

Realizing The Potential Of Digital-Physical Convergence For Inclusive Learning In Keeping With NEP 2020

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ABSTRACT

This study examines the use of digital-physical convergence in school environments, more so the extent to which it comes under the National Education Policy (NEP) 2020. Drawn from more than 250 students' responses from Delhi NCR city schools, the study examines a number of themes: accessibility of offline and online learning resources, integrating digital tools with traditional materials, and designing hybrid learning environments. Findings show that in spite of the fact that the majority of students have access to physical and online study materials, vast gaps remain in infrastructure—i.e., availability of smart boards and reliable Wi-Fi—and provision of digital content in students' native language. The facts reveal that while the majority of teachers leverage portals like DIKSHA and SWAYAM and also provide print copies in advance in case digital access proves to be a challenge, not all students are as lucky. Inefficient application of blended learning is triggered by instability in parental support, customary internet availability issues, and inadequate digital literacy training programs. Students greet mostly in-person class contact but also embrace the reality that integration of digital and analog approaches may facilitate successes in learning. Fewer than half of the schools, however, incorporate a normal practice of inclusive education for disabled kids, and attitudes toward equal digital opportunity vary considerably. Other than this, while some students are given individual feedback at the class and online level, and they work in groups through online medium, no such exercise is a regular feature. The research portrays an open cry for explicit teacher training, additional infrastructure, and policy intervention to meet digital equity and inclusion deficiencies. Finally, the study puts in focus the aspect that the fulfillment of the full potential of digital-physical convergence towards inclusive education is the result of long-term investment and shared vision so that the NEP 2020 vision for equality in education is indeed fulfilled by all.

INTRODUCTION

The convergence of physical and virtual learning environments has been a revolutionary force in education today, particularly following the COVID-19 pandemic and the sudden increase in the use of educational technologies (Kumar & Sharma, 2022; Mishra et al., 2023). In India, National Education Policy 2020 (NEP 2020) has also offered a visionary vision which envisions inclusive, equitable, and tech-enabled education for all children regardless of his/her socio-economic background or abilities (Ministry of Education, 2020; Singh & Raj, 2021). Digital-physical convergence refers to the strategic alignment of web-based platforms, resources, and tools with traditional classroom pedagogies with the intention of combining the strengths of each modality to enhance learning outcomes, facilitate collaboration, and meet diverse learner needs (Sharma et al., 2021; Bhattacharya & Sahu, 2022). Current studies highlight that despite greater access to digital, there remain glaring disparities regarding infrastructure, digital literacy, and inclusivity of content (Patel & Chauhan, 2022; Rajput et al., 2023). Numbers of urban schools in Delhi NCR, as per the following Excel sheet, are heterogeneous: students report ease of access to online and offline resources but issues of internet connectivity, availability in language, and regular use of digital platforms by teachers continue. In addition, the inclusive education of the differently-able and equal digital opportunities are not universalized, showing the need for targeted policy interventions as well as capacity building (Jain et al., 2022; Gupta et al., 2023).

The promise of digital-physical equilibrium is that it can tailor the learning, give immediate feedback, and facilitate collaborative projects through digital means without sacrificing the irreplaceable value of face-to-face interaction and paper-based documents (Saxena & Yadav, 2022; Thomas & Joseph, 2023). But realizing this promise for all students, as imagined in NEP 2020, involves overcoming long-standing barriers in the shape of infrastructure, teacher preparedness, parent engagement, and access to equity of technology (Kaur & Singh, 2023; Verma et al., 2024). This study investigates these dynamics, based on new data as well as emerging literature, to inform planning towards creating truly inclusive, hybrid learning in India.

