

ACCESSIBILITY OF UNIVERSAL DESIGN FOR LEARNING (UDL)-BASED DIGITAL LEARNING MATERIALS AND ITS IMPACT ON LEARNING ENGAGEMENT OF STUDENTS WITH DISABILITIES**Author****Jyoti Pal****Assistant professor, Special Education (ID)
Jay Nand Special Teachers Training Institute, Ayodhya UP****Abstract**

The rapid expansion of digital education has created new opportunities for students with disabilities; however, inaccessible digital learning materials may continue to restrict participation and meaningful learning. Universal Design for Learning (UDL) provides a framework for designing flexible learning environments that accommodate learner diversity through multiple means of engagement, representation, and action and expression. The present study examined the accessibility of UDL-based digital learning materials and their relationship with the learning engagement of students with disabilities. A descriptive survey design was adopted. An illustrative sample of 100 students with disabilities was considered for demonstrating the proposed research framework and analysis. Data were examined using frequency, percentage, mean, standard deviation, Pearson's correlation, and an independent-samples t-test. The illustrative findings indicated that 56% of students perceived the accessibility of digital learning materials as high, while 35% reported moderate accessibility. Overall accessibility obtained a mean score of 3.82 (SD = 0.56), whereas learning engagement obtained a mean of 3.91 (SD = 0.60). A positive and statistically significant relationship was observed between digital accessibility and learning engagement ($r = .64$, $p < .01$). Students with regular digital learning exposure also demonstrated higher engagement scores than those with limited exposure. The study highlights the importance of accessible digital content, flexible representation, navigational simplicity, multimodal resources, and opportunities for learner expression. The findings suggest that UDL-based digital learning can contribute to more participatory and inclusive educational environments when accessibility is incorporated systematically.

Keywords: Universal Design for Learning, digital accessibility, students with disabilities, learning engagement, inclusive education, assistive technology, UDL

1. Introduction

Digital learning has become an important component of contemporary education. Online platforms, digital textbooks, recorded lectures, interactive presentations, multimedia resources, and learning management systems have expanded opportunities for accessing educational content. For students with disabilities, however, the availability of digital material does not automatically ensure educational accessibility. A digital resource may be technologically available but remain difficult to perceive, navigate, understand, or use.

Universal Design for Learning (UDL) addresses this concern by encouraging educational environments to provide multiple means of engagement, representation, and action and expression. The current UDL Guidelines emphasize designing learning experiences that anticipate learner variability rather than requiring individual learners to adapt to a single mode of instruction.

Digital accessibility is particularly significant for students with visual, hearing, physical, specific learning, and other disabilities. Features such as captions, alternative text, keyboard accessibility, readable layouts, transcripts, adjustable presentation formats, accessible documents, and flexible response mechanisms can reduce barriers to participation. The Web Content Accessibility Guidelines (WCAG) 2.2 similarly emphasizes principles of perceivability, operability, understandability, and robustness for accessible digital content.

Learning engagement is another important dimension of inclusive education. Engagement includes students' behavioral participation, emotional involvement, cognitive investment, persistence, and willingness to interact with learning activities. When digital materials are accessible and flexible, students may experience fewer unnecessary barriers and greater opportunities to participate actively.

Therefore, the present study focuses on the accessibility of UDL-based digital learning materials and its relationship with the learning engagement of students with disabilities.

2. Objectives of the Study

The study was undertaken with the following objectives:

1. To examine the perceived accessibility of UDL-based digital learning materials for students with disabilities.
2. To assess the level of learning engagement among students with disabilities using digital learning resources.
3. To examine the relationship between digital accessibility and learning engagement.

4. To compare learning engagement among students with regular and limited digital learning exposure.

3. Research Questions

1. What is the perceived level of accessibility of UDL-based digital learning materials among students with disabilities?
2. What is the level of learning engagement among students with disabilities?
3. Is there a significant relationship between digital accessibility and learning engagement?
4. Does learning engagement differ according to students' level of digital learning exposure?

4. Need and Significance of the Study

The shift towards digital education has made accessibility a central issue in inclusive education. Students with disabilities may encounter barriers when digital resources lack captions, alternative text, accessible navigation, readable formatting, or flexible methods of interaction. Consequently, digital inclusion requires more than providing devices or internet access; it also requires accessible learning content.

UDL offers a proactive approach by incorporating learner variability into instructional design. Instead of developing one standard resource and subsequently modifying it for individual learners, UDL encourages teachers and designers to provide flexible options from the beginning.

The study is significant for special educators, teacher educators, curriculum developers, educational technology designers, and institutions implementing inclusive education. It may also support the implementation of the Rights of Persons with Disabilities Act, 2016, and the inclusive and technology-oriented vision of the National Education Policy (NEP) 2020.

5. Review of Related Literature

Universal Design for Learning is grounded in the principle that learner differences should be anticipated during instructional design. CAST's UDL framework organizes learning design around three broad dimensions: engagement, representation, and action and expression. The framework therefore encourages teachers to provide multiple ways for students to become engaged, access information, and demonstrate learning.

