, Mizoram]

2.6 *Data Synthesis*

Since the studies were heterogeneous in terms of study design and outcome measures, we have done a narrative synthesis according to thematic analysis model of Braun and Clarke (2006). Descriptive statistics were used to summarize quantitative data which were presented in tables. Qualitative data was coded in order to find common themes on barriers to infrastructure preparedness. There was a thematic map created to show correlation between policy aspirations and ground realities. Similar quantitative data on infrastructure availability were attempted to be

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meta- aggregated, but the level of heterogeneity (I^2 greater than 75%) precluded the use of meta-analysis.

3. Results

3.1 *Study Selection*

In the database search, a total of 1, 247 records were retrieved. Because of the elimination of duplicates (n = 156) and screening of titles/abstracts, 89 full-text articles were evaluated in terms of eligibility. After quality appraisal, 47 studies were included in the study: 32 quantitative surveys, 8 qualitative case studies, 5 mixed-method studies as well as 2 government policy analyses. Figure 1 (PRISMA flow diagram) demonstrates the process of the selection.

3.2 *Study Characteristics*

The studies included represented 1,247 institutions across the country and 18 studies (38.3) had Northeastern institutions specifically. The years of publications were 2018 to 2026, with 68% of the publications being published after 2020, which can be explained by increased interest in NEP implementation. The size of the sample ranged between single-institution case studies (n = 1) and large-scale surveys (n = 848 faculty in several states).

3.3 *Infrastructure Preparedness*

National Overview

Digital Infrastructure Availability National-level statistics demonstrate some fundamental discrepancies between the policy requirements and institutional ability. Although 96 percent of the institutions indicate the use of online education portals, including SWAYAM and DIKSHA (Sharma and Verma, 2025), the overall infrastructure preparation is still insufficient:

Learning Management Systems (LMS): LMS systems of any type are integrated into the organizational process only by 29.1% of institutions (Srinivas & Yadav, 2025).

Internet - speed*:* 43.2 percent indicate moderate to poor Internet connection with 8.8 percent having no reliable internet connection (Srinivas and Yadav, 2025).

Smart Classrooms: Only 32.1 percent of establishments have fully furnished smart classrooms that are equipped with digital interactive boards and Artificial Intelligence (AI) (Srinivas and Yadav, 2025)

Digital Repositories*:* 75% of them have online admission systems, though only 65% of them have online assessment systems, and 70-percent have automated systems of attendance

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(Kumar & Sharma, 2025). Faculty Digital Literacy Faculty readiness becomes an essential limitation. The results of a national survey showed that 70 percent of the employees in the public sector feel that their digital skills are at a disadvantage compared to those in the private sector (Das & Sarkar, 2025). The percentage of faculty who received formal training in digital pedagogy or instructional design is only 29.1% (Srinivas & Yadav, 2025), and resistance to change is one of the biggest barriers among elderly faculty (Bansal, 2025).

There is a disproportionate digitization in Administrative Digital Capacity Institutional governance systems. Although 75% of them have automated admissions and 70 percent of them have digital attendance management, only 65 percent of their institutions have adopted online examination systems (Kumar and Sharma, 2025). ERP application is still small, as most of the free-standing colleges have been retaining manual procedures in performing essential roles such as credit transfer and management of student records (Softloom, 2025).

3.4 *Disparities in the Regions Northeast India*

Infrastructure Deficits Northeastern states continue to lag behind the rest of the country in all digital infrastructure indicators. According to a report on UDISE+ 2023-24, the gaps are seen to be severe (Digital India Corporation, 2025):

Table 3. *UDISE+ 2023-2024 Report*

State	Electricity Access (%)	Computer Availability (%)	Internet Connectivity (%)
National Average	78.4	45.2	52.1
Arunachal Pradesh	62.3	28.5	34.7
Manipur	58.7	31.2	38.4
Meghalaya	61.5	29.8	36.2
Mizoram	71.2	38.4	45.8
Assam	68.9	35.6	42.3

In Arunachal Pradesh, it was the government in lower Dibang Valley and East Siang districts that showed in a feasibility study that internet connectivity was reported as very poor and digital infrastructure as minimal, which made national facilities such as SWAYAM virtually unreachable (Kumar and Singh, 2025).

Digital Divide Dimensions The digital divide at Northeast India presents itself at 3 levels (Varghese & Mathew, 2025):

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Access Divide: In Arunachal Pradesh, the penetration of the internet continues to be less than 35% of villages, whereas in urban Mizoram, it is 80 percent (Sharma and Gupta, 2025)

Usage Divide: Despite the existence of infrastructure, overuse is a problem because faculties lack training and there is a lack of relevant content.

Quality Divide: Bandwidth restriction does not allow high-quality video-based content and interactive platforms to be utilized.

Policy-Implementation Gaps Although the Digital Northeast Vision 2022 company has objectified the introduction of smart classrooms in more than 1,000 educational institutions (Sharma and Gupta, 2025), higher learning institutions have very few trickle-down effects. There are no studies being reported to have incorporated the 5G training laboratories into autonomous college programs, even though the initial 5G training workplaces have opened in each of the eight northeastern states in 2023 (OpenGov Asia, 2023), and there have not been any studies that quantitatively demonstrate an effect on college-level digital preparedness.

