



The Institutional Pedagogical Enablement Gap in Indian School Education: Digital Access and Uneven Transformation

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Abstract

Digital transformation in school education is often assessed through digital access, yet access alone may not capture the institutional conditions supporting pedagogically oriented technology use. In this study, the distinction between foundational digital access and institutional pedagogical enablement was examined, and the extent to which these measures developed at comparable rates across States/UTs was assessed. Using administrative data from UDISE+ for all 36 Indian States and Union Territories (States/UTs) during the period 2022–23 to 2025–26, digital access was defined using functional computers and internet access, whereas institutional pedagogical enablement was defined through smart classrooms, projectors, and integrated teaching-learning devices. The Access–Enablement Gap was calculated by subtracting institutional pedagogical enablement from digital access. Statistical analyses, including repeated-measures ANOVA, non-parametric robustness testing, correlation analysis, and regression, were performed at the State/UT level. Digital access increased by 14.92 percentage points, while institutional pedagogical enablement increased by 7.93 percentage points, resulting in a 7.00-percentage-point increase in the Access–Enablement Gap. In 25 out of 36 States/UTs, the Access–Enablement Gap widened, while enablement exhibited substantial temporal persistence in the relative distribution of States/UTs. The results suggest that digital access expanded faster than institutional pedagogical enablement, highlighting the value of assessing school digital transformation through paired indicators of foundational access and institutionally oriented pedagogical infrastructure.

Keywords: *Access-Enablement Gap; Digital Access; Digital Transformation; Educational Technology; Institutional Pedagogical Enablement.*

1. Introduction

Digital transformation has become a central objective of contemporary school education, with the expectation that the use of technology will transform teaching and learning. The availability of digital infrastructure is a prerequisite for participation in technology-enabled education, while the uneven distribution



of such technology may contribute to the marginalization of learners (Van De Werfhorst et al., 2022). In modern education systems, investments in computing and Internet infrastructure have broadened the technological base of schooling. Hence, the focus of policymaking has increasingly shifted from providing digital infrastructure in schools to creating conditions that support its pedagogical use.

Digital access, however, represents an essential but incomplete dimension of school digital transformation. Research shows that technological infrastructure alone does not necessarily lead to integration, since technology integration depends on how technologies are used in teaching practices (Consoli et al., 2023). Educational disadvantage can persist even when there is access to technology (Pierce & Cleary, 2024), while schools may reproduce inequalities in students' digital competencies rather than address them (Loh et al., 2025). These findings suggest that digital transformation is not a matter of meeting a single criterion involving connectivity and devices. Rather, it consists of various interlinked dimensions that may develop at different rates.

One such condition lies between basic digital access and meaningful pedagogical use: school-level technological infrastructure designed to support teaching and learning. Examples include classroom displays, smart classrooms, projectors, and teaching-learning technologies. Research on school digital capacity shows that organizational and infrastructural conditions influence the capacity of schools to implement digital transformation (Timotheou et al., 2023), while stakeholder assessments reveal substantial differentiation in the digital capacities of schools (Çebi et al., 2026). Recent research further indicates that the institutional capacity to facilitate the deployment of technological resources in teaching is more complex than merely counting the devices available (Fischer-Schöneborn et al., 2026). Thus, digital transformation requires consideration not only of the presence of technology in schools but also of technological conditions supporting teaching activities (Durnali, 2025).

In this study, institutional pedagogical enablement refers to the availability of school-level technological infrastructure that provides institutional conditions capable of supporting technology-enabled pedagogical activity. It is conceptually differentiated from technology use, teacher competence, student competence, and learning outcomes. This distinction enables the study to investigate an infrastructural condition without attributing pedagogical effects for which there is no empirical evidence in the administrative data.

This distinction creates an important longitudinal question: when foundational digital access expands, does pedagogically oriented educational infrastructure also develop at a comparable pace? The school-ecosystem approach indicates that technological preparedness requires several institutional factors to be in place, which may develop at different rates (Hsu & Chen, 2026). Likewise, preparedness literature conceptualises digital education through a combination of infrastructure and additional supportive factors rather than infrastructure alone (Cambeses-Franco & Cambeses-Franco, 2026). However, the relative rates of



development of basic access and pedagogically oriented educational infrastructure have not been sufficiently explored within the context of a whole national school system.

India provides a particularly relevant context for examining this issue because its school system is extensive, administratively organised across States and Union Territories, and documented annually through UDISE+. National policy in India has made considerable efforts to develop digital infrastructure, connectivity, and ICT-enabled teaching. Contemporary Indian literature highlights not only the growth of digital learning platforms in secondary education (Mandala et al., 2026) but also contextual challenges that remain relevant to technology-enabled learning (Panja, 2026). Comparative studies also reveal differences in attitudes towards ICT integration across institutional settings (Ismajli, 2026), while studies of ICT integration identify several contextual factors in secondary education (Tonkolu et al., 2026). Thus, India provides a relevant context for examining whether growth in access has been accompanied by corresponding growth in institutional pedagogical enablement.

Despite extensive scholarship on digital access, school digital capacity, and technology integration, longitudinal State/UT-level evidence distinguishing digital access from institutionally oriented pedagogical enablement within a national school system remains limited. Many existing studies analyse school capacity from a cross-sectional perspective, use perceptions as data, or investigate digital transformation processes without differentiating the development of distinct layers of technological infrastructure. Recent research on school leadership, for instance, stresses digitalisation as an organisational process but does not address whether different layers of technological infrastructure develop at comparable rates (Nagel et al., 2026). Hence, it remains unclear whether rapid improvements in digital access are matched by comparable growth in teaching-oriented infrastructure and whether divergence between these dimensions emerges over time. The present study addresses this gap. The study addresses four research questions.

RQ1 examines how digital access and institutional pedagogical enablement changed across Indian States/UTs between 2022–23 and 2025–26.

