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Parental Perceptions and Effectiveness of Home-Based Digital Interventions for Children with Specific Learning Disabilities

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ABSTRACT

This mixed-methods study examined parental perceptions and the effectiveness of home-based digital interventions for children with Specific Learning Disabilities (SLD) across selected districts of Delhi and Haryana. The research investigated 387 parents from Gurugram, Rohtak, Sonipat, Karnal, South-West Delhi, and South Delhi through quantitative surveys and qualitative interviews. Results indicated significant positive correlations between parental engagement levels and perceived intervention effectiveness ($r = 0.68$, $p < 0.001$), with notable regional variations in accessibility and implementation challenges. The study revealed that 72% of parents reported moderate to high satisfaction with digital interventions, though concerns regarding screen time, technical literacy, and professional guidance emerged as persistent barriers. Findings contribute to understanding the socio-cultural factors influencing digital intervention adoption in the National Capital Region and provide implications for educational policy and practice.

Keywords: Specific Learning Disabilities, Digital Interventions, Parental Perceptions, Home-Based Learning, Mixed-Methods Research, NCR Region

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INTRODUCTION

Specific Learning Disabilities (SLD) represent a significant educational concern affecting approximately 5-15% of school-aged children globally (American Psychiatric Association, 2013). In India, the prevalence of SLD ranges between 10-15%, with dyslexia, dysgraphia, and dyscalculia being the most commonly identified conditions (National Institute of Mental Health and Neurosciences, 2019). The National Capital Region (NCR), encompassing Delhi and surrounding Haryana districts, has witnessed increasing awareness regarding SLD identification and intervention, particularly following the implementation of the Rights of Persons with Disabilities Act (2016).

The COVID-19 pandemic accelerated the adoption of digital learning platforms, creating unprecedented opportunities and challenges for children with SLD. Home-based digital interventions emerged as alternative or supplementary educational strategies, placing parents in increasingly prominent roles as facilitators of their children's learning (Singh & Agarwal, 2021). However, the effectiveness of these interventions remained largely dependent on parental perceptions, technological literacy, socioeconomic factors, and available support systems.

Theoretical Framework

This study was grounded in three interconnected theoretical frameworks. First, Vygotsky's Sociocultural Theory (1978) emphasized the role of social interaction and cultural tools—including digital technologies—in cognitive development. This framework was particularly relevant for understanding how parental mediation influenced children's learning experiences with digital interventions. Second, Bronfenbrenner's Ecological Systems Theory (1979) provided a lens for examining the multiple environmental layers affecting intervention implementation, from immediate family dynamics (microsystem) to broader socioeconomic and cultural contexts (exosystem and macrosystem). Third, the Technology Acceptance Model (Davis, 1989) informed our understanding of factors influencing parental adoption and sustained use of digital intervention tools, including perceived usefulness and ease of use.

Context of the Study

The research was conducted across six districts in the NCR: Gurugram, Rohtak, Sonipat, and Karnal in Haryana, and South-West Delhi and South Delhi in the National Capital Territory. These regions represented diverse socioeconomic profiles, ranging from highly urbanized

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Volume 4, Issue 4, December, 2025, pp 203-229

areas with substantial IT infrastructure (Gurugram, South Delhi) to semi-urban and transitioning districts (Rohtak, Sonipat, Karnal). This geographical diversity enabled examination of how contextual factors influenced the adoption and perceived effectiveness of home-based digital interventions.

Previous research in the Indian context had documented challenges including limited awareness about SLD, insufficient special education resources, and stigma associated with learning disabilities (Karande & Kulkarni, 2005). However, gaps existed in understanding parental experiences with digital interventions specifically, particularly in the post-pandemic educational landscape where technology-mediated learning became increasingly normalized.

Significance of the Study

Understanding parental perceptions was crucial because parents served as primary implementers of home-based interventions and their attitudes significantly influenced intervention fidelity and child outcomes (Hoover-Dempsey & Sandler, 1997). This study addressed several critical gaps: documenting the types and patterns of digital intervention usage in the NCR, identifying perceived barriers and facilitators to implementation, examining relationships between parental variables and intervention outcomes, and exploring regional variations in access and effectiveness.

RESEARCH OBJECTIVES

Based on the identified gaps and theoretical framework, three primary research objectives guided this investigation:

Objective 1: To assess the relationship between parental demographic characteristics (education level, socioeconomic status, technological literacy) and their perceptions of home-based digital intervention effectiveness for children with SLD.

Objective 2: To examine the correlation between parental engagement levels in digital interventions and reported improvements in children's academic performance and learning confidence across different types of SLD (dyslexia, dysgraphia, dyscalculia).

Objective 3: To identify and compare region-specific barriers and facilitators to implementing home-based digital interventions across the six selected districts of Delhi and Haryana.

RESEARCH DESIGN

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

This study employed a convergent parallel mixed-methods design (Creswell & Plano Clark, 2018), wherein quantitative and qualitative data were collected simultaneously, analyzed independently, and subsequently integrated to provide comprehensive insights. This approach was selected because neither quantitative nor qualitative methods alone could adequately capture the complexity of parental perceptions and intervention effectiveness.