3.5 *Thematic Synthesis of Inequalities*

Qualitative synthesis produced five major themes:

Theme 1: Infrastructure-Policy Mismatch NEP 2020 was found to rely persistently on its ambitious digital requirements above ground-level infrastructure reality (Govindarajan and Kumar, 2025; Panda and Mishra, 2025). As AI-driven adaptive learning and blockchain-verified credential (Patel and Desai, 2025) become the visions of policy documents, the majority of autonomous colleges cannot cope with such basic issues as connectivity and power stability (Kumar and Singh, 2025; Digital India Corporation, 2025).

Theme 2: Human Resource limitations Faculty faculty digital literacy became more imperative than the presence of hardware (Mei and Zhang, 2025; Das and Sarkar, 2025). The reaction of senior faculty, high teaching loads, and low opportunities of professional development lead to bottlenecks during implementation (Bansal, 2025). Cultural and linguistic differences in Northeast institutions add to this problem of the standardized training methods (Singh and Thomas, 2024).

Theme 3: Governance and Administrative Inertia Despite its flexibility, autonomous institutions tend to have no specific digital transformation strategies (Softloom, 2025). Decision-making is still hierarchical and manual, and the cost factor hinders ERP adoption as it is based on change management challenges (Sharma and Verma, 2025; Softloom, 2025).

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Theme 4: Digital Inequality in Regions Northeast India is burdened by combined disadvantages: it is a geographically isolated region, has lower incentives in the private sector, and is poorly funded at the state level (OpenGov Asia, 2023; NITI Aayog, 2023). The area gets inadequately fewer resources according to centrally sponsored plans, and the application is marginalized by the topography and safety concerns (Kumar and Singh, 2025; Sharma and Gupta, 2025).

Theme 5: Sustainability and maintenance Despite the installation of initial infrastructure, maintenance becomes a major void. It is stated that in Northern colleges in colleges, 40 percent of installed smart classroom devices are not in operation because of the absence of technical support and spares (Kumar & Singh, 2025; Digital India Corporation, 2025).

3.6 *Quality of Evidence*

The quality of methodology was different amongst included studies. Quantitative surveys received more points on MMAT criteria (average 75) but were not always representative of Northeastern institutions. Case studies were descriptive in nature and were qualitative in nature but limited in their generalizability. Government reports were detailed sources of data that were not verified independently. Table 1 gives detailed results of quality assessment.

4. Discussion

This literature review indicates a significant gap between the digital transformation goals of NEP 2020 and the infrastructural preparedness of independent institutions, where the Northeast Indian region is under acute implementation strain. The results are consistent with the international studies that have shown that, to achieve digital transformation in higher education, technology deployment is not enough, but a whole-hearted organizational change should be applied in terms of human resources, governance, and situational aspects.

4.1 *Making sense of the infrastructure-Policy Gap*

The difference of 64-percentage-points between portal adoption (96) and complete infrastructure readiness (32.1) is a highly fatal policy implementation failure. This gap implies that the existing tracking tools are followed in terms of input measures (e.g., registration of platforms) but not outputs of the intervention (e.g., successful entry into teaching-learning). The National Digital Education Architecture (NDEAR) attempts to deal with this using integrated ecosystems, however data on the ground indicates that autonomous colleges in particular those in Northeast

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India do not have the underlying infrastructure to be involved. The observation that fibre core infrastructure has not been properly invested into since the NEP 2020 is the factor that emphasizes blended learning is the reason as to why only 29.1% of institutions have operational Learning Management System platforms. This is unlike world models: Rain Classroom by Tsinghua University operates an AI based analytics without any discrepancies whereas online learning platforms at Harvard offer feedback loops of interactive feedback. The discrepancy does not only lie in the technological aspect but in the larger problem of the institutional ability, and the ability to fund it.

4.2 *A Case of Compound Disadvantage: Northeast India*

The Northeast autonomous institutions are challenged with specific problems, and it needs region-specific approaches to coping with the disadvantages related to compounds. The difference in electricity access between the national averages (78.4%) and Arunachal Pradesh (62.3) is not just an infrastructure statistic (a 16-percentage-point gap) but an example of an inherent obstacle to digital participation. This infrastructure shortage is combined with the problem of human capital: when power and connectivity is available, faculty unpreparedness means that it is not used.

The 5G training laboratories programs and Digital Northeast Vision 2022 show that the needs of the region are identified by the policy. As an indication of implementation disconnects, however, the lack of such programs in our included studies. In contrast with mainland India, where the digital infrastructure development is led by the partnership between the private sector (e.g. ed-tech in Karnataka and Maharashtra), Northeastern institutions are heavily dependent on government finances that can suffer the delay of bureaucracy and the lack of allocation.

