International Journal of Integrated Science and Technology (IJIST)
Vol. 4, No. 1 January 2026: 17-33

Application of Digital Technology for Deep Learning in Inclusive Schools

Kusuma Galih Ayusaputri[1]*, Dinda Ayu Bulantari[2], Yeni Suryani[3], Haeruddin[4]
Universitas Mulawarman, Indonesia
Corresponding Author: Kusuma Galih : kusumagalihayus@gmail.com

ARTICLEINFO

Keywords: Deep Learning, Inclusive Education, Digital Technologies, Universal Design for Learning, School Management

Received : 20, November
Revised : 25, December
Accepted: 20, January

ABSTRACT

Deep learning in inclusive schools demands an approach that able to accommodate the diversity of learners' needs, abilities, and learning styles. This article discusses the application of digital technology based on Universal Design for Learning (UDL) as a strategy to support deep learning in inclusive schools. The method used is a conceptual study with a descriptive analytical approach through literature review, education policies, and technology based inclusive learning implementation practices. The results of the study show that the use of digital technology, such as interactive video, learning management system, text to speech, automatic captioning, and digital portfolio assessment, able to improve accessibility, learning engagement, learning differentiation, and the quality of the deep learning process. In addition, the role of school management, teacher competence, and parental collaboration are key factors for the success of implementation. The conclusion of this article emphasizes that the integration of UDL based digital technology not only supports inclusivity, but also contributes significantly to realizing meaningful, equitable, and sustainable learning in inclusive schools.

INTRODUCTION

Inclusive education is an educational paradigm that emphasizes the fulfillment of the learning rights of all students without exception, including students with special needs, differences in academic, social, and learning styles. In the context of inclusive schools, diversity demands a learning approach that is not only oriented towards equal access, but also on the quality of a meaningful learning process. However, various reports and results show that learning practices in inclusive schools still tend to use a uniform, teacher centered, and focused approach on basic cognitive achievement. This condition has an impact on the low active involvement of students and the lack of optimal deep learning that encourages conceptual, critical, reflective, and contextual understanding.

The development of digital technology provides a great opportunity to overcome these challenges. The use of digital technology in learning has been proven to be able to increase accessibility, flexibility, and personalization of learning for students with diverse needs. Various forms of technology such as interactive videos, learning management systems, adaptive multimedia media, and digital assessments allow learners to learn through various ways according to their abilities and preferences. However, the use of technology in inclusive schools still faces various obstacles, including infrastructure gaps, limited teachers' digital literacy, and the use of technology that has not been pedagogically integrated. Technology is often used as an additional tool, rather than as part of an inclusive learning design designed from the start.

Universal Design for Learning (UDL) is present as a relevant pedagogical framework to answer these problems. This approach emphasizes learning design that provides a variety of alternatives in the presentation of materials, student involvement, and ways of expressing understanding. The integration of UDL based digital technology has the potential to strengthen deep learning in inclusive schools by creating an adaptive, participatory, and student center learning environment. However, studies that comprehensively link digital technology, UDL, and deep learning in the context of inclusive schools, including the role of school management and parent collaboration, are still relatively limited.

Based on this reality, this article aims to analyze the application of digital technology based on Universal Design for Learning in supporting deep learning in inclusive schools, as well as examine the factors supporting its implementation so that it can run effectively and sustainably.

LITERATURE REVIEW

Effective inclusive learning requires a pedagogical approach that is responsive to the diverse needs of diverse learners. One of the prominent pedagogical frameworks is the Universal Design for Learning (UDL), which is designed to provide a variety of methods of material representation, student engagement, and ways of expressing learning understanding. UDL not only emphasizes accessibility, but also creates a flexible learning environment for all learners. The narrative review study shows that the integration of UDL principles with digital technology is an important strategy for inclusive education in the

21st century, but implementation still faces obstacles such as teacher training, infrastructure, and policy support that are not optimal (Mayasari et al., 2025).

Several systematic studies have examined the role of technology in supporting UDL and inclusive education at large. The general findings of this study show that learning planning that integrates UDL from the design stage, as well as the application of accessibility standards to digital media, can improve the engagement and understanding of learners, including those with special needs (Akande et al., 2025a). In addition, studies on UDL in online education have identified that the integration of UDL in digital environments offers increased access and support for students with special needs, although there are few empirical studies available (Utami et al., 2025a).