The quantitative component utilized a cross-sectional survey design to gather numerical data on parental perceptions, engagement patterns, and perceived outcomes across a large sample. This enabled statistical analysis of relationships between variables and generalization of findings across the target population. The qualitative component employed semi-structured interviews with a purposively selected subsample to explore nuanced experiences, contextual factors, and explanatory mechanisms underlying the quantitative findings.

Integration occurred at multiple stages: during research question formulation (addressing complementary aspects), data collection (concurrent timing), and interpretation (comparing and contrasting findings). This integration enhanced the validity and comprehensiveness of conclusions through methodological triangulation.

RESEARCH METHODOLOGY

Population and Sampling

The target population comprised parents of children diagnosed with SLD residing in the six selected districts. Children were aged between 6-14 years, had received formal SLD diagnosis from qualified professionals (educational psychologists or developmental pediatricians), and had utilized home-based digital interventions for at least three months prior to data collection.

A multi-stage sampling strategy was employed. First, districts were purposively selected to represent geographical and socioeconomic diversity within the NCR. Second, within each district, schools and special education centers were identified through the State Education Department databases and disability organizations. Third, parents were recruited through schools, special education centers, parent support groups, and online SLD communities using stratified random sampling to ensure proportional representation across districts.

The initial target sample was 500 participants; however, after excluding incomplete responses and participants not meeting inclusion criteria, the final analytical sample consisted of 387

parents (response rate: 77.4%). Sample distribution was: Gurugram (n=78, 20.2%), Rohtak (n=61, 15.8%), Sonipat (n=58, 15.0%), Karnal (n=52, 13.4%), South-West Delhi (n=71, 18.3%), and South Delhi (n=67, 17.3%).

For the qualitative component, purposive sampling identified 42 parents who demonstrated diverse perspectives based on preliminary survey analysis. Selection criteria included variation in intervention satisfaction levels, child's SLD type, socioeconomic background, and geographical location.

Research Instruments

Quantitative Instrument: A structured questionnaire was developed through extensive literature review and expert consultation with five special educators and two psychologists specializing in SLD. The instrument comprised five sections:

1. **Demographic Information** (10 items): Parents' age, education, occupation, income, family structure, and child's SLD characteristics.
2. **Digital Intervention Usage Pattern** (12 items): Types of applications/platforms used, frequency of use, duration, devices utilized, and support resources accessed.
3. **Parental Perception Scale** (18 items): Assessed perceptions regarding intervention effectiveness, usability, engagement, and appropriateness using a 5-point Likert scale (1=Strongly Disagree to 5=Strongly Agree). Cronbach's alpha demonstrated good internal consistency (α=0.86).
4. **Parental Engagement Inventory** (15 items): Measured frequency and quality of parental involvement in digital intervention activities using a 5-point frequency scale. Reliability coefficient was α=0.82.
5. **Perceived Outcomes Checklist** (16 items): Parents rated observed changes in children's academic skills, learning confidence, motivation, and behavioral aspects.

The questionnaire underwent pilot testing with 45 parents not included in the final sample. Based on feedback, language was simplified, items were reworded for clarity, and estimated completion time was reduced to 25-30 minutes.

Qualitative Instrument: A semi-structured interview guide containing 12 open-ended questions explored: experiences with digital interventions, decision-making processes for

selecting tools, implementation challenges, and perceived changes in child's learning, support needs, and suggestions for improvement. Interview duration ranged from 35-60 minutes.

DATA COLLECTION PROCEDURES

Data collection occurred between September 2023 and February 2024. Ethical clearance was obtained from the institutional review board, and necessary permissions were secured from school authorities and special education centers.

Parents were approached through multiple channels: school principals shared information with eligible families, special education centers displayed recruitment notices, and online parent forums posted study announcements. Interested parents contacted the research team and received detailed information sheets explaining the study purpose, voluntary participation, confidentiality assurances, and right to withdraw.

After obtaining informed consent, parents chose to complete the survey either online (Google Forms) or through paper-and-pencil format based on their preference and comfort. Research assistants, trained in ethical protocols and disability-sensitive communication, were available for clarification. Survey completion occurred individually, typically at parents' homes or convenient locations.

Qualitative interviews were conducted after survey completion. Participants selected interview mode (face-to-face or telephone) and preferred language (Hindi or English). All interviews were audio-recorded with permission and transcribed verbatim. Hindi interviews were transcribed in Hindi and subsequently translated to English by bilingual researchers.

Data Analysis

Quantitative Analysis: Data were analyzed using SPSS Version 26.0. Preliminary analysis included descriptive statistics (frequencies, percentages, means, and standard deviations) to characterize the sample and variable distributions. Data were checked for normality using Kolmogorov-Smirnov tests and visual inspection of histograms.

For Objective 1, Pearson correlation coefficients and multiple regression analysis examined relationships between demographic variables and perception scores. Analysis of variance (ANOVA) compared perception scores across educational and income categories.

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

For Objective 2, Pearson correlation analyzed associations between engagement levels and perceived outcomes. Independent samples t-tests and ANOVA compared outcomes across SLD types. Chi-square tests examined categorical associations.

For Objective 3, ANOVA and post-hoc tests (Tukey HSD) compared barrier and facilitator ratings across districts. Thematic coding categorized open-ended survey responses.

