

Strategies Implementing Deep Learning for Children with Special Needs in The Digital Era

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ABSTRACT

This study was conducted due to limitations in the application of deep learning integrated with digital technology for children with special needs. This is due to differences in the abilities and needs of each individual, which require adaptive, contextually relevant, and enjoyable learning strategies. The purpose of this study is to analyze the application of deep learning for children with special needs. This analysis covers the planning, implementation, evaluation, obstacles, and solutions carried out by teachers at Special Schools. This study uses a qualitative approach with in-depth interviews with a special education teacher who has 15 years of experience and has implemented a deep learning approach and a contextual project-based learning model. The results of the study show that learning must be student-centered, oriented towards real experiences, and integrate adaptive technology in vocational skills learning to support their independence after graduating from school. Evaluation is carried out comprehensively through formative and summative assessments to assess students' understanding, application, reflection, and emotional well-being, thereby supporting conscious, meaningful, and enjoyable learning. The main obstacle faced, namely differences in student abilities, was overcome through alternative assessments and teacher flexibility in designing learning strategies. The success of deep learning was also supported by partnerships between schools, parents, and the government. In conclusion, the implementation of deep learning for students with special needs is highly dependent on good initial assessment, adaptive and contextual teaching strategies, and an inclusive learning environment that supports students' cognitive and emotional aspects. Recommendations from this study emphasize the importance of developing interactive media and adaptive educational technology as inclusive educational innovations that can improve the quality of learning in the digital age.

Keywords: *Deep Learning, Digital Era, Special Needs Education*

1. INTRODUCTION

Technological developments in the digital age have had a major impact on various fields, including education. Special education for children with special needs has also felt the impact of these changes (Riyadi et al., 2025). Students with disabilities often face difficulties arising from cognitive demands, which are exacerbated by the lack of differentiated content, limited support systems, and limited access (Kauts, 2021; Strogilos et al., 2023). However, the application of deep learning integrated with digital technology for children with special needs still faces various limitations. This is evidenced by reports that there are only 4,695 special education teachers, while the number of students with special needs reaches 135,874 (Aranditio et al., 2023). This is

a serious obstacle regarding the shortage of educators with inclusive education competencies for the implementation of adaptive and deep learning for students. The main challenge arises from the different characteristics of each child, both in terms of abilities, obstacles, and the needs of each student through appropriate, contextual, and enjoyable learning strategies (Akmal et al., 2025; Biggs & Tang, 2011; Dinata et al., 2025; Diputera et al., 2024; Kolb, 2014).

Deep learning emphasizes students' learning abilities consisting of three main elements, namely meaningful learning, mindful learning, and joyful learning. This approach is important for children with special needs because it requires a learning process that is not only informative but also applicable to support their cognitive, social, and vocational development (Schall et al., 2012; Westwood, 2008). The universal design learning framework provides guidance that effective learning for students with diverse needs must provide variety in information representation, engagement methods, and forms of expression, so that each student can access learning according to their learning style and capacity (CAST, 2024; Kelly et al., 2022; Meyer et al., 2014).

In the context of education in special schools, deep learning is often associated with an experience-based and project-based approach, where students develop the functional and vocational skills needed in daily life (Kolb, 2014). Adaptive technologies such as interactive multimedia, assistive devices, and digital learning applications can be important tools in supporting deep learning, especially for students who need additional support in communication, literacy, or motor skills (Chahal et al., 2024; Şanal, 2023). However, obstacles still arise related to limited teacher competence, a lack of accessible digital media, and the suboptimal formative and summative assessments needed to evaluate the deep learning process (Salvia et al., 2017). These challenges require creativity and flexibility from teachers in adjusting teaching strategies to remain inclusive and meaningful.

This study formulates strategies for integrating deep learning theory and adaptive technology into learning design. This study aims to analyze the obstacles and opportunities for implementing deep learning supported by digital technology for children with special needs, develop contextual and responsive learning strategies for students, and produce recommendations for digital technology-based instructional design that can support the cognitive, social, and vocational development of students in the context of education.