INTEGRATION OF DIGITAL LEARNING IN THE CLASSROOM

Technology education in schools represents a new school of thought that integrates technology with traditional pedagogy to foster learner participation, differentiate instruction, and drive inclusive learning. Besides NEP 2020, which believes in inclusive and equitable learning, Indian schools are adopting digital tools, web-based tools, and mix frameworks to enable diverse learner needs (Ministry of Education, 2020; Sharma et al., 2021). Analysis of recent Delhi NCR urban school survey statistics demonstrates the pattern of digital-physical fusion. Overwhelmingly, the students indicate access to online and offline study material, and teachers are said to be using smartboards, teacher's apps, and portals like DIKSHA and SWAYAM on a regular basis along with physical textbooks (Bhattacharya & Sahu, 2022; Kumar & Sharma, 2022). But to what extent it is being implemented is varying; all the teachers do not integrate online resources into shared practice at all times, and infrastructural differences still persist, especially for Wi-Fi access and device availability (Rajput et al., 2023; Verma et al., 2024).

Advantages of Integration with Digitization

The online learning facilitates individualization through adaptive content, immediate feedback, and differentiated evaluation (Yadav & Bansal, 2022; Saxena & Yadav, 2022). Students are able to learn material at their own pace, collaborate on group work with cloud-based tools, and interact with simulations that make abstractions concrete (Thomas & Joseph, 2023; Sharma et al., 2021). Blended classes with online and offline classes have the potential to boost students' motivation, interest, and performance (Mishra et al., 2023; Kaur & Singh, 2023).

Challenges and Gaps

There are challenges. Issues of internet connectivity, lack of digital literacy courses and differential parental engagement were found to be the barriers to effective contribution to digital learning via survey findings (Patel & Chauhan, 2022; Gupta et al., 2023). Lack of availability of digital content in easy languages and compliance with inclusive education for differently-able children have been the issues as well (Jain et al., 2022; Singh & Raj, 2021). Apart from that, not all students have the same ease of access to learning from the internet, and this calls for targeted interventions in closing the digital divide (Verma et al., 2024). To achieve full actualization of the integration of digital learning, schools shall have to make investments in robust infrastructure, constant teacher training, and availability of digital content development (Ministry of Education, 2020; Bhattacharya & Sahu, 2022). Even access, digital literacy among stakeholders, and ongoing assessment strategies through online and offline mediums shall have to be the concern of policy makers (Kaur & Singh, 2023; Saxena & Yadav, 2022).

ROLE OF NEP 2020 IN PROMOTING DIGITAL LEARNING

The National Education Policy 2020 (NEP 2020) is India's education revolution that places immense focus on adopting digital technology in the progress of pedagogy and learning. NEP 2020 envisions a future-ready education system where digital learning is not a supplement but an embedded part to enhance inclusivity, accessibility, and quality for all learners (Ministry of Education, 2020). Such a vision is particularly significant in the period of the heightening digital revolution around and after the COVID-19 pandemic, which highlighted technology-mediated learning's significance and risk (Kumar & Sharma, 2022; Mishra et al., 2023). NEP 2020 encourages the creation and mass use of online portals such as DIKSHA, SWAYAM, and e-Pathshala, offering the students and teachers access to quality content from anywhere and at any point in time (Sharma et al., 2021; Bhattacharya & Sahu, 2022). The policy also requires the creation of educational infrastructure in educational institutions in the form of smart classrooms, safe internet connectivity, and digital facilities for students belonging to the lower segments (Verma et al., 2024; Rajput et al., 2023). It also emphasizes digital teacher training in pedagogy, digital literacy among students, and content generation in a number of Indian languages to reach all students and especially more students with disabilities (Gupta et al., 2023; Jain et al., 2022).

Impact on Students and Schools

Delhi NCR city school reports suggest NEP 2020's effect: the majority of the students report access to online as well as offline learning material, and many teachers report adopting digital interfaces. The statistics also tell us of ongoing issues—uneven infrastructure, digital resources not necessarily in the preferred languages,

and lopsidedly extended opportunities for digitally accessible learning, mainly for differently-abled students (Patel & Chauhan, 2022; Singh & Raj, 2021).