Qualitative Analysis: Interview transcripts were analyzed using thematic analysis following Braun and Clarke's (2006) six-phase approach: familiarization, initial coding, theme development, theme review, theme refinement, and report writing. Two researchers independently coded 25% of transcripts, achieving inter-rater reliability of Cohen's kappa = 0.78. NVivo 12 software facilitated data organization and theme identification.

Integration: Findings were integrated through side-by-side comparison tables, joint displays showing convergence and divergence, and narrative weaving where qualitative themes elaborated quantitative patterns.

Results and Statistical Analysis

Demographic Characteristics

Table 1 presents the demographic profile of participating parents and their children.

Table 1: Demographic Characteristics of Participants (N=387)

Variable	Category	Frequency	Percentage
Respondent	Mother	268	69.3%
	Father	119	30.7%
Parental Education	Below Graduate	87	22.5%
	Graduate	176	45.5%
	Postgraduate	124	32.0%
Monthly Family Income	Below ₹30,000	94	24.3%
	₹30,000-₹60,000	168	43.4%

ISSN NO: 2583-7842 (Online)
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Volume 4, Issue 4, December, 2025, pp 203-229

	Above ₹60,000	125	32.3%
Child's Age	6-9 years	189	48.8%
	10-14 years	198	51.2%
Type of SLD	Dyslexia	221	57.1%
	Dysgraphia	98	25.3%
	Dyscalculia	68	17.6%
School Type	Government	132	34.1%
	Private	255	65.9%

Interpretation: The sample predominantly consisted of mothers (69.3%), reflecting the traditional primary caregiving roles in Indian families. Educational qualifications showed diversity, with 45.5% holding graduate degrees and 32% postgraduate qualifications, indicating relatively educated participant pool. Income distribution revealed that 43.4% belonged to middle-income categories, consistent with the socioeconomic profile of NCR regions. Dyslexia was the most commonly reported SLD type (57.1%), aligning with national prevalence patterns. The higher representation from private schools (65.9%) suggested better SLD identification and intervention access in private educational institutions.

DIGITAL INTERVENTION USAGE PATTERNS

Table 2 summarizes the types and patterns of digital interventions utilized by families.

Table 2: Digital Intervention Usage Patterns

Parameter	Categories	Frequency	Percentage
Primary Device	Smartphone	198	51.2%
	Tablet	112	28.9%
	Laptop/Computer	77	19.9%

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

Daily Usage Duration	Less than 30 minutes	134	34.6%
	30-60 minutes	189	48.8%
	More than 60 minutes	64	16.5%
Type of Applications	Reading/Literacy apps	287	74.2%
	Math learning apps	176	45.5%
	Multisensory apps	152	39.3%
	Educational games	223	57.6%
Parental Supervision	Always present	241	62.3%
	Sometimes present	128	33.1%
	Minimal supervision	18	4.6%

Interpretation: Smartphones emerged as the predominant device (51.2%), likely due to affordability and widespread availability. Most parents (48.8%) maintained moderate daily usage duration of 30-60 minutes, reflecting attempts to balance intervention benefits with screen time concerns. Reading and literacy applications showed highest usage (74.2%), corresponding with dyslexia being the most common SLD type. High parental supervision rates (62.3% always present) indicated that parents recognized the importance of guided technology use, though this also reflected concerns about independent usage by children with learning challenges.

OBJECTIVE 1: RELATIONSHIP BETWEEN DEMOGRAPHIC CHARACTERISTICS AND PERCEPTIONS

Table 3: Correlation Between Parental Characteristics and Perception Scores

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

Variable	Perception Score		Correlation Coefficient (r)	p-value
	Mean	SD		
Parental Education Level			0.42**	<0.001
Below Graduate	3.18	0.74		
Graduate	3.56	0.68		
Postgraduate	3.89	0.59		
Monthly Income			0.38**	<0.001
Below ₹30,000	3.22	0.71		
₹30,000-₹60,000	3.54	0.66		
Above ₹60,000	3.81	0.62		
Technological Literacy			0.51**	<0.001
Low (Score 1-2)	2.98	0.77		
Moderate (Score 3)	3.48	0.64		
High (Score 4-5)	3.92	0.56		

*Note: *$p < 0.01$; Perception scores ranged from 1-5*

Statistical Analysis and Interpretation:

Pearson correlation analysis revealed significant positive relationships between all three demographic variables and perception scores. Parental education level demonstrated a moderate positive correlation ($r = 0.42$, $p < 0.001$), suggesting that higher educational qualifications were associated with more favorable perceptions of digital intervention effectiveness. One-way ANOVA confirmed significant differences across education groups, $F(2, 384) = 28.64$, $p < 0.001$. Post-hoc Tukey tests indicated that postgraduate parents rated

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

interventions significantly higher than both graduate ($p < 0.01$) and below-graduate parents ($p < 0.001$).

Monthly family income showed a moderate positive correlation ($r = 0.38$, $p < 0.001$) with perception scores. ANOVA results were significant, $F(2, 384) = 22.17$, $p < 0.001$, with higher-income families reporting more positive perceptions. This relationship likely reflected better access to quality applications, devices, and supplementary support services.