These challenges are clarified in comparison to international contexts. The digital transformation of Harvard was effective due to significant funding (endowment, 4.6 billion a year) and centralized IT governance. The model of Tsinghua was based on the bilateral relationships between the government and industry, as well as a decade-long gradual execution. Institutions of the Northeast Indians are not similarly endowed, and need modified structure with focus on low-bandwidth arrangements, regional content growth, and other models of local maintenance.

4.3 *Consequences to Independent Institution*

The results imply opportunities and demands to the autonomous colleges in the Northeast of India. Curriculum innovation and quick adoption of technology are possible with academic autonomy, with one condition that infrastructure readiness must be present. The review shows that

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effective institutions merge both the top-down alignment of policies with bottom-up faculty involvement.

4.4 *Key implications include*

Strategic Planning: Autonomous status enables personalized digital road maps, although it needs special digital transformation committees that are technically knowledgeable.

Faculty Development: Programs of continuous professional development should also focus on technical skills as well as pedagogical redesign and should be carried out on a long-term basis, other than the single-workshop approach.

Public- Private Partnerships: NGOs and collaboration with the local industries are ways to complement government financing, especially in maintenance and technical support.

Regional Content: Adoption will be achieved through creation of culturally relevant digital material in local languages, which will result in justification of infrastructure investment.

4.5 *Limitations*

There are a number of limitations to this review. To begin with, the name of the scarcity of rigorous studies that explicitly look into Northeastern autonomous institutions is a limitation to generalization. The vast majority of research contained is national in nature and not disaggregated in regions. Second, publication bias can give an advantage to the positive results; the institutions with the ineffective infrastructure can be less likely to make self-assessment and be published. Third, the rapid development of online technologies implies that some of these findings can be already outdated, especially about the use of 5G and AI. Fourth, a quality comparison of grey literature was diversified as the government reports were not self-verified. Lastly, a snapshot period is taken by the review; longitudinal research should be conducted to determine sustainability.

5. Conclusion and Recommendations

The systematic review proves that there are significant gaps between digital transformation goals set by NEP 2020 and the availability of infrastructure by independent institutions, and Northeast India faces severe implementation challenges. The institutions in the country currently only have sufficient infrastructure in 32.1 percent of institutions with 96 percent of the institution using portals, and the Northeastern states also are 15-20 percent below the national averages on all measures of readiness. Synthesis: the infrastructure shortfall, human capital limitations, inertia of

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governance, regional unfairness and sustainability issues are interdependent failures which can only be solved by combining their efforts.

5.1 *Evidence-Based Recommendations*

For Policymakers:

Regional Designation Station: Have a special Digital transformation Fund that is used by Northeastern autonomous institutions, with 25 percent of higher education technology spending going to that region due to its compound disadvantages.

Infrastructure-First Approach: Develop basic infrastructure (quality electricity, high-speed internet) before deployment of advanced technology. Install backup systems with power sources based on solar energy and satellite connectivity at remote institutions.

Monitoring Framework: It is necessary to switch between input-based measurements (platform registration) and outcome-based measurements (effective integration, student engagement, learning gains).

For Institutional Leaders:

Digital Transformation Offices: Have offices that have budgets and technical capacity to both establish and operationalize institution-specific roadmaps.

Faculty Development Requirement: Have 40 hours of digital pedagogy training per year and encourage certification and innovation in all teaching personnel.

Maintenance Budgets: Use 15-20 percent of technology purchase and maintenance costs to maintain technology yearly adding support costs.

In the case of Northeast-Specific Context:

1. **Design that is Culturally Responsive**: Develop digital content in the local languages, and contextualize platforms that are culturally relevant to the areas and learning preferences.
2. **Partnerships with the community:** Collaborate with regional non-governmental organizations, community centers and industries to maintain the infrastructure such as the creation of jobs and the sustainability of these jobs.
3. **Staged Adoption**: use a three-stage model: Phase 1 (primary connectivity and power), Phase 2 (LMS and digital content), Phase 3 (AI and advanced analytics)

5.2 *For Future Research*

1. **Longitudinal Studies**: Track digital transformation progress in Northeastern autonomous institutions over 5-10 years to assess sustainability and impact

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2. **Implementation Science**: Conduct mixed-methods research on effective strategies for faculty development, change management, and community engagement in resource-constrained settings
3. **Comparative Analysis**: Systematically compare digital transformation models across Northeastern states to identify best practices and context-specific solution

5.3 *Final Synthesis*

Achieving NEP 2020's digital vision requires moving beyond one-size-fits-all approaches to embrace region-specific, institution-specific strategies that address the unique challenges of autonomous colleges in Northeast India. The evidence clearly indicates that infrastructure readiness is not merely a technological issue but a complex socio-technical challenge requiring coordinated action across policy, institutional, and community levels. For autonomous institutions, especially in Northeast India, the path forward involves leveraging academic autonomy to pioneer context-appropriate digital models while advocating for targeted infrastructure investment and policy support. Only through such integrated efforts can the promise of digital transformation become reality for all Indian students, regardless of geography.

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