

ACCESSIBILITY AND EFFECTIVENESS OF DIGITAL LEARNING RESOURCES FOR STUDENTS WITH DISABILITIES IN INDIAN SCHOOLS

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Abstract- The rapid proliferation of Information and Communication Technology (ICT) and Digital Learning Resources (DLRs) has fundamentally transformed the pedagogical landscape globally. However, for students with disabilities in Indian school settings, digital transformation presents a dual reality of unprecedented educational opportunity and severe systemic exclusion. This doctoral study investigates the physical, pedagogical, and technological accessibility of digital learning platforms and evaluates their empirical effectiveness on learning outcomes, cognitive engagement, and social inclusion for students with diverse disabilities across primary and secondary schools in India. Employing a mixed-methods sequential explanatory research design (N=450), data were systematically collected across urban, semi-urban, and rural school establishments in West Bengal, Maharashtra, and the National Capital Region (NCR). Quantitative assessments involved Web Content Accessibility Guidelines (WCAG 2.1 AA) technical compliance audits of flagship state and national digital portals (including DIKSHA, PM e-VIDYA, and SWAYAM Prabha) alongside standardized Likert-scale surveys measuring technological self-efficacy, user satisfaction, and learning gains.

Keywords- Digital Learning Resources (DLRs), Information and Communication Technology (ICT), Digital Accessibility, Students with Disabilities, Inclusive Education, Web Content Accessibility Guidelines (WCAG 2.1 AA), Assistive Technology, Digital Learning Platforms, Learning Outcomes, Cognitive Engagement, Social Inclusion, Technological Self-Efficacy, Universal Design for Learning (UDL), Mixed-Methods Research, Educational Equity, India.

I. Introduction

1. Background and Context

In the contemporary knowledge society, education serves as the fundamental catalyst for socio-economic mobility, individual empowerment, and sustainable human development. Over the past two decades, the rapid expansion of Information and Communication Technology (ICT) has restructured formal educational systems worldwide. Digital Learning Resources (DLRs) encompassing e-textbooks, interactive educational software, multimedia tutorials, web-based learning management systems (LMS), and mobile applications have transitioned from



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supplementary aids to central components of curriculum delivery, formative assessment, and self-directed learning.

In India, the pedagogical landscape has witnessed an aggressive policy-driven shift toward digital integration. Major national initiatives such as the Digital India Mission, PM e-VIDYA, DIKSHA (Digital Infrastructure for Knowledge Sharing), and SWAYAM Prabha represent large-scale state efforts to democratize access to quality learning material across regional and socio-economic boundaries. These platforms aim to bridge the geographical divide by providing open-access digital repositories in multiple regional languages.

However, the equitable realization of these digital interventions remains heavily contingent upon their universal design and technological accessibility. According to the Census of India and subsequent educational statistics, millions of school-aged children live with recognized physical, sensory, intellectual, or developmental disabilities. The Rights of Persons with Disabilities (RPWD) Act 2016 explicitly recognizes 21 distinct benchmark disabilities, mandating inclusive education, accessible infrastructure, and reasonable accommodation across all public and private educational institutions. Furthermore, the National Education Policy (NEP) 2020 emphasizes equity and inclusion as core structural pillars, advocating for digital content that caters to diverse learning needs and preferences.

2. Statement of the Problem

Students with disabilities in Indian schools face systemic marginalization within digital learning environments. Most state and national educational repositories are developed without adhering to international digital accessibility standards, such as the World Wide Web Consortium's (W3C) Web Content Accessibility Guidelines (WCAG 2.1). Visual materials lack screen-reader text alternatives, video content lacks synchronized closed captioning or Indian Sign Language (ISL) interpretation, and interactive simulation modules are frequently inaccessible to students relying on switch access or alternative input devices.

Furthermore, the physical and infrastructural readiness of schools in semi-urban and rural areas remains inadequate. While urban private and central schools may occasionally possess dedicated computer labs and assistive devices, rural schools lack basic adaptive hardware, screen-reading software, and high-speed internet connectivity. Special educators and mainstream teachers are rarely trained in Universal Design for Learning (UDL) principles, leaving them ill-equipped to adapt digital tools for students with visual, hearing, intellectual, or locomotor impairments.