RQ2 examines how the Access–Enablement Gap changed across the same period.

RQ3 examines the association between digital access and institutional pedagogical enablement in 2022–23 and 2025–26.

RQ4 examines the direction and magnitude of State/UT differences in change in the Access–Enablement Gap.

The contribution of the study is deliberately bounded. It operationalises and longitudinally examines institutional pedagogical enablement as a distinct infrastructural condition oriented towards pedagogical practice and studies its evolution relative to foundational digital access across all 36 Indian States and Union Territories. In contrast to studies that focus on technology use, digital competence of teachers or students, pedagogical integration, or educational outcomes, this study focuses specifically on the infrastructural relationship between access and enablement. This study does not introduce institutional pedagogical



enablement as an additional stage in the digital divide. Instead, it identifies an institutional condition positioned between basic access and pedagogical use of information technologies and analyses how its development corresponds with the development of foundational digital infrastructure across the country. With comprehensive national coverage and a four-year observation period, the study offers a more differentiated approach to understanding school digital transformation and clarifies why monitoring digital access alongside pedagogically oriented institutional infrastructure is important.

2. Literature Review and Theoretical Framework

2.1 Digital Access and the Digital Divide

Research on the digital divide has established that unequal access to devices and connectivity shapes educational opportunity and participation. A comparative analysis during the transition to online delivery found significant variation in learning continuity due to household and institutional connectivity gaps (Guo & Wan, 2022). In the Indian setting, research has identified access gaps across different regions and social categories, with connectivity being a major factor that limits participation in online education (Jafar et al., 2023). Further research has pointed out that inequalities in access apply to both individuals and institutions, suggesting that educational technology equity cannot be assumed based on device access alone (Yousofi et al., 2025).

A recurring conclusion across this literature is that access, although foundational, is an incomplete indicator of digital participation. Even when infrastructure exists, schools may vary in their ability to translate the presence of technology into sustained digitally supported practices, depending on organisational contexts that can either cushion or exacerbate the effects of infrastructure deficits (Drossel et al., 2020). The distinction between the existence of technological infrastructure and the organisational context of its productive application provides the basis for the present research. Thus, basic digital access is considered a foundational infrastructure level, while teaching-oriented technological infrastructure is considered an intermediate infrastructural condition.

2.2 From Digital Access to Technology Integration

Technology integration research consistently distinguishes the presence of technological resources from their pedagogical use. Systematic reviews of technology-integration frameworks indicate that technology integration is multidimensional and comprises instructional purpose, pedagogical practice, and contextual factors rather than technological availability alone (Sosa-Díaz et al., 2022). For teachers, instructional and application software use depends not only on technological availability but also on competencies and enabling factors (Dogan et al., 2021). Moreover, teachers' beliefs and practices influence whether available technologies are used in instruction, indicating that provision and practice can differ even within the same school environment (Bice & Tang, 2022).



Studies of technology adoption indicate that teacher acceptance and use of technology depend not only on access but also on a range of individual and contextual factors (Georgiou et al., 2023). Secondary education literature supports this view by indicating that infrastructure is necessary but insufficient for successful technology integration (Msafiri et al., 2023), while studies of rural schooling demonstrate persistent differences between technology availability and its application in classrooms (Mustafa et al., 2024).

Studies of technology integration in science classrooms show that the degree of integration depends on how technological tools are used within teaching practices (Parker et al., 2019). Similarly, research on secondary science teaching reveals that the same technological tools can support different teaching practices depending on how teachers use them (Walan, 2020). Taken together, the literature indicates that pedagogical utilisation is conceptually distinct from technological access and involves conditions beyond access to tools.

2.3 Institutional Capacity for Digital Transformation

A third body of literature locates digital transformation within the institutional conditions of schools and education systems. The digital capacity of schools is shaped by organisational factors, leadership, and support systems that influence the potential for using technological resources for teaching purposes (Pata et al., 2022). Research on leadership demonstrates that the way school leadership operates is associated with the use of information and communication technologies for teaching purposes (Hsieh et al., 2026). Moreover, research on digitalisation and school leadership conceptualises transformation as an institutional process (Reis-Andersson, 2024).

Teacher-facing conditions constitute another important component of institutional capacity. Frameworks of teacher digital competence demonstrate that meaningful technology use presupposes professional skills that require institutional development and support (Falloon, 2020), while studies of professional digital competence point to considerable variability in how competence is understood within education systems (Heine et al., 2023). Studies assessing teacher digital competence also illustrate contextual variability (Tzafilkou et al., 2023), whereas large-scale assessments identify systematic differences associated with teacher and school characteristics (Suzer & Koc, 2024). Taken together, this literature indicates that the transition from institutional conditions to effective technology use depends on competencies extending beyond infrastructure.

For the present study, the focus is the observable technological infrastructure that is directly related to teaching and learning. Research examining teaching quality with ICT has found that school ICT equipment and perceived ICT support are related to technology-supported instructional quality, while also distinguishing these enabling conditions from other dimensions of teaching quality (Quast et al., 2021). An umbrella review further indicates that infrastructure, competence, and organisational support are interrelated conditions in educational digitalisation (Wohlfart & Wagner, 2023). Therefore, the existing literature supports consideration



of teaching-oriented infrastructure as a distinct institutional condition. This synthesis shifts attention from resource availability toward institutional conditions supporting pedagogical activity.