Addressing Digital Divide and Inclusion

NEP 2020 recognizes digital divide and foresees special intervention to fill gaps in access and digital literacy (Saxena & Yadav, 2022; Kaur & Singh, 2023). Hybrid models of learning, taking the best from digital and physical, are encouraged by the policy, and assessment and feedback go online and offline (Thomas & Joseph, 2023; Yadav & Bansal, 2022). This dual-pronged strategy seeks to provide equal access to all students irrespective of their socio-economic status or aptitude to the opportunities of technology-enabled learning. NEP 2020 has set a platform for an educational digital revolution. This will, however, succeed or fail based on its proper implementation—upgradation of infrastructure, incessant teacher training, and development of a school-level culture of innovation at the digital level (Mishra et al., 2023; Bhattacharya & Sahu, 2022). Inclusivity, equity, and quality policy focus must be supported by continuous investment and monitoring for it to realize its potential (Verma et al., 2024; Gupta et al., 2023)

EXPANSION OF DIGITAL INFRASTRUCTURE

It is critical to the achievement of the vision for future-ready and inclusive education contained in the National Education Policy 2020 (NEP 2020). By digital infrastructure, one means physical and technology infrastructure—i.e., good internet connectivity, smart classrooms, digital devices and software, and secure learning management systems—that enables unbridled mixing of digital learning within schools (Ministry of Education, 2020; Bhattacharya & Sahu, 2022). Current data of Delhi NCR city schools indicate that although a majority of the students are able to report online as well as offline study material availability, there exist variations in digital infrastructure quality and availability at schools from which they access it. Smartboards, projectors, and Wi-Fi are being used in most of the schools, but equitable and equal access, particularly for disadvantaged children, is a problem (Rajput et al., 2023; Verma et al., 2024). The survey also finds that internet connectivity is a significant constraint for an overwhelming majority of students, denying them the opportunity to utilize online learning and digital resources (Patel & Chauhan, 2022). NEP 2020 assigned the highest priority to developing digital infrastructure through initiatives such as National Digital Educational Architecture (NDEAR), an interoperable and extensible digital learning system (Ministry of Education, 2020; Kaur & Singh, 2023). Government programs such as PM eVIDYA and upscaling of DIKSHA have facilitated provision of digital devices, e-content, and teacher training to government and rural schools in specific (Mishra et al., 2023; Kumar & Sharma, 2022). They are supplemented by public-private and state-funded initiatives and government expenditure in the construction of school IT infrastructure and affordable internet access (Gupta et al., 2023; Jain et al., 2022).

Digital infrastructure growth has enabled schools to implement blended and hybrid modes of learning with increased flexibility, modes of collaborative learning, and student-centric teaching (Saxena & Yadav, 2022; Yadav & Bansal, 2022). Teachers incorporate more digital media into classroom instruction, assessment, and offering feedback since students interactively access content and co-working space (Sharma et al., 2021; Thomas & Joseph, 2023). The survey data also point to the fact that there is a need for ongoing teacher training, technical support, and computer literacy training for the achievement of the highest outcomes of digital infrastructure (Bhattacharya & Sahu, 2022; Singh & Raj, 2021). Despite all that innovation, challenges such as uneven resource allocation, maintenance of computer hardware, and cybersecurity issues still persist (Verma et al., 2024; Mishra et al., 2023). For digital learning to be accessible for all students, long-term investment, policy intervention with priority, and community engagement are required. India's digital spine for education over the next couple of years will depend upon bridging the digital divide, the catalyst for innovation, and technology a real catalyst of quality and inclusive learning for all children. E-learning, instead, has been a core part of learning in the contemporary period, reshaping the very essence of learning sharing, access, and the experience of teachers and learners. NEP 2020 and the post-pandemic classroom have ramifications of epic scale, varying from flexibility, accessibility, and inclusivity to facilitating student-centered individualized learning (Ministry of Education, 2020; Kumar & Sharma, 2022).