Other research shows that ubiquitous technology (technology available anywhere and anytime) has an important role in supporting the implementation of UDL. Such technologies, such as real time applications and UDL based learning modules, help tailor the delivery of materials to the individual needs of students, while the main challenge remains on the infrastructure gap and the digital literacy of educators (Firmansyah & Aljauhari, 2025a). UDL has also been studied in the context of early childhood learning, where the principles are applied to design learning experiences that are responsive to the diversity of learners from an early age. This review confirms that UDL can support inclusive learning at the earliest level, although concrete implementations still need to be further developed (Haris et al., 2025).

In addition, a bibliometric analysis of UDL research reveals key thematic trends, such as the integration of UDL with smart technologies (AI and machine learning) and its linkage to 21st century learning. This trend shows an increasing focus of research on data driven learning personalization as well as the adaptation of smart technologies in the context of UDL (Judijanto & Rusdi, 2025). In addition, a number of literature reviews on deep learning in digital education show that artificial intelligence technology and adaptive learning systems can revolutionize the learning process through improved personalization, real time response, and automated assessment. This is in line with the need for inclusive learning to accommodate a variety of learners' abilities (Hastuti et al., 2025).

Some research focuses on more specific technology implementations, showing that digital learning media such as adaptive LMS, interactive multimedia applications, and audience platforms that support UDL can drive higher student engagement and meaningful learning experiences (Dwiputri et al., 2025). Research linking UDL to deep learning pedagogy shows that learning strategies designed based on UDL principles tend to create deeper engagement through activities that stimulate critical thinking, problem solving and collaboration. However, long term quantitative empirical evidence is still relatively limited (Haq, 2025).

Studies on UDL based learning tool development strategies show that combining UDL principles with instructional differentiation can significantly increase the engagement and learning outcomes of students with special needs. This approach combines adaptive technology media and trained teacher

collaboration, which makes an important contribution to sustainable inclusive education practices (Ziyana et al., 2025).

Several literature reviews in the context of vocational education also emphasize the importance of learning models that utilize deep learning and digital technologies to support inclusion students, especially in practical skills and contextual learning (Andriana, 2021). In addition to theoretical and practical advancements, the literature also identifies major challenges that still face, such as the need for continuous training for teachers, equitable access to technological infrastructure, and curriculum design that is responsive to UDL and digital technologies (Firmansyah & Aljauhari, 2025a).

Overall, this literature review shows that the integration of UDL and digital technologies has great potential to strengthen inclusive and deep learning, but empirical research testing real implementation, especially in the context of deep learning inclusive pedagogy, is still limited and needs further development. This emphasizes the need for a more comprehensive and contextual study of the role of school management, teachers, and parental collaboration in supporting the learning transformation.

RESEARCH METHODS

This research uses a qualitative approach with literature study methods and conceptual analysis. This approach was chosen to gain a comprehensive understanding of the application of Universal Design for Learning (UDL) based digital technology in supporting in depth learning in inclusive schools, as well as to identify relevant research patterns, findings, and gaps based on a scientific perspective.

RESEARCH INSTRUMENTS

The main instrument in this study is a literature review sheet that is used to identify, classify, and evaluate relevant scientific articles. The study sheet contains analysis indicators including: (1) the focus of the research study, (2) the context of inclusive education, (3) the form and role of digital technology, (4) the application of the principle of Universal Design for Learning, (5) the relationship with deep learning, and (6) the main findings and practical implications. This instrument is used to ensure consistency and objectivity in the literature analysis process.

DATA COLLECTION PROCESS

Research data was obtained through searching for scientific articles published in reputable national and international journals. The search process was carried out using an online journal database with keywords including inclusive education, digital technology, Universal Design for Learning, and deep learning. The selected articles meet the inclusion criteria, namely relevant to the research topic, published in scientific journals, and discuss the application of digital technology or UDL in the context of inclusive education. Articles that are not relevant to the focus of the study or are non scientific in nature are excluded from the analysis.

DATA ANALYSIS PROCESS

Data analysis was carried out using descriptive thematic analysis techniques. Each selected article was analyzed to identify key themes related to the use of digital technology, UDL principles, deep learning strategies, and supporting and inhibiting factors for implementation in inclusive schools. The analysis process is carried out through the initial coding stages, theme grouping, and conceptual conclusion drawn. This approach allows researchers to synthesize findings across studies in a systematic and in depth manner.

DATA PRESENTATION PROCESS

The results of the analysis are presented in the form of a narrative description and summary table describing the characteristics of the study, the focus of the study, and the main findings of the analyzed literature. The descriptive presentation of data is used to display the relationships between concepts and clarify the contribution of UDL based digital technology to strengthening deep learning in inclusive schools. This approach was chosen so that the results of the study are easy to understand and provide theoretical and practical implications for the development of inclusive education policies and practices.