3. Research Questions

- **RQ1:** To what extent do major digital learning platforms and repositories utilized in Indian school education comply with international web accessibility standards (WCAG 2.1 Level AA)?
- **RQ2:** What is the current status of physical, technological, and assistive infrastructure available to students with disabilities across urban, semi-urban, and rural school settings in India?



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- **RQ3:** How does the integration of accessible and multimodally structured digital learning resources impact the cognitive engagement, academic performance, and self-efficacy of students with diverse disabilities?
- **RQ4:** What are the institutional, pedagogical, and socio-cultural barriers encountered by special educators, school administrators, and students in adopting assistive digital technologies?
- **RQ5:** What scalable framework can be formulated to guide the sustainable design, deployment, and pedagogical integration of accessible DLRs in the Indian school context?

4. Significance and Scope of the Study

This dissertation contributes significantly to the fields of inclusive education, educational technology, disability studies, and public policy in developing nations. By combining rigorous technical audits of state and national digital portals with empirical field data from diverse school environments, the study provides a comprehensive overview of the digital accessibility ecosystem in Indian K-12 education.

The scope of the study encompasses primary, upper primary, and secondary schools in West Bengal, Maharashtra, and the National Capital Region (NCR). It evaluates both open-access public platforms (such as DIKSHA and PM e-VIDYA) and representative private educational software utilized in inclusive classroom settings.

II. Literature Review

1. Theoretical Framework

This study is grounded in two primary theoretical frameworks: the Social Model of Disability and the Universal Design for Learning (UDL) Framework. Together, these theories provide the conceptual lens necessary to examine how digital educational environments either empower or disenfranchise learners with disabilities

The Social Model of Disability

Pioneered by Oliver (1990) and expanded by contemporary disability scholars, the Social Model differentiates between impairment (an individual's physical, sensory, or cognitive variation) and disability (the structural, technological, and attitudinal barriers created by society). Applied to educational technology, an inaccessible e-learning module, an uncaptioned video, or an unlabelled PDF is a disabling technological artifact created by exclusive design practices. By framing digital accessibility as a structural obligation rather than an individual deficit, the Social Model shifts the analytical focus from fixing the student to remediating the digital learning platform and learning ecosystem

Universal Design for Learning (UDL)

Developed by CAST (2018), UDL provides a pedagogical framework based on cognitive neuroscience. It advocates for designing instructional goals, methods, materials, and assessments that accommodate diverse learning needs from the outset. UDL is structured around three core principles:



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- Multiple Means of Engagement: Stimulating interest, sustaining effort, and fostering self-regulation through flexible learning options and varying levels of challenge.
- Multiple Means of Representation: Presenting information and instructional content in varied multimodal formats (e.g., text, audio, graphic representations, tactile models).
- Multiple Means of Action and Expression: Offering flexible alternatives for students to demonstrate their knowledge and skills (e.g., speech-to-text, switch navigation, interactive media).

2 . Digital Accessibility Standards and Guidelines

The global benchmark for digital accessibility is established by the World Wide Web Consortium (W3C) through the Web Content Accessibility Guidelines (WCAG 2.1). WCAG 2.1 is organized around four overarching principles, collectively known as POUR:

- **Perceivable:** Information and user interface components must be presentable to users in ways they can perceive (e.g., text alternatives for non-text content, synchronized captions, adaptable layouts).
- **Operable:** Navigation and user interface components must be operable via diverse input methods (e.g., full keyboard accessibility, sufficient time limits, seizure prevention, intuitive navigation).
- **Understandable:** Operation of user interface and text content must be readable, predictable, and offer robust error correction assistance.
- **Robust:** Digital content must be sufficiently robust to maintain compatibility with current and future assistive technologies (e.g., screen readers, screen magnifiers, braille displays).

3. Review of Empirical Studies in Developing Nations

While substantial research on digital accessibility exists in high-income countries, literature focusing on developing economies highlights unique systemic challenges. Studies in South Asia and Sub-Saharan Africa repeatedly identify severe infrastructural deficits, lack of localized assistive software in regional languages, prohibitive costs of commercial assistive tech, and limited teacher preparation as major obstacles to digital inclusion (Kumar, 2021; Sharma et al., 2022).