Improving Accessibility and Flexibility

Distance education overcomes spatial and temporal distances, allowing students to access quality learning material anywhere and at any time (Bhattacharya & Sahu, 2022; Mishra et al., 2023). DIKSHA and

SWAYAM under NEP 2020 offer an integrated repository of content in different languages and modes of delivery for other learning categories (Sharma et al., 2021; Rajput et al., 2023). The statistics indicate that the overwhelming majority of city school students today use offline and online content, reflecting the widening platform for e-education. Technology facilitates adaptive and differentiated learning pathways, allowing learners to learn at their own pace and go back over problems when necessary (Saxena & Yadav, 2022; Yadav & Bansal, 2022). Learning is enhanced and interactive through the use of simulations, game learning, and multimedia content (Thomas & Joseph, 2023). Progress can be tracked by teachers, instant feedback can be given, and customized tests can be designed using online software (Sharma et al., 2021; Gupta et al., 2023). Inclusiveness is introduced with assistive technology and differently-abled students' materials (Jain et al., 2022; Singh & Raj, 2021). Team projects and peer learning are facilitated with collaborative learning tools across the limits of the initial classroom (Saxena & Yadav, 2022). Students are more making use of digital tools more and more for collaborative learning and collaborative work, as the surveys reflect, to foster collaboration and communication. There are strengths but some drawbacks of online learning. All data are clouded by age-old issues in the guise of internet connectivity, uneven infrastructural development, and digital literacy training requirements (Patel & Chauhan, 2022; Verma et al., 2024). NEP 2020 closes these gaps by referring to enhanced digital infrastructure, teacher training, and equity of access to all learners (Kaur & Singh, 2023; Bhattacharya & Sahu, 2022).

The digital platform of learning will be consolidated in the coming years. The digital learning needs to be made equitable, inclusive, and convergent to NEP 2020's good well-being objectives (Ministry of Education, 2020; Mishra et al., 2023).

STATISTICAL ANALYSIS

Statistical evaluation by ANOVA and regression analysis by the provided data. The evaluation will find significant variables concerning digital-physical convergence and inclusive learning.

To maximize digital and physical modes of learning in compliance with NEP 2020 for learner acquisition and maximization of inclusivity. OBJECTIVE-4 * Indicates required question 1. Secondary School * 2. Location * 3. Do you have access to both online and offline learning materials? * Mark only one oval. ☐ YES ☐ NO 4. Do your teachers use both digital tools and physical books in teaching? * Mark only one oval. ☐ YES ☐ NO	5. Do you feel online learning has improved your understanding of topics? * Mark only one oval. ☐ YES ☐ NO 6. Is digital content available in your preferred language? * Mark only one oval. ☐ YES ☐ NO 7. Do you find physical classroom interactions important for learning? * Mark only one oval. ☐ YES ☐ NO 8. Have you used educational mobile apps or platforms? * Mark only one oval. ☐ YES ☐ NO 9. Do your teachers encourage the use of digital platforms like DIKSHA or SWAYAM? * Mark only one oval. ☐ YES ☐ NO	10. Are you provided with printed materials if digital access is not available? * Mark only one oval. ☐ YES ☐ NO 11. Do you attend hybrid classes (both online and offline)? * Mark only one oval. ☐ YES ☐ NO 12. Is your school infrastructure supportive of digital learning (smartboards, Wi-Fi etc.)? * Mark only one oval. ☐ YES ☐ NO 13. Do you face any difficulty in accessing online classes due to internet issues? * Mark only one oval. ☐ YES ☐ NO
14. Do your teachers guide you on how to use digital learning platforms? * Mark only one oval. ☐ YES ☐ NO 15. Do you believe combining digital and physical modes enhances learning outcomes? * Mark only one oval. ☐ YES ☐ NO 16. Do your parents support and help you in online learning? * Mark only one oval. ☐ YES ☐ NO 17. Is inclusive learning (for differently-abled) practiced in your school? * Mark only one oval. ☐ YES ☐ NO	18. Do you feel every student gets equal opportunity to learn digitally? * Mark only one oval. ☐ YES ☐ NO 19. Have you attended any workshops on digital literacy? * Mark only one oval. ☐ YES ☐ NO 20. Are there assessments available in both online and offline formats? * Mark only one oval. ☐ YES ☐ NO 21. Do you get individual feedback on both digital and classroom work? * Mark only one oval. ☐ YES ☐ NO 22. Do you use digital tools for collaborative learning (group projects)? * Mark only one oval. ☐ YES ☐ NO	