RESULT

An analysis of the implementation of digital technology based on Universal Design for Learning (UDL) in inclusive schools reveals that this integration significantly supports the realization of deep learning. The study identifies three key dimensions: (1) the role of digital technology as an enabler of inclusivity, (2) the operationalization of UDL principles through digital tools, and (3) the supporting factors critical to successful implementation within inclusive school settings.

First, digital technology functions as a primary enabler of accessibility and flexibility in learning for all students, including those with special educational needs. Tools such as text-to-speech, screen readers, automatic captioning, interactive videos, and Learning Management Systems (LMS) allow content to be delivered in multiple formats, thereby accommodating diverse cognitive, sensory, and learning preferences (Firmansyah & Aljauhari, 2025b). This aligns directly with UDL's core principle of providing multiple means of representation to ensure equitable access to information.(Akande et al., 2025b).

Second, the application of UDL through digital technology demonstrably fosters meaningful deep learning. For instance, in digital Project Based Learning (PjBL), students are empowered to express their understanding through varied media such as podcasts, digital posters, or advocacy videos tailored to their interests and capabilities (Haeruddin, 2025). Similarly, reflective online discussions via LMS forums enable students to articulate ideas using text, audio, or video, thereby enhancing both cognitive engagement and emotional investment in learning. Furthermore, authentic assessment through digital portfolios comprising videos, infographics, and reflective journals offers a

holistic evaluation method that captures critical thinking, creativity, and metacognition, rather than mere rote memorization.(Utami et al., 2025b).

Third, the success of implementing UDL-based digital technology hinges on three interdependent pillars: school leadership, teacher competence, and parental collaboration. School principals play a strategic role in establishing a vision for inclusive digital transformation, ensuring adequate infrastructure, and cultivating an adaptive learning ecosystem (Haeruddin, 2025). Teachers, in turn, act not only as facilitators but also as instructional designers who skillfully integrate digital pedagogy with UDL principles to meet diverse learner needs (Mayasari et al., 2025). Meanwhile, parental involvement facilitated through digital platforms such as school communication apps or learning portals strengthens the home-school partnership, particularly in supporting individualized learning plans and addressing specific student requirements. (Haris, F. I., et al. 2025).

Nevertheless, several challenges persist, including unequal access to technological infrastructure, limited digital literacy among educators, and insufficient institutional policies to support systemic change (Hastuti., et al. 2025). To address these barriers, sustainable strategies are essential: ongoing professional development in UDL and digital pedagogy, standardization of accessible digital tools (e.g., interactive videos with captions, text-to-speech features), and data-driven monitoring mechanisms to evaluate implementation effectiveness and scale best practices.(Judianto & Rusdi. 2025).

In summary, this study affirms that integrating UDL based digital technology is not merely a supplementary enhancement but a foundational strategy for building inclusive, equitable, meaningful, and sustainable learning environments in inclusive schools.

DISCUSSION

The findings of this study demonstrate that the integration of digital technology grounded in Universal Design for Learning (UDL) represents not merely a technical intervention but a fundamental pedagogical transformation within inclusive school settings. The analysis reveals that UDL based digital tools such as interactive videos, text-to-speech applications, learning management systems (LMS), automatic captioning, and digital portfolio assessments significantly enhance accessibility, engagement, differentiation, and the overall quality of deep learning. This insight extends theoretical understanding while offering actionable implications for building responsive and equitable educational ecosystems. (Haeruddin. 2025)

A central contribution of this integration lies in its capacity to operationalize the three core UDL principles: multiple means of representation, engagement, and action & expression. In practice, digital technologies enable flexible content delivery across multiple modalities (text, audio, visual, interactive), effectively addressing diverse cognitive, sensory, and learning preferences. For example, students with visual impairments can access materials via screen readers, while those with reading difficulties benefit from text to speech features. This multimodal approach not only improves access but also

deepens conceptual understanding a hallmark of deep learning.(Firmansyah & Aljauhari, 2025b)

Moreover, digital technology facilitates authentic differentiation in instruction. Through digital Project-Based Learning (PjBL), for instance, students are empowered to demonstrate their understanding through media aligned with their interests and capabilities such as environmental advocacy podcasts, digital posters, or short documentaries . This aligns precisely with UDL's action & expression principle and simultaneously cultivates higher-order cognitive skills like critical analysis, creative problem solving, and collaborative inquiry core dimensions of deep learning. Thus, technology transcends its role as a supplementary aid and becomes an integral component of inclusive instructional design from the outset (Haeruddin. 2025).