Technological literacy exhibited the strongest correlation ($r = 0.51$, $p < 0.001$), indicating that parents comfortable with technology perceived interventions more positively. ANOVA showed highly significant differences, $F(2, 384) = 42.89$, $p < 0.001$. Parents with high technological literacy scored significantly higher than moderate ($p < 0.001$) and low literacy groups ($p < 0.001$).

Hypothesis Testing for Objective 1:

H_1: There is a significant positive relationship between parental demographic characteristics and perceived effectiveness of digital interventions.

Decision: The null hypothesis was rejected. Statistical analyses confirmed significant positive correlations between parental education ($r = 0.42$, $p < 0.001$), income ($r = 0.38$, $p < 0.001$), technological literacy ($r = 0.51$, $p < 0.001$), and perception scores. Multiple regression analysis indicated that these three variables collectively explained 37.2% of variance in perception scores ($R^2 = 0.372$, $F(3, 383) = 75.94$, $p < 0.001$), with technological literacy emerging as the strongest predictor ($\beta = 0.33$, $p < 0.001$), followed by education level ($\beta = 0.24$, $p < 0.001$) and income ($\beta = 0.18$, $p < 0.01$).

OBJECTIVE 2: PARENTAL ENGAGEMENT AND CHILD OUTCOMES

Table 4: Correlation Between Parental Engagement and Perceived Child Outcomes

Outcome Measure	Mean	SD	Correlation with Engagement (r)	p-value
Academic Performance	3.64	0.82	0.68**	<0.001
Learning Confidence	3.71	0.76	0.72**	<0.001

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

Motivation to Learn	3.58	0.81	0.64**	<0.001
Frustration Levels (reduction)	3.42	0.88	0.59**	<0.001
Overall Improvement	3.67	0.79	0.71**	<0.001

*Note: *$p < 0.01$; All scales ranged from 1-5*

Table 5: Perceived Outcomes by SLD Type

SLD Type	**Academic Performance**		**Learning Confidence**		**Overall Improvement**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Dyslexia (n=221)	3.72	0.79	3.78	0.72	3.74	0.76
Dysgraphia (n=98)	3.58	0.84	3.65	0.79	3.61	0.81
Dyscalculia (n=68)	3.42	0.88	3.54	0.82	3.49	0.84
F-value	4.26*		3.18*		3.67*	
p-value	0.015		0.043		0.026	

*Note: $p < 0.05$

Statistical Analysis and Interpretation:

Pearson correlation analyses revealed strong positive relationships between parental engagement levels and all measured child outcome variables. The strongest correlation emerged with learning confidence ($r = 0.72$, $p < 0.001$), suggesting that active parental involvement significantly enhanced children's self-belief in their learning abilities. Academic performance showed substantial correlation ($r = 0.68$, $p < 0.001$), indicating that higher engagement was associated with greater perceived academic improvements.

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

Comparative analysis across SLD types revealed significant differences. Parents of children with dyslexia reported the highest improvement scores across all outcome measures. ANOVA confirmed significant differences in academic performance ($F(2, 384) = 4.26$, $p = 0.015$), learning confidence ($F(2, 384) = 3.18$, $p = 0.043$), and overall improvement ($F(2, 384) = 3.67$, $p = 0.026$). Post-hoc analyses indicated that dyslexia outcomes significantly exceeded dyscalculia outcomes ($p < 0.05$), possibly reflecting greater availability of literacy-focused digital tools compared to mathematics interventions.

Linear regression analysis examined engagement as a predictor of overall improvement, controlling for SLD type, child's age, and intervention duration. Results showed that engagement significantly predicted improvement ($\beta = 0.61$, $p < 0.001$), explaining 48.3% of variance ($R^2 = 0.483$, $F(4, 382) = 89.27$, $p < 0.001$).

Hypothesis Testing for Objective 2:

H_2: There is a significant positive correlation between parental engagement levels in digital interventions and reported improvements in children's academic performance and learning confidence.

Decision: The null hypothesis was rejected. Statistical evidence strongly supported the hypothesis, demonstrating significant positive correlations between engagement and academic performance ($r = 0.68$, $p < 0.001$) and learning confidence ($r = 0.72$, $p < 0.001$). The strength of these relationships indicated that parental involvement was a critical factor in intervention success. Additionally, engagement predicted outcomes across different SLD types, though with varying magnitudes, suggesting universal importance of parental participation while acknowledging intervention-specific and disability-specific variations.

OBJECTIVE 3: REGIONAL VARIATIONS IN BARRIERS AND FACILITATORS

Table 6: Region-wise Comparison of Perceived Barriers (Mean Scores)

Barrier	Gurugram (n=78)	Rohtak (n=61)	Sonipat (n=58)	Karnal (n=52)	SW Delhi (n=71)	S Delhi (n=67)	F-value	p-value

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD		
Internet connectivity issues	2.18	1.02	3.67	0.89	3.52	0.95	3.81	0.87	2.34	1.06	2.21	1.01	38.72**	<0.001
Cost of applications	2.64	1.12	3.89	0.82	3.76	0.91	3.92	0.78	2.78	1.08	2.56	1.14	28.46**	<0.001
Lack of professional guidance	3.72	0.94	4.12	0.76	4.08	0.81	4.18	0.71	3.68	0.97	3.54	1.02	8.94**	<0.001
Technical literacy challenges	2.89	1.08	3.94	0.84	3.78	0.92	4.02	0.79	3.12	1.04	2.98	1.11	18.32**	<0.001
Screen time concerns	3.98	0.86	4.18	0.72	4.12	0.78	4.21	0.68	4.02	0.84	3.89	0.91	2.18	0.056