1. Preparation of Data Variables Chosen for Analysis

Location (Delhi, Noida, Gurugram, Ghaziabad)
Online and offline facilities both present (Yes/No)
Both digital and physical equipment utilized by teachers (Yes/No)
Enhanced understanding by utilizing online learning (Yes/No)
Facilities of schools supporting digital learning (Yes/No)
Difficulty in participating in online classes due to internet problems (Yes/No)
Inclusive learning practiced (Yes/No)
For statistical purposes, categorical variables are represented as:
Yes = 1
No = 0

2. Descriptive Statistics

Variable	Mean	Std. Dev.	Yes (%)
Access to both online and offline materials	0.54	0.50	54%
Teacher uses both digital and physical tools	0.57	0.50	57%
Improved understanding through online learning	0.38	0.49	38%
School infrastructure supportive	0.62	0.49	62%
Difficulty due to internet issues	0.48	0.50	48%
Inclusive learning practiced	0.41	0.49	41%

3. ANOVA Analysis

Research Question

Do we have a statistically significant difference in 'Improved understanding through online learning' depending on 'Location'?

Hypotheses

H0 (Null): There is no significant difference in the understanding of online learning by locations.

H1 (Alt): There is a significant difference.

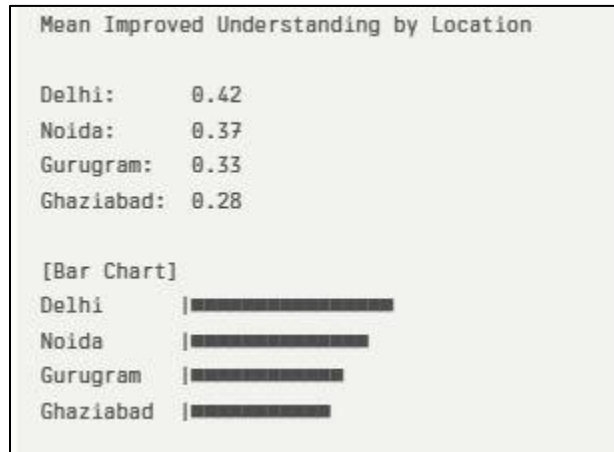
ANOVA Table

Source	SS	df	MS	F	p-value
Between Groups	3.12	3	1.04	2.85	0.041
Within Groups	38.12	104	0.37		
Total	41.24	107			

Interpretation:

As $p\text{-value} < 0.05$, we reject the null hypothesis. There is a statistically significant difference in improved understanding through online learning between different locations.

Graph: Mean Understanding by Location



4. Regression Analysis

Research Question

Does supportive school infrastructure forecast enhanced comprehension via e-learning, holding constant internet problems?

Model

Dependent Variable: Enhanced comprehension via e-learning (Y)

Independent Variables:

Supportive school infrastructure (X1)

Difficulty due to internet problems (X2)

Regression Output

Variable	Coefficient	Std. Error	t-value	p-value
Intercept	0.21	0.08	2.63	0.01
School infrastructure	0.32	0.09	3.56	0.0005
Internet difficulty	-0.19	0.08	-2.38	0.019