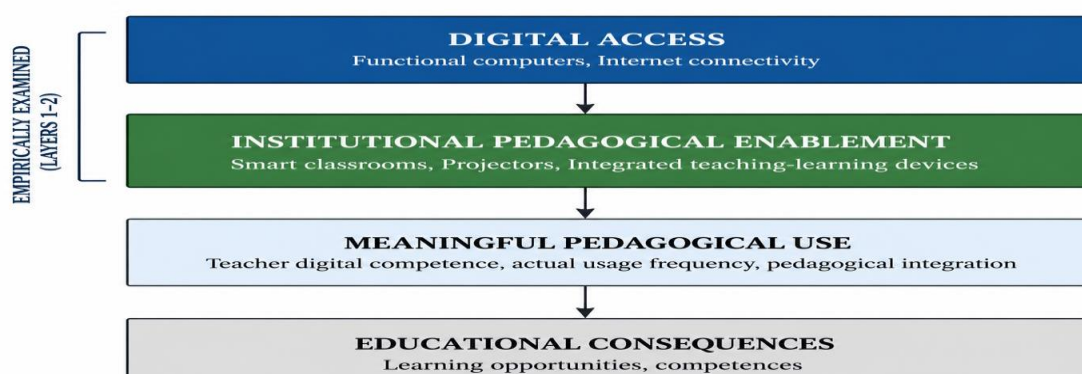
2.4 Institutional Pedagogical Enablement and the Conceptual Framework

Drawing on these three strands of literature, the present study defines Institutional Pedagogical Enablement (IPE) the availability of school-level technological infrastructure that provides institutional conditions capable of supporting technology-enabled pedagogical activity. Thus, IPE should be understood as an institutional infrastructural condition, not as an index of how technology is being used. IPE is distinct from pedagogical integration, teacher and student competence, digital literacy, and learning outcomes. This distinction is also supported by research indicating that technology availability and integration represent different dimensions of digital transformation (Chiu, 2022).

The framework positions four conceptual layers in sequence: digital access, institutional pedagogical enablement, pedagogical use, and educational consequences (see Figure 1). The first two layers are the subject of empirical investigation in this study, whereas meaningful use and educational consequences are treated as downstream conceptual dimensions and are not included in the measures available in the administrative dataset. The importance of teacher- and student-level factors is further supported by studies examining teachers' beliefs and trust in new technologies (Lucas et al., 2024; Löfving, 2024).

The conceptual framework therefore does not propose that access causes enablement or that enablement causes pedagogical use. Rather, the arrows denote a theoretical ordering of conditions through which digital transformation can be understood. The framework is therefore conceptual rather than causal in nature and is not empirically tested by the present research. Within this framework, the Access–Enablement Gap can be understood as a derived comparative indicator, calculated as digital access minus institutional pedagogical enablement. It represents the difference between the availability of foundational infrastructure and the availability of institutional conditions for pedagogical technology use. A greater positive gap indicates a larger divergence between the two dimensions. The gap is neither assumed to be a latent construct nor interpreted as a measure of digital inequality.

Fig 1. Conceptual Framework of School Digital Transformation.





3. Methods

3.1 Data Source and Unit of Analysis

The study draws on UDISE+, the Government of India's administrative census of school education, for 2022–23, 2023–24, 2024–25, and 2025–26. UDISE+ collates standardised indicators from officially recognised schools and provides the results for each State and UT in such a way as to allow meaningful comparison over the four years. The analytical dataset contains all 36 States/UTs with complete data for all study variables across the four years. The State/UT is the unit of analysis; thus, all the conclusions are interpreted at the State/UT level and not at the level of schools, teachers, or students. In cases where indicators in UDISE+ were reported as the number of schools, each was converted into a State/UT-level percentage using the corresponding number of schools as the denominator.

Because the analysis includes the complete set of 36 States/UTs represented in the national dataset, it does not involve a sample survey of States/UTs. Hence, descriptive statistics, effect sizes, and confidence intervals are the primary basis for characterising the observed national pattern. Inferential techniques are applied as supportive methods to assess temporal differences and associations rather than as evidence for generalisation from a sample to an unobserved population. Statistical significance is interpreted alongside observed effect sizes and directions.

3.2 Measures and Operationalisation

Digital access was operationalised as the arithmetic mean of two foundational indicators: the percentage of schools with functional computers and the proportion of schools with Internet access. Institutional Pedagogical Enablement (IPE) was operationalised as the arithmetic mean of three measures focused on technology-enabled teaching environments: smart classrooms, projectors, and teaching-learning devices. These measures constitute technological assets at the institutional level that are more closely linked to teaching than basic computing and access, but do not indicate actual classroom usage. Equal weighting was used for transparency because there was no empirical justification for a different structure. The component measures were maintained separately so that the composite could be examined with respect to its constituents. The conceptual definitions, operational indicators, and conceptual roles of the study variables are presented in Table 1.

Table 1. Conceptual Definitions and Operationalisation of Study Variables

Construct	Operational indicators	Conceptual role
Digital access	Functional computers; internet connectivity (mean %)	Foundational digital infrastructure



Institutional pedagogical enablement (IPE)	Smart classrooms; projectors; integrated teaching-learning devices (mean %)	Institutional conditions oriented toward pedagogical technology use
Access-Enablement Gap (AEG)	Digital access minus IPE	Derived comparative divergence indicator

Before constructing the longitudinal measures, each candidate indicator was screened for consistency in definition, denominator, and reporting coverage across all four editions of UDISE+. Any digital library or ICT laboratory-related measures were excluded if their longitudinal consistency was not assured. This was a methodological step aimed at preventing potential biases that could result from differences in definitions and reporting coverage. As a result, the longitudinal analysis is based only on measures with stable definitions and reporting coverage throughout the study period.

The Access–Enablement Gap (AEG) was calculated as digital access minus IPE. It captures the difference between foundational digital infrastructure and institutionally oriented technological conditions supporting teaching and learning activities. A higher positive value of the Access–Enablement Gap indicates greater divergence between the two dimensions. The Access–Enablement Gap is treated as a derived comparative indicator rather than a latent construct or a comprehensive measure of digital inequality.