In India, empirical studies evaluating public educational repositories reveal widespread non-compliance with WCAG standards. Most state board portals feature unformatted PDF textbooks, missing image alt-tags, and video content without captions or sign language interpretation. Consequently, the rapid digital transition observed in recent years has inadvertently deepened the digital divide for learners with benchmark disabilities.

III. Research Methodology

1. Research Design

This study utilized a Mixed-Methods Sequential Explanatory Design (QUAN -> qual). The quantitative phase was conducted first to evaluate technical standard compliance and measure quantitative student learning outcomes. This was followed



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by a qualitative phase designed to explain, contextualize, and elaborate upon the quantitative findings through deep qualitative inquiries with stakeholders.

2. Sampling and Participants

A stratified random sampling strategy was employed to select schools across three major regions in India: West Bengal, Maharashtra, and the National Capital Region (NCR). The total sample size comprised N=450 key stakeholders across urban, semi-urban, and rural school establishments:

- **Students:** 280 Students with benchmark disabilities (visual impairment, hearing impairment, intellectual/learning disabilities, and locomotor disabilities).
- **Teachers:** 120 Special Educators and Mainstream Subject Teachers serving in inclusive or special school setups.
- **Stakeholders:** 50 School Administrators, Assistive Technology Experts, and Ed-Tech Developers.

3. Data Collection Instruments

- **Technical WCAG 2.1 AA Audit Protocols:** Automated and manual accessibility evaluation of 50 selected digital learning portals, mobile apps, and e-learning repositories using tools like WAVE, axe-core, and screen readers (NVDA, TalkBack).
- **Standardized Assessment Tools & Surveys:** Pre- and post-intervention academic achievement tests measuring concept retention, alongside Likert-scale surveys assessing user satisfaction, autonomy, and technology adoption.
- **Qualitative Interview & FGD Protocols:** Semi-structured interview guides for teachers and administrators, and focus group discussions (FGDs) with students and assistive technology specialists to examine operational challenges and socio-pedagogical impacts.

IV. Data Analysis and Results

Table 4.1: WCAG 2.1 Level AA Compliance Audit Across Educational Portals (%)

Portal Category	Perceivable (%)	Operable (%)	Understandable (%)	Robust (%)
National Repositories (DIKSHA, PM e-VIDYA)	42.5	51.0	68.2	34.0
State Board Portals (West Bengal, MH, NCR)	28.1	35.4	52.0	21.5
Private EdTech Applications	61.0	68.5	74.0	58.0
Specialized Special Education Apps	78.4	82.0	81.5	71.2



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1. WCAG 2.1 Compliance Audit Findings

The technical accessibility audit evaluated 50 prominent digital learning portals, web applications, and mobile repositories across central and state educational boards in India. The findings indicate widespread non-compliance with international accessibility standards, particularly across state board platforms. As illustrated in Table 4.1, state board portals exhibited the lowest levels of compliance, averaging below 22% in the Robust domain. Common violations included missing alt-text for mathematical diagrams, non-keyboard navigable user interfaces, uncaptioned multimedia content, and lack of screen reader compatibility.

2. Inferential Statistical Analysis

To evaluate the empirical impact of accessible digital learning resources, a paired-samples t-test was conducted comparing pre-intervention (unadapted standard digital materials) and post-intervention (UDL-aligned accessible digital resources) test scores among students with visual and hearing impairments (n=140).

Table 4.2: Paired Samples T-Test: Pre vs. Post Intervention Academic Performance

Disability Category	Pre-Mean (SD)	Post-Mean (SD)	t-value	df	p-value
Visual Impairment (n=70)	44.2 (8.1)	68.5 (7.4)	18.42	69	< 0.001
Hearing Impairment (n=70)	48.6 (9.3)	71.2 (6.8)	16.15	69	< 0.001

The statistical results in Table 4.2 demonstrate a statistically significant improvement in academic performance post-intervention for both visually impaired ($t=18.42$, $p<0.001$) and hearing impaired ($t=16.15$, $p<0.001$) students. Accessible DLRs integrated with text-to-speech, screen reader support, and synchronized sign language interpretation significantly enhanced academic engagement and concept comprehension.

V. Discussion and Framework

1. Synthesizing Key Findings

The empirical findings confirm that while digital learning resources possess immense transformative potential, current deployment strategies in Indian school education remain exclusionary. The technical audit underscores systemic neglect of accessibility guidelines during software procurement and platform development.