Meyer, Rose, and Gordon (2014) explained UDL as a framework for reducing barriers and increasing opportunities for learners. Rao, Ok, and Bryant (2014), through their review of

UDL research, reported that UDL-based approaches can support diverse learners when instructional flexibility is systematically incorporated.

Digital learning environments can particularly benefit from UDL because digital resources can be modified and presented through multiple modes. Text may be accompanied by audio, video, images, captions, transcripts, and interactive elements. Such flexibility can support students with different sensory, cognitive, and learning needs.

Digital accessibility is also addressed through international accessibility standards. WCAG 2.2 emphasizes that digital content should be perceivable, operable, understandable, and robust. These principles are relevant to educational materials because accessibility barriers can directly influence students' ability to access instructional content.

Research on students with disabilities indicates that technology can improve educational participation when appropriate accessibility features and instructional support are available. However, technology itself does not guarantee inclusion. The accessibility, usability, instructional design, and relevance of digital resources remain important.

AlRawi and AlKahtani (2022), in a systematic review of UDL for students with intellectual disabilities, highlighted the potential of UDL for addressing learner diversity while also noting the need for further empirical research. This indicates a continuing need to examine how specific accessibility features relate to students' actual engagement.

Research Gap

Existing literature provides substantial theoretical support for UDL and digital accessibility, but there remains a need for empirical examination of the relationship between perceived accessibility of UDL-based digital learning materials and the learning engagement of students with disabilities, particularly within the Indian inclusive education context. The present study addresses this area.

6. Theoretical and Conceptual Framework

The theoretical foundation of the study is based primarily on the UDL framework. The framework assumes that learning barriers often arise from inflexible curriculum and instructional design rather than solely from learner characteristics.

The conceptual relationship examined in the study can be represented as:

UDL-Based Digital Learning Materials → Digital Accessibility → Learner Access and Participation → Learning Engagement

Digital accessibility was considered through dimensions such as perceptual accessibility, navigation, cognitive-linguistic accessibility, interaction, and communication. Learning



engagement was considered through behavioral, cognitive, emotional, and persistence-related indicators.

7. Research Methodology

7.1 Research Design

A descriptive survey design was considered appropriate because the study examined students' perceptions of digital accessibility and learning engagement.

7.2 Sample

For the present manuscript model, an illustrative sample of **100 students with disabilities** was considered. The sample included students with intellectual, visual, hearing, physical, specific learning, and other/multiple disabilities.

7.3 Variables

The major variables were:

- **Independent/Predictor Variable:** Accessibility of UDL-based digital learning materials
- **Dependent Variable:** Learning engagement
- **Background Variable:** Digital learning exposure

7.4 Tools

A structured questionnaire was conceptualized with two major components:

1. **Digital Accessibility Scale** – assessing perceptual, navigational, cognitive-linguistic, communication, and interaction accessibility.
2. **Learning Engagement Scale** – assessing behavioral, cognitive, emotional engagement, and persistence.

Responses were considered on a five-point scale.

7.5 Statistical Techniques

Frequency, percentage, mean, standard deviation, Pearson's product-moment correlation, and independent-samples t-test were used for analysis.

Important note: The numerical results below are illustrative/simulated and are included to demonstrate the structure of a publication-ready manuscript. They should not be reported as actual empirical findings without replacing them with collected data.

8. Results and Data Analysis

Table 1

Profile of the Illustrative Sample (N = 100)

Variable	Category	f	%
Gender	Male	43	43
	Female	57	57
Disability	Visual	24	24
	Hearing	20	20
	Physical/Locomotor	18	18
	Specific Learning Disability	20	20
	Other/Multiple	18	18
Digital exposure	Regular	68	68
	Limited	32	32

The sample represented different disability groups. A majority of the illustrative participants (68%) reported regular exposure to digital learning resources.

Table 2

Perceived Accessibility of UDL-Based Digital Learning Materials

Accessibility Level	f	%
High	56	56
Moderate	35	35
Low	9	9
Total	100	100

The findings indicate that 56% of the illustrative participants perceived digital learning materials as highly accessible, while 35% perceived them as moderately accessible.

Accessibility Dimension	Mean	SD
Perceptual accessibility	4.02	0.61
Navigational accessibility	3.78	0.70
Cognitive-linguistic accessibility	3.84	0.65
Communication accessibility	3.71	0.73
Interaction/response accessibility	3.76	0.69
Overall accessibility	3.82	0.56

Perceptual accessibility received the highest mean score (4.02), whereas communication accessibility received the comparatively lower mean score (3.71). The overall mean of 3.82 indicates a generally positive perception of accessibility.

Table 3

Level of Learning Engagement

Engagement Level	f	%
High	49	49
Moderate	41	41
Low	10	10
Total	100	100

Nearly half of the illustrative participants demonstrated a high level of engagement.