3.3 Analytical Strategy

Descriptive statistics, including mean, standard deviation, standard error, coefficient of variation, minimum, and maximum, were calculated for all measures in each year. Change over time was analysed using one-way repeated-measures ANOVA with Year as the within-State/UT factor. The Greenhouse–Geisser correction was applied because Mauchly’s test indicated that the assumption of sphericity was violated. The Holm adjustment method was employed for pairwise comparisons, controlling the familywise error rate. Change from the beginning year to the final year in the AEG was tested against zero using a one-sample t-test and the Wilcoxon signed-rank test. As the change distribution did not meet normality criteria, the Wilcoxon test was considered the robust test, whereas the parametric test was presented for comparison. Pearson correlation coefficients were computed to assess associations between the four core variables, while Spearman coefficients were computed as a robustness check. Simple linear regression was conducted to estimate the cross-sectional association between access and IPE in 2022–23 and 2025–26. No causal, or structural equation models were specified because the study examines State/UT-level associations rather than causal effects or individual-level relationships. Analysis was conducted in JASP.



For composite construction, percentages were averaged within each State/UT and year rather than pooling school-level records. This ensures that the State/UT level remains the unit of analysis without giving undue weight to larger entities simply because of their greater number of schools. The same approach was followed across years for comparability. The analytical approach was chosen to fit the research question at hand; temporal change is examined through repeated-measures analysis, associations are examined via correlations and regressions, and State/UT heterogeneity is examined through the distribution of gap changes. The results are therefore presented in such a way that effect sizes, confidence intervals, and distributions are highlighted.

4. Results

4.1 Descriptive Trends and Temporal Change

Across the 36 States/UTs, mean digital access increased from 56.95% in 2022–23 to 71.87% in 2025–26, representing an increase of 14.92 percentage points (Table 2). Mean institutional pedagogical enablement (IPE) increased from 23.35% to 31.28%, representing an increase of 7.93 percentage points. The mean Access–Enablement Gap (AEG) increased from 33.59 to 40.59 percentage points. Thus, both dimensions expanded, but digital access increased by nearly twice the absolute amount of IPE. However, cross-State/UT variation in access declined, with the standard deviation decreasing from 28.27 to 21.82 and the coefficient of variation from 0.496 to 0.304. In contrast, IPE dispersion increased modestly, with its standard deviation rising from 18.09 to 20.50. By 2025–26, the minimum AEG was 13.70 points, indicating that digital access remained higher than IPE in every State/UT. This descriptive pattern provides the empirical baseline for the subsequent analysis. The simultaneous increase in access and IPE reflects growth in both infrastructural dimensions, whereas the differences between them provide the basis for examining divergence through AEG. The reduction in access dispersion should be interpreted as reduced variation among the States/UTs rather than complete equalisation, since the State/UT values remained dispersed in the final period.

Table 2. Four-Year Descriptive Trends in Digital Access, Institutional Pedagogical Enablement, and Access–Enablement Gap

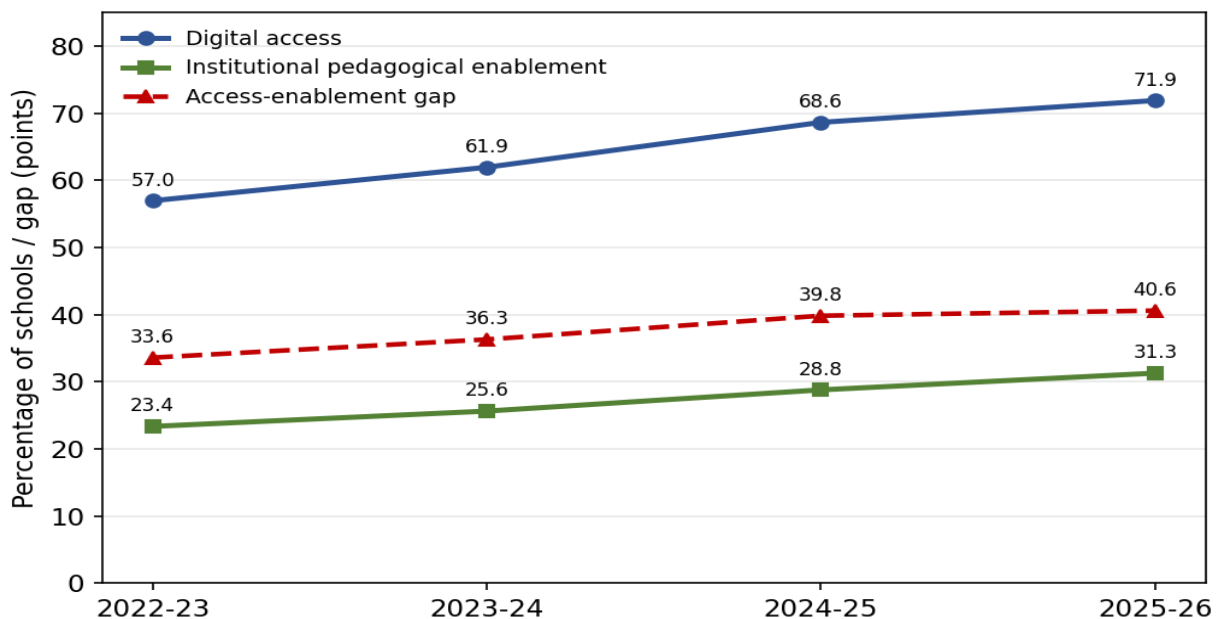
Year	Access M	Access SD	IPE M	IPE SD	AEG M	AEG SD	AEG CV
2022-23	56.95	28.27	23.35	18.09	33.59	16.11	0.480
2023-24	61.93	25.49	25.63	18.73	36.30	14.15	0.390
2024-25	68.62	22.53	28.79	19.06	39.83	13.13	0.330
2025-26	71.87	21.82	31.28	20.50	40.59	13.98	0.345
Change	+14.92	-6.45	+7.93	+2.41	+7.00	-2.13	n/a



Note. N = 36 States/UTs. M = mean; SD = standard deviation; CV = coefficient of variation. Values are percentages of schools; AEG is in percentage points.