*Note: *$p < 0.01$; Scale: 1=Not a barrier to 5=Major barrier*

Table 7: Facilitators Across Regions (Percentage Reporting as Important)

Facilitator	Gurugram	Rohtak	Sonipat	Karnal	SW Delhi	S Delhi	χ^2	p-value
Affordable/free apps	68.2%	88.5%	86.2%	90.4%	71.8%	65.7%	28.64**	<0.001

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

Hindi language support	71.8%	93.4%	91.4%	94.2%	76.1 %	73.1 %	32.17**	<0.001
Teacher guidance	82.1%	75.4%	77.6%	71.2%	83.1 %	85.1 %	7.42	0.192
Peer parent networks	65.4%	54.1%	56.9%	51.9%	67.6 %	70.1 %	11.28*	0.046
Flexible timing	89.7%	86.9%	84.5%	88.5%	91.5 %	90.0 %	3.21	0.667

*Note: **p < 0.01, *p < 0.05*

Statistical Analysis and Interpretation:

Significant regional variations emerged in perceived barriers. Internet connectivity issues were rated significantly higher in Haryana districts (Rohtak: M=3.67, Sonipat: M=3.52, Karnal: M=3.81) compared to Delhi regions (Gurugram: M=2.18, SW Delhi: M=2.34, S Delhi: M=2.21), $F(5, 381) = 38.72$, $p < 0.001$. Post-hoc tests confirmed that all three Haryana districts (excluding Gurugram) significantly differed from Delhi regions ($p < 0.001$), reflecting infrastructure disparities.

Application costs presented greater barriers in semi-urban regions (Rohtak: M=3.89, Karnal: M=3.92) versus urban areas (S Delhi: M=2.56), $F(5, 381) = 28.46$, $p < 0.001$. This pattern suggested income-based accessibility challenges in less urbanized districts.

Interestingly, lack of professional guidance emerged as a universal barrier across all regions (overall M=3.89, SD=0.91), with no significant regional differences in certain comparisons, though Haryana districts reported slightly higher concerns. This finding highlighted systemic inadequacies in special education support services throughout the NCR.

Technical literacy challenges showed significant variation, $F(5, 381) = 18.32$, $p < 0.001$, with Karnal (M=4.02) and Rohtak (M=3.94) parents reporting greatest difficulties. Screen time concerns remained consistently high across all regions (overall M=4.07), with no significant

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

differences ($F(5, 381) = 2.18$, $p = 0.056$), indicating universal parental anxiety about technology exposure.

Chi-square analyses revealed significant regional differences in facilitator importance. Affordability of applications was rated significantly more important in Haryana districts ($\chi^2(5) = 28.64$, $p < 0.001$), with Karnal showing highest emphasis (90.4%). Hindi language support demonstrated similar patterns ($\chi^2(5) = 32.17$, $p < 0.001$), particularly crucial in Rohtak (93.4%) and Karnal (94.2%), reflecting linguistic preferences in non-metropolitan areas.

Hypothesis Testing for Objective 3:

H_3: Significant regional differences exist in perceived barriers and facilitators to implementing home-based digital interventions across the six selected districts.

Decision: The null hypothesis was rejected. Statistical analyses confirmed significant regional variations in multiple barriers including internet connectivity ($F = 38.72$, $p < 0.001$), application costs ($F = 28.46$, $p < 0.001$), and technical literacy ($F = 18.32$, $p < 0.001$). Chi-square tests showed significant differences in facilitator importance, particularly for affordability ($\chi^2 = 28.64$, $p < 0.001$) and language support ($\chi^2 = 32.17$, $p < 0.001$). These findings demonstrated that contextual factors—including infrastructure, socioeconomic conditions, and cultural-linguistic preferences—substantially influenced intervention implementation experiences across the NCR.

QUALITATIVE FINDINGS

Thematic analysis of 42 interviews yielded five major themes that complemented and enriched quantitative findings.

Theme 1: Technology as a "Double-Edged Sword"

Parents consistently described digital interventions using contradictory language, recognizing both benefits and concerns. One mother from Sonipat explained: *"The app helps my son practice reading without feeling pressured like in school. But I worry—is he spending too much time on screens? Will it affect his eyes, his concentration?"*

This ambivalence reflected broader societal tensions regarding technology's role in children's lives, intensified by concerns specific to children with learning disabilities who already faced attention and processing challenges.

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

Theme 2: The Quest for Professional Validation

Despite positive experiences, parents expressed persistent uncertainty about intervention appropriateness. A father from Rohtak stated: *"I see improvements, but I don't know if we're doing the right exercises. We need experts to tell us—is this app suitable for his type of dyslexia? Are we using it correctly?"*

This theme underscored the gap between technology availability and professional guidance, leaving parents feeling isolated in decision-making responsibilities.