Engagement Dimension	Mean	SD
Behavioral engagement	4.01	0.64
Cognitive engagement	3.83	0.67
Emotional engagement	3.88	0.69
Persistence	3.92	0.65
Overall engagement	3.91	0.60

Behavioral engagement had the highest mean score (4.01), while cognitive engagement was comparatively lower (3.83).

Table 4

Relationship Between Digital Accessibility and Learning Engagement

Variable	Learning Engagement (r)
Overall accessibility	.64**
Perceptual accessibility	.49**
Cognitive-linguistic accessibility	.58**
Interaction/response accessibility	.55**
Teacher support	.46**

Note: $p < .01$. Values are illustrative.

The illustrative analysis indicates a positive relationship between overall digital accessibility and learning engagement ($r = .64$, $p < .01$). Cognitive-linguistic accessibility also demonstrated a positive association with engagement ($r = .58$, $p < .01$). These findings

suggest that students who perceive digital materials as more accessible may also report greater engagement.

Table 5

Comparison of Learning Engagement by Digital Learning Exposure

Digital Exposure	N	Mean	SD	t
Regular exposure	67	4.05	0.53	2.71**
Limited exposure	33	3.63	0.69	
Total	100			

Note: $p < .01$; illustrative data.

Students with regular digital learning exposure showed a higher illustrative engagement mean than students with limited exposure. The difference was statistically significant in the simulated analysis.

9. Major Findings

The major findings of the illustrative analysis were as follows:

1. More than half of the participants perceived UDL-based digital learning materials as highly accessible.
2. Overall perceived digital accessibility was relatively positive.
3. Perceptual accessibility received the highest mean among the accessibility dimensions.
4. Approximately half of the participants demonstrated high learning engagement.
5. Overall digital accessibility showed a positive relationship with learning engagement.
6. Cognitive-linguistic and interaction-related accessibility were also positively associated with engagement.

7. Students with regular digital learning exposure reported higher engagement than students with limited exposure.

10. Discussion

The findings support the broader theoretical proposition of UDL that flexible and accessible instructional design can reduce unnecessary learning barriers. The positive relationship between accessibility and engagement suggests that when students can perceive, navigate, understand, and interact with digital learning materials more effectively, their participation may also increase.

The relatively high score for perceptual accessibility indicates the importance of features such as readable content, appropriate visual presentation, captions, alternative formats, and multimodal resources. At the same time, the comparatively lower score for communication accessibility suggests that opportunities for students to express their learning through flexible modes require further attention.

The findings are broadly consistent with the UDL literature emphasizing multiple means of representation and action and expression. They also correspond with the accessibility principles reflected in WCAG 2.2. However, the relationship observed in the illustrative data should not be interpreted as evidence of causation.

The higher engagement among students with greater digital exposure may reflect greater familiarity with digital platforms, increased confidence, or greater opportunities to use accessible resources. Further empirical studies are required to determine the specific mechanisms involved.

11. Educational Implications

The study has several implications for inclusive and special education.

For teachers: Digital learning materials should include captions, transcripts, alternative text, readable layouts, clear navigation, and flexible response options.

For special educators: Teachers should assess individual accessibility needs and provide multiple ways of accessing and demonstrating learning.

For teacher education institutions: UDL and digital accessibility should be integrated into pre-service and in-service teacher education programmes.

For educational technology developers: Accessibility should be incorporated at the design stage rather than treated as a later modification.

For institutions: Digital learning platforms should be evaluated using accessibility standards and student feedback.

For policy makers: Implementation of inclusive education policies should include measurable digital accessibility indicators.

12. Recommendations

1. Teacher education programmes should provide systematic training in UDL and digital accessibility.
2. Digital educational resources should comply with recognized accessibility principles.
3. Captions, transcripts, alternative text, keyboard accessibility, and adjustable presentation should become standard features.
4. Students with disabilities should be involved in evaluating digital learning materials.
5. Institutions should conduct periodic accessibility audits of digital platforms.
6. Teachers should receive practical training in creating accessible documents, presentations, videos, and online assessments.
7. Further research should examine specific disability groups and different digital learning environments.

13. Limitations

The present manuscript model is based on illustrative data and therefore does not represent actual empirical findings. A future empirical study should use a clearly defined population, scientifically selected sample, validated tools, and appropriate statistical procedures. The relationship between accessibility and engagement should also be examined using longitudinal or experimental designs where possible.

14. Conclusion

UDL-based digital learning has considerable potential to support the participation of students with disabilities when accessibility is integrated into instructional design. The present illustrative analysis indicates a positive association between perceived digital accessibility and learning engagement. The findings emphasize that inclusive digital education requires more than technological availability; it requires accessible content, flexible representation, clear navigation, meaningful interaction, and multiple opportunities for learners to demonstrate understanding.

UDL therefore provides a useful framework for moving digital education from simple access towards meaningful participation. For students with disabilities, accessible digital learning environments can contribute to greater engagement and more equitable educational opportunities when supported by appropriate teacher preparation, institutional commitment, and accessibility standards.

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