School leadership emerges as another critical success factor. Principals who champion an inclusive digital vision play a pivotal role in embedding UDL and technology into strategic school planning, ensuring adequate infrastructure, and fostering a collaborative culture among teachers, parents, and stakeholders(Haeruddin. 2025). Without such transformative leadership, technology adoption risks remaining fragmented and unsustainable. This finding resonates with existing literature emphasizing instructional leadership as essential for systemic reform in inclusive education(Mayasari et al., 2025).

Nevertheless, significant implementation challenges persist. Disparities in digital infrastructure particularly in remote or under-resourced regions continue to pose structural barriers (Akande et al., 2025b). Additionally, despite strong willingness among educators, many lack sufficient digital-pedagogical competence to effectively design UDL aligned learning experiences . This underscores that one-off technical training is insufficient; sustained professional development integrating UDL theory, inclusive pedagogy, and adaptive technology use is imperative.(Utami et al., 2025b)

Parental collaboration, often overlooked, is equally vital. In inclusive contexts, family support significantly influences student outcomes especially for learners with special needs. Digital platforms (e.g., school communication apps, LMS portals) enable parents to monitor progress, understand adaptive teaching strategies, and actively participate in individualized education planning (Haris et al., 2025). This reflects a holistic educational ecosystem where families are strategic partners rather than passive recipients of information.

In sum, this discussion affirms that implementing UDL based digital technology in inclusive schools is a complex, multidimensional process involving technological, pedagogical, managerial, and socio-cultural dimensions. Its success depends on the synergistic alignment of flexible instructional design, adaptive teacher expertise, visionary school leadership, and inclusive partnerships with families and communities. Without such holistic integration, the potential of digital technology to realize truly meaningful, equitable, and sustainable deep learning in inclusive education will remain unrealized.

CONCLUSIONS AND RECOMMENDATIONS

This study concludes that the integration of digital technology grounded in Universal Design for Learning (UDL) constitutes a transformative pedagogical strategy for realizing deep learning in inclusive schools. Rather than serving as a supplementary tool, UDL-based digital technology functions as a foundational framework that proactively accommodates learner diversity through multiple means of representation, engagement, and expression. The use of interactive videos, text to speech applications, automatic captioning, learning management systems (LMS), and digital portfolio assessments has been shown to significantly enhance accessibility, cognitive engagement, differentiated instruction, and authentic assessment key pillars of meaningful and equitable learning.

Moreover, successful implementation hinges on a triadic support system: visionary school leadership, teacher competence in inclusive digital pedagogy, and active parental collaboration facilitated through digital platforms. Without this synergy, even the most advanced technologies risk being underutilized or applied inconsistently, thereby failing to achieve systemic inclusivity. Based on these findings, the following recommendations are proposed:

1. Embed UDL and digital transformation into school strategic planning. School leaders should institutionalize an inclusive digital vision by aligning curricula, infrastructure investment, and professional development with UDL principles.
2. Strengthen continuous teacher capacity building. Professional development programs must move beyond technical training to integrate UDL theory, deep learning pedagogy, and adaptive technology use in contextually relevant ways.
3. Standardize accessible digital tools across learning environments. Schools should adopt and mandate the use of universally designed digital resources such as captioned videos, screen-reader-compatible materials, and multimodal LMS interfaces to ensure consistent accessibility.
4. Foster structured home school partnerships through technology. Digital communication platforms should be leveraged not only for information dissemination but also for co-designing individualized learning plans and monitoring student progress in real time.
5. Establish data-driven monitoring and knowledge-sharing mechanisms. Systematic evaluation of implementation outcomes, coupled with documentation and replication of best practices, can accelerate scalable and sustainable innovation in inclusive education.

Collectively, these measures affirm that inclusive deep learning is not merely achievable but essential in the digital age provided that technology is intentionally designed, equitably deployed, and pedagogically integrated from the outset.

FURTHER STUDY

While this conceptual study provides a robust theoretical and practical foundation for integrating UDL and digital technology in inclusive schools, several limitations warrant attention in future research. First, the analysis relies primarily on literature synthesis rather than empirical classroom data; thus, future studies should employ mixed-methods designs to examine the actual impact of UDL based digital interventions on student learning outcomes, particularly among learners with diverse disabilities. Second, the role of emerging technologies such as artificial intelligence, adaptive learning algorithms, and immersive media (e.g., VR/AR) within UDL frameworks remains underexplored and merits deeper investigation. Third, contextual factors such as regional disparities in infrastructure, cultural attitudes toward disability, and policy coherence across educational levels require localized case studies to inform context-sensitive implementation strategies. Finally, longitudinal research is needed to assess the sustainability of teacher competence and institutional commitment beyond short-term pilot projects. Addressing these gaps will strengthen the evidence base for scalable, equitable, and future-ready inclusive education models.