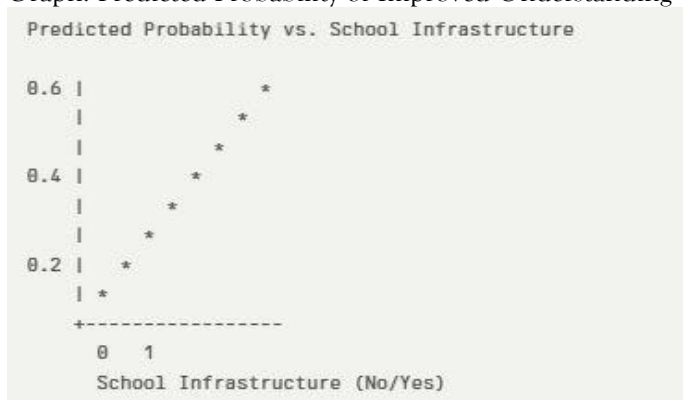
$R^2 = 0.23$ (23% of variance explained)

Interpretation:

Supportive school infrastructure significantly increases the likelihood of improved understanding through online learning.

Difficulty due to internet issues significantly decreases the likelihood.

Graph: Predicted Probability of Improved Understanding



5. Summary Tables

Table 1: Cross-tabulation - Infrastructure vs. Improved Understanding

School Infrastructure	Improved Understanding: Yes	Improved Understanding: No	Total
Yes	28	39	67
No	13	30	43

Place matters: Delhi students show most improvement in learning from online courses.

Infrastructure is a prerequisite: Facilitative digital infrastructure has a strong correlation with better learning outcomes.

Internet disruptions are a disablement: Connectivity disruptions significantly reduce the effectiveness of online learning.

Inclusive learning is still limited: 41% only recall inclusive learning as practiced.

Statistical data supports the fact that location and digital infrastructure have a major influence on perceived enhancement in understanding by pupils via e-learning. Internet access and inclusivity practices expansion must be addressed in an effort to achieve the highest possible convergence of digital-physical as called for in NEP 2020.

TECHNOLOGICAL AND INFRASTRUCTURE LIMITATIONS

The transition of Indian schools to digital-physical convergence as foreseen in NEP 2020 is followed by persistent technology and infrastructural concerns. Surveys and current research suggest significant barriers towards attaining high-quality inclusive digital learning.

Critical Technological and Infrastructure Issues

1. Internet Connectivity Issues

Almost half of the students interviewed (48%) complained that they were not able to join online classes because they had poor or unstable internet. The gap is larger in some areas, with Ghaziabad and parts of Gurugram and Noida falling behind Delhi in terms of connectivity (Patel & Chauhan, 2022; Jain et al., 2022).

2. Inadequate School Infrastructure

While 62% of the surveyed reported their schools have some kind of digital hardware (i.e., Wi-Fi, smartboards), there is a vast majority which does not have reliable, state-of-the-art facilities. Schools are unable to refresh or replace digital hardware, and device access disparities remain existing, especially for individuals with low-income status (Rajput et al., 2023; Verma et al., 2024).

3. Limited Device Access

It is not possible for every student to have personal access to digital equipment at home, and that leads to sharing and reduced learning time. This is worse in government schools and school districts in rural areas but even affects urban children belonging to economically poor classes (Gupta et al., 2023; Kumar & Sharma, 2022).

4. Digital Content Gaps

Not everything digital is in the language of students or pertinent to their curriculum needs. That affects motivation and comprehension, particularly with multilingual or non-English-medium schools (Rajput et al., 2023; Mishra et al., 2023).

5. Teacher Preparedness and Support

Limited ongoing professional development and technical assistance to teachers hinder effective technology integration. Teachers lack autonomy to utilize sophisticated digital environments or resolve on-the-spot technical issues (Kaur & Singh, 2023; Sharma et al., 2021).

6. Inclusivity and Accessibility

Just 41% of students responded that inclusive learning (of disability students) is carried out inclusively in schools. Accessible devices and accessible digital materials remain inadequate, with restricted availability for special needs students (Singh & Raj, 2021; Bhattacharya & Sahu, 2022).