Theme 3: Regional Digital Divide

Stark contrasts emerged in access experiences. A Gurugram mother shared: *"We have excellent internet, I can afford premium apps, and there are many special educators nearby for consultations."* Conversely, a Karnal parent described: *"Internet disconnects frequently, especially during rains. Free apps are limited, and we've never met a special educator—only heard about them."*

These narratives illustrated how geographical and socioeconomic contexts created vastly different intervention landscapes, even within the relatively small NCR region.

Theme 4: Empowerment Through Understanding

Many parents described how digital interventions enhanced their understanding of their child's learning patterns. A mother from South Delhi explained: *"The app shows exactly where he struggles—specific letter combinations, particular number operations. I finally understand his dyslexia instead of just knowing he has it."*

This metacognitive benefit extended beyond direct skill building, transforming parents from passive observers to informed advocates.

Theme 5: Community as Catalyst

Parents emphasized the importance of peer networks. A South-West Delhi mother noted: *"Our WhatsApp group of SLD parents is invaluable. We share which apps work, how to solve technical problems, and emotionally support each other. Without them, I would have given up."*

This finding highlighted the role of informal social capital in sustaining intervention efforts, particularly where formal support systems were inadequate.

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

DISCUSSION

DISCUSSION OF OBJECTIVE 1: DEMOGRAPHIC INFLUENCES ON PERCEPTIONS

The significant positive relationships between parental education, income, technological literacy, and intervention perceptions aligned with existing literature on technology adoption and educational engagement (Hoover-Dempsey & Sandler, 1997; Selwyn, 2004). Higher educational qualifications likely equipped parents with better skills to evaluate intervention quality, navigate digital platforms, and support children's learning metacognitively. The strong correlation with technological literacy ($r = 0.51$) suggested that comfort with technology was not merely a technical skill but a critical mediating factor in recognizing and actualizing intervention potential.

These findings held important implications for equity in special education. If intervention effectiveness was partially contingent on parental characteristics, children from less-educated or lower-income families might experience compounded disadvantages. This pattern resonated with Bronfenbrenner's ecological framework, wherein family-level resources (microsystem) interacted with broader socioeconomic structures (exosystem) to shape educational opportunities.

However, the moderate effect sizes indicated that demographic factors explained only 37.2% of perception variance, suggesting other unmeasured variables—such as intervention quality, child responsiveness, professional support, and prior educational experiences—also played substantial roles. Qualitative data enriched understanding by revealing that education and income influenced not just perceptions but actual access to resources, professional consultations, and higher-quality applications.

Interestingly, some parents with lower formal education but high technological literacy reported positive experiences, suggesting that targeted digital literacy programs might mitigate educational disadvantages. This finding offered optimistic directions for intervention—rather than accepting demographic constraints as fixed, strategic capacity-building could democratize access to effective digital tools.

ISSN NO: 2583-7842 (Online)
Gateway International Journal of Innovative Research
Volume 4, Issue 4, December, 2025, pp 203-229

DISCUSSION OF OBJECTIVE 2: PARENTAL ENGAGEMENT AND CHILD OUTCOMES

The strong positive correlations between parental engagement and child outcomes (r = 0.68-0.72) provided compelling evidence that parental involvement was not merely supplementary but central to intervention success. This finding strongly supported Vygotsky's sociocultural theory, wherein parents served as "more knowledgeable others" who scaffolded children's interaction with digital tools, mediated learning experiences, and provided emotional support that enhanced motivation and reduced frustration.

The particularly strong relationship with learning confidence (r = 0.72) was noteworthy. Children with SLD often experienced years of academic struggles, leading to learned helplessness and negative self-perceptions (Lackaye & Margalit, 2006). Engaged parental involvement appeared to counteract these patterns by providing consistent encouragement, celebrating small improvements, and reframing challenges as surmountable obstacles. Qualitative interviews revealed that parents who actively participated offered real-time feedback, adjusted difficulty levels, and connected digital activities to everyday contexts—practices that enhanced transfer and generalization.

The differential outcomes across SLD types merited consideration. Higher improvement ratings for dyslexia compared to dyscalculia might reflect the current landscape of available interventions. Literacy applications had proliferated following decades of reading research and phonics-based intervention development, whereas mathematics learning disability interventions remained less developed (Butterworth & Kovas, 2013). This gap suggested that technological solutions had not equally addressed all SLD types, potentially disadvantaging children with dyscalculia.

Alternatively, measurement artifacts might have influenced results. Parents might more readily observe reading improvements through tangible indicators (word recognition, reading fluency) compared to mathematical reasoning, which involved abstract concepts less visible in daily life. Future research employing standardized assessments rather than parental reports could clarify whether differences reflected actual outcome disparities or perceptual biases.

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Volume 4, Issue 4, December, 2025, pp 203-229

The engagement-outcome relationship also raised questions about directionality. While the study hypothesized that engagement improved outcomes, reverse causation was plausible—positive child responses might have motivated sustained parental engagement. Likely, bidirectional relationships existed wherein initial engagement yielded small improvements, reinforcing continued involvement, creating positive feedback loops. Longitudinal designs could disentangle these temporal dynamics.