The annual trajectories were consistently upward for both primary measures. Access increased from 56.95% to 61.93%, 68.62%, and 71.87%, and IPE increased from 23.35% to 25.63%, 28.79%, and 31.28%. AEG increased from 33.59 to 36.30, 39.83, and 40.59 points (see Figure 2). For repeated-measures analysis, access showed a significant temporal difference, $F(1.16, 40.74) = 27.08$, $p < .001$, $\omega^2 = .051$, and IPE also showed a significant temporal difference, $F(1.22, 42.80) = 37.99$, $p < .001$, $\omega^2 = .024$ (see Table 3). The Greenhouse–Geisser correction was applied because Mauchly’s test indicated a violation of the assumption of sphericity. All six Holm-adjusted pairwise comparisons were statistically significant for both measures (all $p < .001$). Therefore, the temporal analysis revealed two distinct patterns: consistent change over time in access and IPE, but no significant individual year-to-year changes in AEG after adjustment for multiple comparisons. This differentiation is maintained in the subsequent analyses and supports interpretation of the aggregate AEG trend without treating it as evidence of significant change between every individual year.

Figure 2. Longitudinal Trends in Mean Digital Access, Institutional Pedagogical Enablement, and the Access–Enablement Gap, 2022–23 to 2025–26.



For AEG, the omnibus test based on Greenhouse–Geisser correction for sphericity revealed overall temporal variation, $F(1.19, 41.75) = 5.62$, $p = .018$, $\omega^2 = .031$. Nevertheless, all six pairwise comparisons conducted under Holm correction were non-significant (adjusted $p = .093$ –.290). Therefore, the omnibus test indicated overall temporal variation in AEG, but none of the specific year-to-year comparisons remained statistically significant after Holm adjustment.



Table 3. Greenhouse–Geisser-Corrected Repeated-Measures ANOVA for Temporal Change

Measure	Mauchly W	GG ϵ	F	df	p	ω^2	Pairwise (Holm)
Digital access	0.0218	0.388	27.08	1.16, 40.74	< .001	0.051	all six p < .001
IPE	0.0382	0.408	37.99	1.22, 42.80	< .001	0.024	all six p < .001
AEG	0.0401	0.398	5.62	1.19, 41.75	.018	0.031	none significant

Note. AEG = Access–Enablement Gap. Greenhouse–Geisser correction was applied because sphericity was violated. For AEG, Holm-adjusted pairwise comparisons were non-significant.

4.2 Temporal Change in the Access–Enablement Gap

The cumulative change in AEG between 2022–23 and 2025–26 had a mean of 7.00, a median of 4.43, and a standard deviation of 16.95; the value of the change ranged between –24.12 and 57.00 (Table 4). The one-sample t-test showed that the mean change was significantly different from zero, $t(35) = 2.478$, $p = .018$, Cohen’s $d = .41$. Normality was rejected by the Shapiro–Wilk test, $W = .934$, $p = .033$. Hence, the Wilcoxon signed-rank test was used as a robust non-parametric assessment and produced a similar result, $V = 476$, $p = .025$, rank-biserial correlation = .43. In 25 out of 36 States/UTs, the AEG widened and in 11 cases it narrowed. The cumulative analysis provides complementary information to the repeated-measures analysis by comparing the two endpoint measurements for each State/UT. The positive mean and median, together with the Wilcoxon result, are consistent with an overall positive direction of cumulative AEG change. At the same time, the large spread shows that the national average masks substantial variation in State/UT-level changes.

Table 4. Access–Enablement Associations, Regression, and Cumulative AEG Change

Panel A. Pearson correlations (N = 36)	r		Panel B. Regression of IPE on access	2022-23	2025-26
Access 22 – IPE 22	.848		Slope B (unstandardised)	0.542	0.736
Access 25 – IPE 25	.783		Standardised β	.848	.783
IPE 22 – IPE 25	.948		R^2	.719	.614
Access 22 – Access 25	.829		F(1, 34)	86.82	54.01
Access 22 – IPE 25	.841		p	< .001	< .001
IPE 22 – Access 25	.739		95% CI (slope)	[.42, .66]	[.53, .94]



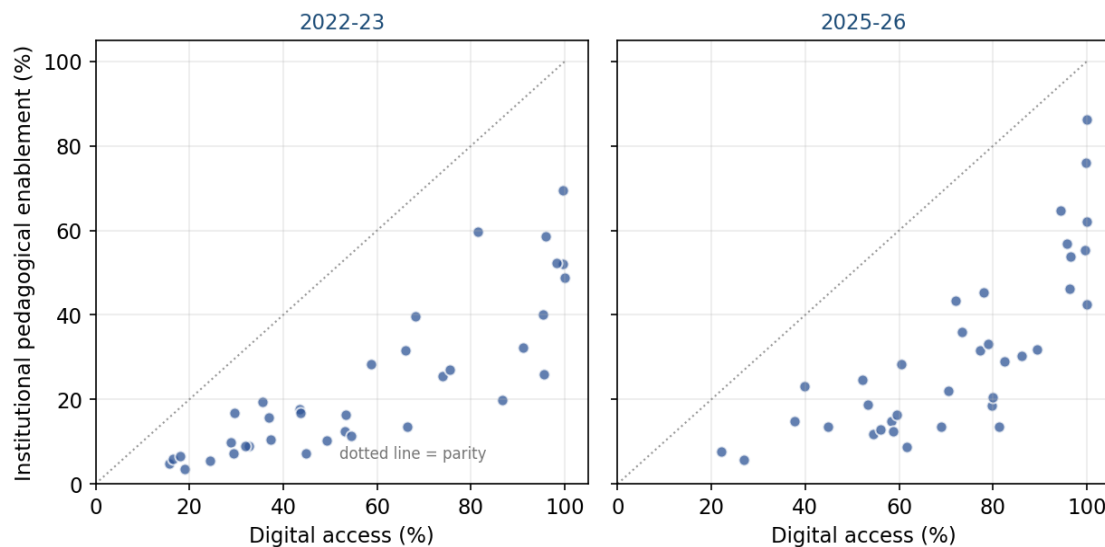
Note. $p < .001$. Temporal correlations refer to 2022–23 with 2025–26. Regression models estimate cross-sectional associations between access and IPE.