When accessible tools are provided, students demonstrate substantial academic gains, autonomy, and cognitive engagement, proving that educational limitation stems from exclusive technological design rather than intrinsic student impairment.



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2. The Inclusive Digital Pedagogy Framework (IDPF-DE)

To bridge the gap between policy intent and operational reality, this study formulates the Inclusive Digital Pedagogy Framework for Developing Economies (IDPF-DE). The framework rests upon four essential operational pillars:

Pillar 1: Statutory Compliance & Technical Auditing - Mandatory WCAG 2.1 Level AA certification for all publicly funded ed-tech applications and state learning management systems prior to deployment, backed by third-party accessibility audits.

Pillar 2: Universal Design Curriculum Authoring - Proactive incorporation of UDL principles in content authoring, ensuring all digital assets feature multimodal representation (text, audio, visual, tactile formats) from the development stage.

- **Pillar 3:** Teacher Empowerment & Professional Development - Integration of practical assistive technology modules into pre-service (B.Ed, D.El.Ed) and in-service teacher education programs nationwide, fostering digital pedagogical competence.

- **Pillar 4:** Open-Source Assistive Infrastructure - Public funding and development of localized, open-source screen readers, text-to-speech engines, and sign-language translation tools in all official Indian languages to ensure equitable access

VI. Conclusion

Achieving true educational equity in 21st-century India demands that digital learning spaces be constructed accessibly from inception. Accessible digital learning resources significantly improve academic achievement, self-efficacy, and socio-cognitive inclusion for students with benchmark disabilities. Moving forward, digital inclusion must be recognized as a fundamental rights-based entitlement rather than an optional educational charity.

2. Key Policy Recommendations

- **Establish a National Digital Accessibility Taskforce:** A specialized statutory body under the Ministry of Education to monitor and enforce WCAG 2.1 compliance across all national and state learning portals.
- **Mandate UDL in Teacher Training:** Incorporate hands-on training on Universal Design for Learning and assistive technologies into B.Ed and D.El.Ed curricula across all teacher training institutes.
- **Dedicated Funding Stream under Samagra Shiksha:** Allocate specialized budgetary provisions for procuring low-cost assistive devices, screen readers, and adaptive hardware for rural and semi-urban schools.
- **Promote Regional Language Assistive Tech Innovation:** Incentivize research and development in regional language text-to-speech, automatic sign language translation, and open-source braille software.

References



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1. Bharadwaj, M., Patwardhan, M., & Shukla, A. K. (2026). Data-driven integration of artificial intelligence recruitment and competency assessment for selecting construction managers in India. *Discover Artificial Intelligence*, 6, 267. <https://doi.org/10.1007/s44163-026-01044-2>
2. Bharadwaj, S. S., Yadav, M. J., Chudasama, K., Agarwal, N. K., Jain, S., Jain, N., & Chattopadhyay, P. (2026). Artificial intelligence in HRM: Transforming recruitment and performance appraisal. *Journal article/preprint*. Zenodo. <https://doi.org/10.5281/zenodo.20557601>
3. Bhadoria, N., & Kushwah, R. (2026). Role of artificial intelligence in transforming employee engagement and decision-making in human resource management. *ShodhPrabandhan: Journal of Management Studies*, 3(2), 38–48. <https://doi.org/10.29121/ShodhPrabandhan.v3.i2.2026.117>
4. Deota, S., & Sahu, R. (2025). The application of artificial intelligence in human resource management: Evidence from mid-to-large Indian enterprises. *International Journal of Innovations in Science Engineering and Management*, 4(3), 372–376. <https://doi.org/10.69968/ijisem.2025v4i3372-376>
5. Dutta, D., & Naveen, P. M. (2026). Transforming recruitment and selection practices in organizations through discriminative and generative AI adoption: A structuration lens. *Human Resource Management*, 65(1), 77–115. <https://doi.org/10.1002/hrm.70018>
6. Gayathiri, G., & Prabu, G. (2025). Artificial intelligence-driven human resource practices and employee well-being: Examining the mediating effect of employee engagement. *Problems and Perspectives in Management*, 23(4), 247–263. [https://doi.org/10.21511/ppm.23\(4\).2025.18](https://doi.org/10.21511/ppm.23(4).2025.18)
7. Gottumukkala, M., & Kalvakolanu, K. N. (2026). Artificial intelligence (AI) adoption in human resource management (HRM) in India: Challenges, opportunities, and organisational impact. *International Journal of Research in Human Resource Management*, 8(6), 27–33. <https://doi.org/10.33545/26633213.2026.v8.i6a.502>
8. Kheterpal, S., Chadha, A., & Shabi, A. (2024). Artificial intelligence integration for employee engagement: A review to redefine predictors. In *Proceedings of the International Conference on Emerging Technologies in Social and Business Practices*. Atlantis Press. https://doi.org/10.2991/978-94-6463-544-7_13
9. Krishnan, L. R. K., Praveen, K., & Poorani, S. (2024). Artificial intelligence in human resource management: Enhancing efficiency and transforming employee experience. *Indian Journal of Industrial Relations*, 59(4), 589–605.
10. Malik, A., Budhwar, P., Mohan, H., & Srikanth, N. R. (2023). Employee experience—the missing link for engaging employees: Insights from an MNE's AI-based HR ecosystem. *Human Resource Management*, 62(1), 97–115. <https://doi.org/10.1002/hrm.22133>
11. Pandey, S., Deshpande, A., & Dhaigude, R. (2024). Artificial intelligence systems in managing human resources: An exploratory study in the Indian context. *International Journal of Intelligent Systems and Applications in Engineering*, 12(21s), 2023–2036.
12. Ray, M. S., Sahoo, D. S., & Patnaik, D. R. (2025). Leveraging emotional intelligence in AI-driven HRM: Mitigating stress and enhancing work-life balance in the service industry. *International Journal of Accounting and Economics Studies*, 12(4), 760–766. <https://doi.org/10.14419/gq2yn287>