DISCUSSION OF OBJECTIVE 3: REGIONAL VARIATIONS AND SYSTEMIC INEQUITIES

Regional variations in barriers starkly illustrated how macro-level infrastructure and policy decisions shaped micro-level family experiences. Internet connectivity problems in semi-urban Haryana districts reflected broader digital divide issues plaguing India despite rapid technological advancement (Bhatia & Pathak-Shelat, 2017). Children in Karnal and Rohtak faced double jeopardy—having learning disabilities and residing in regions with inadequate digital infrastructure. This inequity violated the inclusive education principles enshrined in the Rights of Persons with Disabilities Act (2016), which mandated equal educational opportunities regardless of location.

The cost barrier patterns revealed economic stratification effects. While numerous free applications existed, parents often found these inadequate for specialized SLD needs, necessitating premium paid applications. In lower-income regions, this created access barriers, potentially exacerbating existing educational inequalities. The finding that affordability emerged as a significantly greater concern in Haryana districts underscored how regional economic profiles intersected with special education access.

Language emerged as an unexpected but critical factor. The significant importance of Hindi support in Haryana districts (90%+ parents) revealed that English-dominant applications, while globally available, created linguistic accessibility barriers. This finding resonated with India's linguistic diversity and debates regarding medium of instruction (Mohanty, 2017). For children with SLD who already struggled with language processing, being forced to use interventions in non-native languages potentially compounded difficulties. Developers' predominant focus on English-language tools reflected global market dynamics but failed to serve India's multilingual reality.

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The universal concern about professional guidance shortage—spanning all regions—pointed to systemic special education workforce inadequacies. India faced severe shortages of trained special educators, educational psychologists, and SLD specialists (Singal, 2016). Parents described feeling abandoned to navigate complex intervention decisions without expert support, leading to anxiety and reduced confidence. This gap suggested that technological solutions alone were insufficient; effective implementation required robust professional ecosystems providing assessment, recommendation, training, and ongoing consultation services.

Intriguingly, screen time concerns showed no regional variation, suggesting universally shared anxieties about technology's impact on children. This finding reflected broader cultural tensions as traditional parenting values encountered digital realities. For children with SLD, screen time concerns created particular dilemmas—digital interventions offered valuable learning opportunities, yet excessive use might exacerbate attention difficulties or reduce time for physical activities and social interactions. Parents struggled to balance these competing considerations, often without clear guidelines.

The qualitative theme of community support as a facilitator highlighted how informal networks compensated for formal system inadequacies. Parent support groups, particularly those organized through WhatsApp and Facebook, provided practical advice, emotional validation, and collective problem-solving. This finding resonated with social capital theory (Coleman, 1988), wherein community relationships served as resources enabling goal achievement. However, reliance on informal networks raised equity concerns—parents without access to such communities remained isolated.

INTEGRATION OF FINDINGS AND THEORETICAL IMPLICATIONS

Integrating quantitative and qualitative findings through the theoretical frameworks yielded several insights. Vygotsky's sociocultural theory was validated through evidence that learning occurred not through isolated child-technology interaction but through mediated, socially situated processes. Effective implementation required parents to serve as cultural and cognitive mediators, translating technological affordances into meaningful learning experiences tailored to children's needs and family contexts.

Bronfenbrenner's ecological systems theory illuminated how multiple environmental layers influenced outcomes. At the microsystem level, family dynamics and parent-child interactions shaped intervention fidelity. The mesosystem level revealed connections between home and school—parents who received school-based guidance implemented interventions more effectively. Exosystem factors including regional infrastructure, economic conditions, and healthcare systems determined access and quality. Macrosystem influences—cultural beliefs about disability, technology, and education—shaped acceptance and utilization patterns.

The Technology Acceptance Model required contextual adaptation. While perceived usefulness and ease of use influenced adoption, additional factors emerged as critical in this population: perceived appropriateness for SLD type, confidence in independent usage, and alignment with cultural parenting values. The model's individualistic orientation needed supplementation with collectivist considerations, given that intervention decisions involved family systems and community networks rather than isolated parental choices.

LIMITATIONS

Several limitations warranted acknowledgment. First, the cross-sectional design precluded causal inferences. While correlations between engagement and outcomes were documented, experimental or longitudinal designs would more definitively establish causality and rule out confounding variables. Second, reliance on parental self-reports introduced potential biases. Parents might have over-reported positive outcomes due to social desirability or justified their time investments by emphasizing improvements. Future studies incorporating objective assessments (standardized tests, teacher reports, direct observation) would strengthen validity. Third, the sample, while geographically diverse, might not fully represent the target population. Recruitment through schools and special education centers potentially excluded families without formal SLD diagnosis or those disengaged from institutional support systems. Children from the most marginalized communities—rural areas, lower castes, extreme poverty—were likely underrepresented. Fourth, the study examined digital interventions broadly without differentiating specific application characteristics, pedagogical approaches, or technological features that might differentially influence effectiveness.

Fifth, the three-month minimum usage criterion, while establishing some sustained engagement, might have been insufficient to observe longer-term impacts or developmental

trajectories. Some interventions might show delayed effects or require extended implementation before benefits emerged. Finally, the study did not examine child perspectives directly. Understanding children's own experiences with digital interventions—their preferences, frustrations, and perceived benefits—would provide crucial complementary insights.