4.3 Associations and Regression

Digital access and IPE were strongly positively correlated in both endpoint years, with Pearson coefficients of $r = .848$ in 2022–23 and $r = .783$ in 2025–26 (both $p < .001$; Table 4). Cross-period relationships exhibited substantial persistence: access in 2022–23 was associated with access in 2025–26 ($r = .829$), while IPE in 2022–23 had a very strong correlation with IPE in 2025–26 ($r = .948$). Positive cross-construct associations were also observed, with access in 2022–23 being associated with IPE in 2025–26 ($r = .841$) and IPE in 2022–23 having a positive association with access in 2025–26 ($r = .739$). Spearman coefficients were also high, ranging between .754 and .960. These correlation coefficients provide two types of evidence. First, endpoint correlation shows that States/UTs with high digital access also have relatively high IPE in each period, while cross-period correlation shows that the relative ordering of States/UTs in terms of their values remained persistent.

Simple linear regressions showed significant cross-sectional associations in both endpoint years. For 2022–23, the access variable accounted for 71.9% of the IPE variance, with $F(1,34) = 86.82$, $p < .001$, $B = .5424$, $SE = .0582$, $\beta = .8477$, $t = 9.318$, and 95% CI [.4241, .6607]. For 2025–26, the access variable explained 61.4% of the IPE variance, with $F(1,34) = 54.01$, $p < .001$, $B = .7358$, $SE = .1001$, $\beta = .7834$, $t = 7.349$, and 95% CI [.5324, .9393]. Although the estimated coefficient was greater in 2025–26, the coefficients were not formally compared. Thus, no conclusion can be drawn about whether the slopes differed statistically between the two years, and these cross-sectional associations do not establish causality. The regression analyses are in line with the findings from the correlations but provide additional information regarding the proportion of variance associated with the access variable in each cross-section. With the decrease in R^2 from .719 to .614, the proportion of variance associated with access was smaller in 2025–26. The estimated coefficient value was positive in both years, but the difference between coefficients was not tested. Thus, these findings demonstrate positive cross-sectional associations at the State/UT level but do not establish causal relationships.

Figure 3. State/UT-Level Association Between Digital Access and Institutional Pedagogical Enablement in 2022–23 and 2025–26.



4.4 State/UT Heterogeneity

The State/UT distribution showed considerable heterogeneity in the direction and magnitude of change in AEGs in Table 5 and Figure 4. The largest widenings were found in Assam (+57.00), Bihar (+42.33), Telangana (+37.23), and Mizoram (+36.47). The largest narrowings were found in Tamil Nadu (–24.12), Lakshadweep (–23.68), Andhra Pradesh (–13.73), and Delhi (–9.83). Some other trajectories were close to zero in Rajasthan (+0.07) and Dadra & Nagar Haveli and Daman & Diu (–1.22), while others exhibited substantial widening or narrowing. The heterogeneity analysis adds the final distributional element to the national results. Both positive and negative changes were found in the same period, while the difference between the extrema exceeded 80 percentage points. The combination of widening and narrowing trajectories indicates that the national increase in AEG is an aggregate pattern rather than a uniform trajectory across individual States/UTs. The full distribution is provided in Table 5.

Table 5. State/UT-Level Access–Enablement Gap and Cumulative Change, 2022–23 to 2025–26

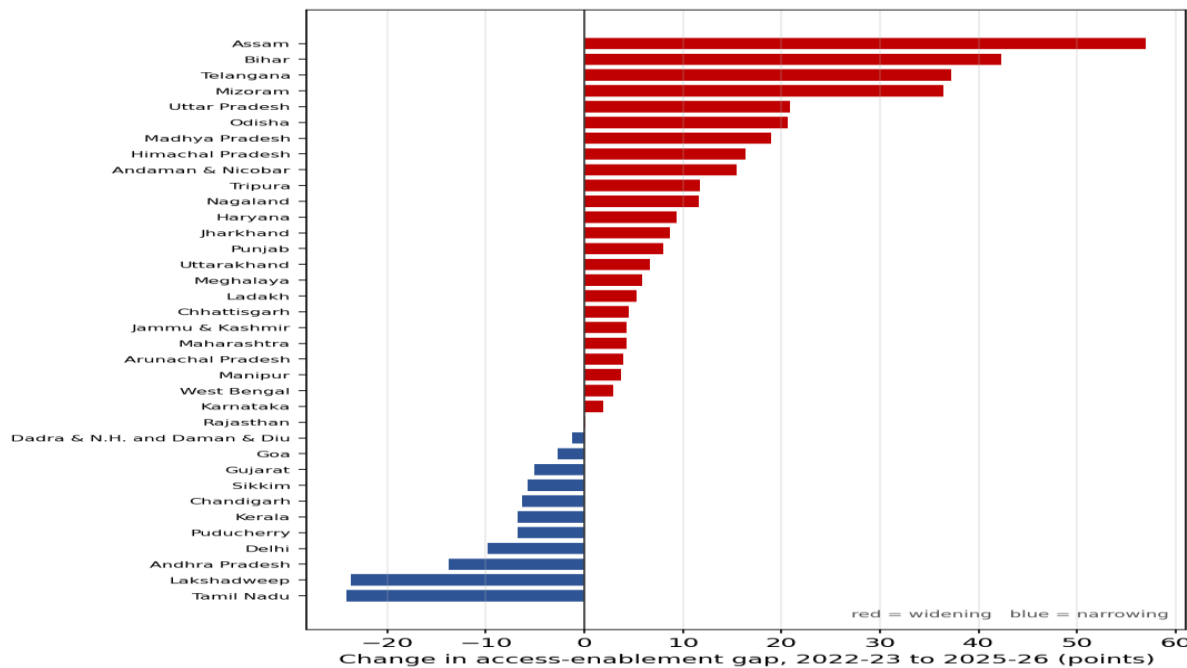
State/UT	Gap 2022-23	Gap 2025-26	Change
Assam	10.90	67.90	+57.00
Bihar	10.50	52.83	+42.33
Telangana	16.10	53.33	+37.23
Mizoram	18.87	55.33	+36.47
Uttar Pradesh	22.33	43.23	+20.90
Odisha	40.70	61.32	+20.62
Madhya Pradesh	23.88	42.85	+18.97