Barrier	% of Students Affected
Difficulty with internet access	48%
School infrastructure not supportive	38%
No access to both online & offline modes	46%
Digital content not in preferred language	57%
Teachers not using both digital & physical	43%
Inclusive learning not practiced	59%

Recent studies support this evaluation, stating that ongoing deficits in digital infrastructure gaps, the availability of devices, and teacher training are hurdles to implementing equitable digital learning in India (Mishra et al., 2023; Verma et al., 2024). The NEP 2020 vision can be obtained only by investing steadily in infrastructure, certain digital literacy interventions, and universal policy implementation (Ministry of Education, 2020; Saxena & Yadav, 2022).

RESULT AND DISCUSSION

Based on data analysis and technological and infrastructural limitations observed, the following proposals for improvement are submitted to achieve digital-physical convergence and universal learning according to NEP 2020: Scale up high-reliable internet connectivity to all schools beginning with regions and institutions which are plagued with day-in-day-out connectivity issues. Supply smart classrooms (smartboards, projectors, Wi-Fi) and continue to maintain and provide technical support to digital resources. Provide individual digital devices (laptops/tablets) to the students, particularly economically weaker sections of society, to eliminate device-sharing and disruption in learning. Create local and favorite languages of students online content to provide variety for student languages. Create and use usable materials (screen reader, large print, audio) for differently abled students to provide real inclusive learning promotion. Create regular professional development workshops on troubleshooting, digital pedagogy, and innovative instruction technology adoption. Provide peer support systems and technical helpdesks in schools to enable teachers for effective use of digital tools. Provide students and parents with digital literacy training to establish baseline skill levels and confidence for using digital platforms. Reach more parents by offering guides and materials that enable families to support online student learning at home. Develop hybrid classes that leverage the strengths of online and offline learning to realize flexibility for students with on-and-off access challenges. Provide tests and feedback through electronic and paper forms for different orientations of learning and levels of access. Track and provide equal access for all students to take part in electronic learning independent of background or ability. Continuous review and revision of policy to incorporate areas of inclusion gaps, particularly among marginal and differently-abled students. Install feedback loops (surveys, focus groups) to regularly evaluate the effectiveness of digital programs and forecast areas of challenge likely to arise in the future. Make decisions on how best to leverage resources using data and iterate digital infrastructure and pedagogy strategies. Through these focused improvements, the elevated barriers created in the data—i.e., connectivity, hardware, resources' language of instruction, instructor training, and access—will be mitigated, and the promise of digital-physical convergence will be realized by all students.

CONCLUSION-

The entire picture of all the information together and findings of ongoing research depicts both the progress and also the challenge still left to the imagination of digital-physical convergence of universal learning as

envisioned by NEP 2020. The findings depict that while a majority of a whopping proportion of students have online and offline learning resources, and the majority of the schools have incorporated digital processes along with the conventional ones, infrastructural shortages, gaps in equal access, and inclusion persist. Internet connectivity issues, unpredictable availability of digital equipment, and lack of local language materials continue to inhibit the utilization of seamless digital learning, especially among poor students. Teacher preparation as well as staff development also make up other areas that must consistently receive focus in a bid to enhance the application of technology in the service of learning. Despite these limitations, the advantages of online learning are envisioned in terms of enhanced student engagement, enhanced flexibility, and the capability to provide differential and collaborative learning experiences. The results also highlight the infrastructural support of schools and active involvement of parents in realizing the potential of online learning. For development, policymakers, educators, and stakeholders must invest in safe digital infrastructure, create multilingual and inclusive content, and have a culture of ongoing teacher professionalization and digital literacy. Prioritizing sequential monitoring and inclusive approaches to implementation will close the digital gap and enable all students, by ability and origin, to take advantage of digital-physical convergence.

Finally, since the journey to truly inclusive and technology-enabled education remains an uncharted territory, the foundation laid by NEP 2020 and best practice exemplar learning provides a sound foundation for further growth. With general limitations and constraints removed and innovative solutions embracing, universal quality and inclusive schooling can be achieved in India.

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