CONCLUSION

This mixed-methods investigation provided comprehensive insights into parental perceptions and effectiveness of home-based digital interventions for children with SLD in the Delhi-Haryana NCR context. Three primary conclusions emerged, aligned with the research objectives.

First, parental demographic characteristics—particularly technological literacy, education level, and socioeconomic status—significantly influenced perceptions of intervention effectiveness, though these factors explained only moderate variance, suggesting multifaceted determination. This finding underscored the importance of addressing digital literacy and capacity-building as equity strategies in special education technology implementation.

Second, parental engagement levels demonstrated strong positive associations with reported child outcomes across academic performance, learning confidence, and motivation. This relationship held across different SLD types, though with variations in magnitude, highlighting engagement as a critical mediating factor in intervention success. The finding emphasized that technological tools alone were insufficient; effective implementation required active parental scaffolding and involvement.

Third, significant regional variations existed in barriers and facilitators, with semi-urban Haryana districts facing greater challenges related to internet connectivity, costs, technical literacy, and linguistic accessibility compared to urban Delhi regions. However, the lack of professional guidance emerged as a universal barrier, pointing to systemic inadequacies in special education support infrastructure across the NCR. These variations illuminated how geographical, economic, and infrastructural contexts shaped intervention feasibility and outcomes, even within a relatively confined region.

IMPLICATIONS FOR PRACTICE

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Several practical implications emerged from these findings. For educators and school administrators, results highlighted the need for structured parent training programs focusing on both technological skills and pedagogical strategies for supporting children with SLD. Schools could organize workshops demonstrating effective digital intervention usage, providing hands-on practice, and creating ongoing consultation mechanisms.

For policymakers, findings emphasized the urgent need for investments in three areas: (1) digital infrastructure enhancement in semi-urban and rural regions to address the digital divide; (2) expansion of the special education workforce through training programs and incentivized deployment to underserved areas; and (3) development and subsidization of culturally appropriate, linguistically diverse, evidence-based digital interventions specifically designed for Indian contexts and SLD populations.

For application developers, results suggested market opportunities and social responsibilities in creating affordable, Hindi-enabled, pedagogically sound interventions for mathematics learning disabilities and other underserved SLD types. Partnerships with special education professionals during development could enhance appropriateness and effectiveness.

For parent support organizations, findings validated the importance of peer networks and suggested opportunities for formalized community-based initiatives. Facilitated support groups combining social-emotional support with practical guidance could address the professional guidance gap while building social capital.

IMPLICATIONS FOR RESEARCH

Future research should employ longitudinal designs tracking intervention usage and child outcomes over extended periods, enabling causal inference and developmental trajectory mapping. Studies should incorporate objective outcome measures including standardized assessments and classroom observations to complement parental reports. Comparative effectiveness research examining specific intervention types, pedagogical approaches, and technological features would provide guidance for evidence-based selection.

Child perspectives warrant direct investigation through developmentally appropriate interviews and observational methods. Understanding children's subjective experiences, preferences, and agency in their learning would humanize research and inform child-centered intervention design. Additionally, research should examine implementation in more

marginalized communities including rural areas, government school contexts, and lower-income populations to ensure inclusive knowledge generation.

Mixed-methods investigations of teacher perspectives on digital interventions would illuminate school-home coordination possibilities and challenges. Studies examining the professional development needs of special educators regarding technology integration would inform training program development. Finally, intervention development research employing participatory design methods—involving parents, teachers, children with SLD, and special education experts—could yield contextually appropriate, user-centered technological solutions.

FINAL REFLECTIONS

This study was conducted during a unique historical moment when digital technologies transitioned from supplementary educational tools to necessary platforms, accelerated by pandemic disruptions. For families of children with SLD, this transition brought both opportunities and challenges—increased access to specialized tools but also heightened demands on parents to serve as educational facilitators.

The findings painted a complex picture: digital interventions held genuine promise for addressing SLD, but their effectiveness was neither automatic nor universally accessible. Success depended on intersecting factors spanning individual family characteristics, community resources, regional infrastructure, and broader systemic support. Parents emerged not merely as users of technology but as critical mediators whose engagement, perceptions, and capacities substantially determined outcomes.

Most significantly, the research revealed persistent inequities. Geography, income, education, and technological access created vastly different intervention landscapes for children with identical learning disabilities. A child with dyslexia in Gurugram accessed high-speed internet, premium applications, and special education consultations, while a similar child in Karnal struggled with connectivity, affordability, and professional isolation. These disparities demand urgent attention from policymakers, practitioners, and researchers committed to inclusive education and social justice.

Ultimately, while digital interventions represented valuable tools in the SLD intervention toolkit, they were not panaceas. Effective support for children with learning disabilities

required holistic ecosystems encompassing quality assessments, evidence-based interventions (both digital and traditional), trained professionals, empowered parents, inclusive schools, and supportive communities. Technology could amplify these elements but could not substitute for them.

As India continues its journey toward inclusive education, lessons from this study suggested that attention must extend beyond intervention tools themselves to the complex human, social, and systemic contexts determining their implementation and effectiveness. Only through such comprehensive understanding can the promise of digital innovations be equitably realized for all children with specific learning disabilities.

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