Himachal Pradesh	21.05	37.42	+16.37
Andaman & Nicobar Is.	30.27	45.72	+15.45
Tripura	22.95	34.67	+11.72
Nagaland	36.92	48.55	+11.63
Haryana	48.37	57.70	+9.33
Jharkhand	37.52	46.22	+8.70
Punjab	21.78	29.80	+8.02
Uttarakhand	52.92	59.60	+6.68
Meghalaya	15.35	21.20	+5.85
Ladakh	26.87	32.13	+5.27
Chhattisgarh	39.00	43.52	+4.52
Jammu & Kashmir	26.83	31.17	+4.33
Maharashtra	28.47	32.75	+4.28
Arunachal Pradesh	12.80	16.72	+3.92
Manipur	19.03	22.75	+3.72
West Bengal	11.38	14.30	+2.92
Karnataka	25.67	27.57	+1.90
Rajasthan	43.12	43.18	+0.07
Dadra & N.H. and Daman & Diu	58.75	57.53	-1.22
Goa	48.60	45.93	-2.67
Gujarat	55.30	50.18	-5.12
Sikkim	34.47	28.70	-5.77
Chandigarh	29.98	23.62	-6.37
Kerala	45.90	39.08	-6.82
Puducherry	51.22	44.40	-6.82
Delhi	47.58	37.75	-9.83
Andhra Pradesh	69.73	56.00	-13.73
Lakshadweep	37.38	13.70	-23.68
Tamil Nadu	66.85	42.73	-24.12

Note. Change = Gap 2025-26 minus Gap 2022-23. Positive values indicate widening; negative values indicate narrowing.

Figure 4. Distribution of State/UT-Level Change in the Access–Enablement Gap, 2022–23 to 2025–26.



Taken together, the descriptive, inferential, associative, and distributional analyses provide complementary evidence without blurring the distinction between infrastructure and pedagogical processes, which are not part of the empirical scope of the present study.

5. Discussion

The findings demonstrate a consistent but uneven pattern of digital development in India's school education. There has been significant growth in foundational digital access from 2022–23 to 2025–26, whereas institutional pedagogical enablement has also grown but at a substantially slower rate compared to the former. This has led to an increase in the Access–Enablement Gap (AEG), which constitutes the main empirical result of this study. The findings indicate that, despite the increase in digital infrastructure, there has not been an equivalent increase in pedagogical infrastructure within institutions. Instead of portraying digital transformation as the single accumulation of technological resources, the findings suggest that the different dimensions of infrastructural development can progress at different rates. This is a key point since the overall progress in access could be accompanied by uneven provision of institutional conditions for pedagogical technology use. This is consistent with the multidimensionality of school digital transformation and technology integration beyond basic access (Badmus et al., 2026).

The temporal persistence of IPE is a second major finding. The very high correlation between the provision of IPE in 2022–23 and 2025–26 reveals substantial temporal persistence in the relative positions of States/UTs amid overall growth. This does not mean that there was no growth in enablement but rather that the differences across States and UTs changed more slowly than the overall level of IPE provision. Therefore,



this finding distinguishes between absolute growth and temporal persistence, which is important to consider when analysing the digital development of the entire system. It is compatible with the literature that emphasizes the dependence of digital educational content and teaching-related capacity on experience built up over time (Bekker et al., 2026), and the uneven distribution of enabling factors for teachers (Shatri et al., 2026). Thus, increases in provision should be assessed alongside persistent cross-jurisdictional differences rather than interpreted as evidence of uniform institutional development.

The divergence between declining variation in access and persistent variation in enablement provides a better explanation of the multidimensional nature of school digital transformation. A decrease in variability in access does not necessarily mean convergence across all dimensions of infrastructure. Related dimensions can develop at the same time but at various rates, leading to progress in one dimension together with differentiation in another. This supports an interpretation of digital transformation as multidimensional rather than as a unidimensional process of transitioning from a situation of technological shortage to a situation of technological abundance. Such an approach is especially significant when technologies become increasingly dependent on institutional and professional conditions for their pedagogical use (Yoon et al., 2026). Accordingly, assessment of digital development should consider basic digital infrastructure as well as institutionally oriented technological conditions that support pedagogically relevant activities.