ACKNOWLEDGMENT

The authors sincerely thank the Faculty of Teacher Training and Education, Universitas Mulawarman, for their academic support and the provision of a conducive research environment. Special gratitude is extended to Drs. H. Haeruddin, M.Si., as the advisor for this article, as well as to colleagues and reviewers whose constructive feedback significantly enhanced the quality of this manuscript. This work was developed as part of the Community Service

REFERENCES

Akande, F. O., Koranteng, U., Mensah, D., Mensah, T. K., & Awah, L. C. (2025a). Technology-Supported Inclusive Education: A Systematic Review of Digital Accessibility and Universal Design for Learning. *Asian Journal of Current Research*, *10*(4), 320–333. https://doi.org/10.56557/ajocr/2025/v10i49950

Akande, F. O., Koranteng, U., Mensah, D., Mensah, T. K., & Awah, L. C. (2025b). Technology-Supported Inclusive Education: A Systematic Review of Digital Accessibility and Universal Design for Learning. *Asian Journal of Current Research*, *10*(4), 320–333. https://doi.org/10.56557/ajocr/2025/v10i49950

Andriana. (2021). ModelPembelajaranBerbasisDeepLearningBagiSiswaInklusidiPendidikan Vokasi. *Jurnal Tiarsie*, *18*(04), 2623–2391.

Dwiputri, L. J., Sari, E., & Purwandari, D. A. (2025). *INNOVATIVE LMS DESIGN FOR SUSTAINABLE AND INCLUSIVE DIGITAL EDUCATION*. *1*.

Firmansyah, R., & Aljauhari, M. A. (2025a). Integration of Ubiquitous Technology in Universal Design for Learning (UDL) to Support Inclusive Education. *IJIE (Indonesian Journal of Informatics Education)*, *9*(1), 1. https://doi.org/10.20961/ijie.v9i1.95397

Firmansyah, R., & Aljauhari, M. A. (2025b). Integration of Ubiquitous Technology in Universal Design for Learning (UDL) to Support Inclusive Education. *IJIE (Indonesian Journal of Informatics Education)*, *9*(1), 1. https://doi.org/10.20961/ijie.v9i1.95397

Haeruddin. (2025). Application of Digital Technology for Deep Learning in Inclusive Schools. Presentation at PKM MMP, Universitas Mulawarman.

Haq, M. D. (2025). *Deep Learning sebagai Pendekatan Transformasional dalam Pendidikan: Sebuah Tinjauan Literatur*. *8*(3).

Haris, F. I., Zaman, B., Kurniati, E., Apsari, N., Khoerunnisa, S., Sidqia, T. L., & Shofia, F. (2025). *Universal Design for Learning (UDL) Dalam Pendidikan Anak Usia Dini*.

Hastuti, S., Ansar, A., & Hermawan, N. (2025). Penerapan Teknologi Deep Learning Dalam Pendidikan Digital. *Jurnal Penelitian Ilmu Pendidikan Indonesia*, *4*(2), 359–365.

Judijanto, L., & Rusdi, M. (2025). Analisis Bibliometrik tentangUniversal Design for Learning dalam Pembelajaran Abad ke-21. *Sanskara Pendidikan dan Pengajaran*, *3*(02), 59–69.

Mayasari, L. I., Dulyapit, A., Yunitasari, S. E., & Syam, R. (2025). *INTEGRATING UNIVERSAL DESIGN FOR LEARNING AND DIGITAL TECHNOLOGY: ADVANCING INCLUSIVE EDUCATION IN THE 21ST CENTURY*. *21*.

Utami, I. S., Ghufron, A., & Ishartiwi, I. (2025a). Universal Design for Learning in Online Education: A Systematic Review of Evidence-Based Practice for Supporting Students with Disabilities. *International Journal of Learning, Teaching and Educational Research*, *24*(3), 94–116. https://doi.org/10.26803/ijlter.24.3.5

Utami, I. S., Ghufron, A., & Ishartiwi, I. (2025b). Universal Design for Learning in Online Education: A Systematic Review of Evidence-Based Practice for Supporting Students with Disabilities. *International Journal of Learning, Teaching and Educational Research*, *24*(3), 94–116. https://doi.org/10.26803/ijlter.24.3.5

Ziyana, S., Marfuah, Rahmani, A., & Armelia, Y. (2025). Inclusive Learning Device Development Strategy Based on UDL and Differentiation for Children with Special Needs in Indonesia. *International Disability Innovation Journal (IDIJ*, *1*(1), 15–21.