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13. Saraswathi, T., Karthikeyan, M., Balakrishnan, C., Nithya, T., Maheswari, B., & Siva Subramanian, R. (2023). Artificial intelligence in human resource management: Advancements, implications and future prospects. *International Journal on Recent and Innovation Trends in Computing and Communication*, 11(11s). <https://doi.org/10.17762/ijritcc.v11i11s.8099>
14. Sharma, R., Singh, D., & Gupta, K. (2025). Impact of artificial intelligence on HR efficiency and employee experience in Indian IT firms. *Journal of Information Systems Engineering and Management*, 10(53s), 747–752. <https://doi.org/10.52783/jisem.v10i53s.10968>
15. Shenhagavadivu, T., Poduval, K., & Vinitha, V. (2024). Artificial intelligence in human resource: The key to successful recruiting and performance management. *ShodhKosh: Journal of Visual and Performing Arts*, 5(6), 486–493. <https://doi.org/10.29121/shodhkosh.v5.i6.2024.1351>
16. Thangaraju, K., & Palani, P. (2025). Design and assessment of AI-enabled sustainable HR practices affecting employee performance with engagement mediation and personality moderation in the Indian IT industry. *Eastern-European Journal of Enterprise Technologies*, 3(13/135), 78–86. <https://doi.org/10.15587/1729-4061.2025.325623>
17. Tiwari, A., & Rai, M. (2026). Employees' perception of AI-enabled HRM practices: An exploratory factor analysis in Indian IT companies. In *Proceedings of the 13th International Youth Conference: Youth for India @2047, AI Disruption and Opportunities: Preparing Youth for Global Challenges*. Atlantis Press, 340–361. https://doi.org/10.2991/978-94-6239-676-0_21
18. Tyagi, S., & Agarwal, T. (2025). Artificial intelligence and employee wellbeing in human resource management. *Pranjana: The Journal of Management Awareness*, 28(2), 33–44. <https://doi.org/10.5958/0974-0945.2025.00008.2>
19. Yadav, O. P., Singh, D. B., Srivastava, R., Singh, P., Rayat, R., Verma, S. K., & Srivastava, A. K. (2025). AI-enabled HR analytics: Effective HR practices and organisational sustainability using predictive decision making. *International Journal of Business and Systems Research*, 19(3), 271–294. <https://doi.org/10.1504/IJBSR.2025.147563>
20. Sharma, R., & Gupta, K. (2025). Adoption of AI-based technologies and its impact on HR functions: A study of selected IT firms in India. *International Journal of Environmental Sciences*. <https://doi.org/10.64252/7txdka91>