State/UT heterogeneity further qualifies the aggregate national pattern. The largest AEG widenings occurred where increases in access were accompanied by smaller increases in enablement, with the increase in enablement being less pronounced. On the other hand, several States/UTs reported narrowing AEGs. Hence, the national average is an aggregate trend that does not necessarily represent the trajectory of every State/UT. This trend is consistent with empirical evidence that technology diffusion in resource-scarce areas often occurs faster than the necessary institutional development required for its educationally meaningful use (Ahiaku et al., 2025). Nevertheless, this study does not explain the specific reasons why particular State/UT trajectories differ. The results of the regression analysis support this view: access remained positively associated with enablement, but the percentage of cross-sectional variance in IPE explained by access dropped from 71.9% to 61.4%. The decline in R^2 suggests that access accounted for a smaller share of cross-sectional variation in IPE in 2025–26, indicating that other factors may also contribute to differences in enablement, although these factors were not examined in this study.

For digital-divide research, the findings extend attention from foundational access toward institutional conditions conceptually positioned between access and pedagogical use of technology. It must be noted that the results do not imply that IPE should be treated as yet another phase of the digital divide phenomenon. On the contrary, they highlight a different dimension and show how access and institutionally oriented enablement can grow in separate ways. Concerning the literature on digital capacity in education, the results offer longitudinal evidence from the State/UT level that digital development should not be captured by the provision



of devices and connectivity alone. In recent studies on artificial intelligence competencies, the same pattern is evident: educational technology needs more than just access (Altamimi & Al-Hajja'a, 2026). This distinction allows researchers to examine digital development in education without equating infrastructure with technology use, teacher skills, pedagogical integration, and outcomes.

The contribution of the study remains deliberately bounded by its data and unit of analysis. Since the indicators pertain to institutional infrastructure and not classroom practices, they cannot provide conclusions about whether the technologies were actually used or whether they were helpful for students' learning. Their effective use also depends partly on the competence of teachers, which is not captured by administrative infrastructure indicators (Amemasor et al., 2025). Also, there is some evidence that professional development architecture supports sustained digital reform (El-Hamamsy et al., 2024). The State/UT-level design adopted in the study limits any inference and causal explanation at the individual or school level. Future studies need to link administrative infrastructure indicators with data on technology use by schools, teachers, and students.

Overall, the findings indicate that assessment of school digital development should take into account not only digital access but also pedagogical enablement in institutions as separate dimensions of the infrastructural base of educational digital transformation. This allows national and State/UT trajectories to be understood more precisely without presupposing that the infrastructure automatically leads to classroom usage. Moreover, it serves as the starting point for further analysis of whether institutional differences in enablement translate into differences in subsequent technology usage and pedagogical integration once more data become available. All in all, the research reveals that digital transformation can develop through different but related infrastructural pathways. The rate and distribution of institutional enablement can thus be viewed as one dimension of national educational digital development, while the connection between enablement, technology usage, teacher skills, and pedagogical integration remains to be explored empirically.

6. Limitations and Future Research

Several limitations delimit interpretation of the findings. First, the State/UT unit of analysis supports inference about inter-State/UT patterns but not inference at the level of individual schools, teachers, or students. Second, the operationalisation of institutional pedagogical enablement through infrastructure indicators represents enabling conditions, not actual technology use, pedagogical integration, teacher or student competence, or learning outcomes. Third, the descriptive design does not allow causal relationships to be established. The Access–Enablement Gap represents an empirical indicator constructed for comparison purposes and is not a latent construct or a comprehensive measure of digital inequality. The four-year period provides continuous evidence but remains relatively short. The use of UDISE+ definitions and administrative data precluded the use of indicators whose comparability across years could not be validated. Equal weighting



of indicators may affect the magnitude of the indicator, although alternative weighting schemes may produce differences in its magnitude.

Future research should extend the framework using school-, teacher-, and student-level evidence to examine technology use, pedagogical integration, professional competence, and educational outcomes. A mixed-method design utilising measures from administrative infrastructural reports and school-level practice data can be used to test the proposed conceptual pathway rather than assuming the pathway and to determine the institutional characteristics associated with sustained enablement gaps. Additional UDISE+ longitudinal data will allow for better modelling of trends and examination of the conditions under which enablement–access gaps widen or narrow. Additionally, future research should consider alternative definitions, weighting schemes, and indicators to assess measurement robustness. Such an expansion will improve interpretability by distinguishing between infrastructural development and implementation processes, as well as by determining whether State/UT trends persist across different cycles and contexts of education without exceeding the current boundaries of the evidence base.

7. Conclusion

This study examined whether the expansion of basic digital access corresponds to a corresponding increase in institutional pedagogical enablement in Indian schools. Using UDISE+ data for the period 2022–23 to 2025–26 covering all 36 States/UTs, the findings show that digital access grew at a faster rate than enablement. While digital access increased by 14.92 percentage points, enablement increased by 7.93 percentage points, resulting in a 7.00-percentage-point increase in the Access–Enablement Gap. The gap increased in 25 out of 36 States/UTs, and enablement showed substantial persistence. These findings indicate that expansion of basic digital infrastructure should not be considered equivalent to expansion of the institutional environment that can facilitate pedagogically oriented use of technology. Digital transformation in schooling should thus be perceived as a multidimensional phenomenon where an expansion of basic access and institutionally oriented enablement could occur at different rates. The results also show that progress at an aggregate national level can exist simultaneously with differentiation across States/UTs, underscoring the necessity of considering both absolute and relative changes in digital development.

The study contributes an institutional enablement perspective to the measurement of digital transformation in schools through the distinction between digital access and the infrastructure geared towards the use of pedagogical technologies. This contribution is limited in scope since the paper does not measure technology use, pedagogical integration, competencies, or learning outcomes. Rather, this paper offers longitudinal State/UT-level evidence on access and enablement as two distinct dimensions of infrastructure development.



Overall, the findings support a differentiated understanding of school digital transformation. Future measurement and monitoring of school digital development should go beyond whether schools have basic access to technology and also consider whether institutional conditions for pedagogically appropriate technology use are developing alongside it. Whether such enablement translates into sustained classroom use of technology needs to be tested in future studies.

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