2. METHODOLOGY

This study aims to analyze the application of deep learning in special needs education in the digital age, focusing on planning, implementation, evaluation, obstacles, and solutions applied. Research data was obtained from in-depth interviews as the main source, supported by information about the curriculum and teaching and

learning activity reports. To analyze the data, a thematic approach was used to identify patterns or main themes, such as the use of adaptive technology and the role of collaboration between stakeholders. The sampling method used purposive sampling to select appropriate participants, with the sample characteristics consisting of experienced teachers in special schools. Prior to analysis, a pre-analysis phase was conducted, including instrument testing through pilot interviews to ensure the consistency and relevance of the questions, as well as the use of data triangulation to strengthen the validity of the research findings.

2.1. Research Design

This study uses a qualitative approach with an exploratory study design. The qualitative approach was chosen to understand the personal experiences of participants in the context of special education, while the exploratory study design allows for in-depth analysis of one teacher who represents the application of deep learning in special schools. This design is in line with the research objectives, which are to explore implementation strategies that are appropriate to the context, rather than statistical generalizations, and to enable the integration of research results with theories such as universal design for learning.

2.2. Participants of the Study

The main participant in this study was a special education teacher with 15 years of experience in special schools. She has applied deep learning methods and contextual project-based learning models. The sampling technique used purposive sampling, which is sampling based on specific criteria, namely experience and expertise in the field of inclusive education, so that participants could provide in-depth insights. The number of participants was limited to one main participant so that the analysis could focus on an in-depth qualitative approach. The sample characteristics consisted of a relevant educational background, namely Special Education, as well as direct experience in a school environment, which enabled discussion of obstacles such as resource limitations and solutions through a partnership approach.

2.3. Instruments

The main instrument used was a semi-structured interview guide containing 15 to 20 open-ended questions related to the application of deep learning, such as “How do you plan student-centered learning for students with special needs?” and “What are the main obstacles to integrating adaptive technology in special schools?”. This guide was used in face-to-face interviews with key participants, with each session lasting approximately 60 to 90 minutes. Additionally, supplementary instruments included field observation notes and school documents, such as curricula and student evaluation

reports, as a means of strengthening data validity through triangulation. These instruments were administered to teachers through face-to-face interviews, with the recording process using video recordings to ensure the accuracy of the transcripts.

2.4. Data Analysis Techniques

The data obtained from interviews and documentation studies were analyzed using a thematic analysis approach. This technique was chosen to identify, categorize, and interpret the main patterns related to the implementation of deep learning in special needs education. The analysis began with a pre-analysis stage, in which all interview recordings were transcribed verbatim, and observation notes were organized to ensure completeness and clarity. At this stage, the researchers also conducted an initial reading to gain a comprehensive understanding of the data set.

The next step involved the team understanding specific data that reflected important concepts such as the use of adaptive technology, learning planning, student engagement, evaluation practices, and obstacles in the learning environment. This was done manually to maintain proximity to the data and allow for nuanced interpretations of the research team's experiences.

After understanding certain data, the team then aligned their perceptions of the main components of this research topic, starting from the implementation of deep learning, including teaching strategies, technology integration, collaboration between stakeholders, and solution-oriented practices. After that, the discussion topics were reviewed and refined to ensure their suitability with the research objectives and theoretical framework, such as universal design for learning.

To strengthen the credibility of the findings, triangulation was carried out by cross-checking interview data with documents such as curriculum plans and evaluation notes that had been submitted by the informants during the interviews. The analysis ended with an interpretation phase, in which themes were synthesized to provide an in-depth understanding of how deep learning is applied in the context of special schools, including the challenges faced and solutions designed by the participants.

3. RESULT AND DISCUSSION

a. Implementation of Concrete and Contextual Deep Learning Stages

The main finding of this study shows that effective deep learning implementation is not the application of a radical new theory, but rather the reinforcement and internalization of fundamental student-centered pedagogical practices. This finding aligns with the characteristics of deep learning where learning should implement the principles of being meaningful, mindful, and joyful, realized through a three-stage process (understanding, applying, reflecting) and supported by contextual partnerships (Kemendikdasmen, 2025).

In the IPAS subject, for example, learning on the topic of waste management is designed as a continuous project using a Project-Based Learning approach. Project-Based Learning (PjBL) is seen as a "great vehicle for meaningful inclusion" because its design elements and teaching practices consistently incorporate these key markers (Uliasz, 2016). This project is not limited to a single subject but is carried out by integrating multiple disciplines. The project is not completed in a single meeting but is implemented gradually to provide more meaningful learning experiences for students. This finding directly supports Kolb's (2014) argument regarding the importance of an experience-based approach. The three-stage process (understanding, applying, reflecting) can be interpreted as a practical application of the experiential learning cycle.

The understanding stage is conducted by introducing basic concepts related to healthy and unhealthy environments. Students are invited to observe environmental conditions, such as the presence of scattered waste, and recognize various types of waste they encounter in daily life. This approach helps students connect learning materials with real-world experiences in their surroundings. The applying stage involves direct activities, such as picking up and sorting waste in the school environment. Additionally, the learning activity includes visits to waste processing facilities, allowing students to witness the sorting process firsthand. The reflecting stage is not limited to having students retell their experiences but also aims to encourage them to apply these behaviors in daily life. For instance, when they notice a dirty area at home, they are expected to initiate cleaning it, or when encountering plastic waste, they should be able to sort it correctly. Thus, reflection is understood as a process of internalization reflected in behavioral changes, not merely a verbal activity at the end of the lesson.

b. Functional Partnerships

The interview findings indicate that deep learning for children with special needs is fundamentally dependent on functional partnerships among schools, families, and the wider community. Rather than serving as supplementary support, these partnerships emerged as a central enabler of deep learning implementation, particularly in sustaining meaningful, mindful, and joyful learning processes beyond the classroom. This finding confirms that deep learning in special education cannot be effectively designed or maintained without a collaborative learning ecosystem in which responsibilities are shared across multiple actors.

In this context, functional partnerships operate as contextual learning mechanisms that connect instructional goals with students' real-life environments. Schools act as the primary designers and facilitators of learning experiences, families reinforce learning continuity and behavioral internalization at home, and community institutions provide authentic contexts that support experiential and vocational

learning. This three-way collaboration aligns with prior research emphasizing that special education requires schools, communities, and service providers to unite as partners with families to create optimal learning conditions (Walker et al., 2022) and to make a crucial contribution to students' academic and developmental outcomes (Chatenoud & Odier-Guedj, 2022).

Partnerships are realized through both formal and informal arrangements. Formal collaboration includes cooperation with government institutions, such as local environmental agencies during visits to waste processing facilities, which strengthens the applying stage of deep learning through authentic, experience-based activities. Informal partnerships, such as parental involvement in reinforcing learning routines at home or providing resources for basic life-skills training, support the reflecting stage by facilitating the internalization of learned behaviors. When families encounter limitations, schools extend partnerships to internal support units, such as school kitchens, to ensure continuity of functional skill development. These findings indicate that partnerships in deep learning are not ceremonial in nature but are adaptive, needs-based, and directly linked to pedagogical decision-making, reinforcing their role as a foundational component of the learning design.

c. Curriculum Characteristics Responsive to Specific Needs

Based on the interview results, the findings indicate that special education has unique curriculum characteristics that shape the strategies used in implementing deep learning. Although the curriculum structure is equivalent to that of regular education levels, special education includes a Special Needs Program that must be taught at every level. The goal becomes very practical, namely functional and vocational independence after graduation, which aligns with the goal of developing "social and vocational" skills identified by Schall et al. (2012) and Westwood (2008).

This program is designed according to the characteristics and needs of each type of disability. Students with visual impairments, for example, follow the Orientation, Mobility, Social, and Communication Development Program. Students with hearing impairments participate in the Auditory Perception and Rhythm Development Program, while students with intellectual disabilities follow the Self-Development Program. For students with autism, learning focuses on developing social interaction, communication, and behavior management skills. Furthermore, at the junior and senior high school levels, vocational skills are included with a larger instructional portion, especially at the senior high school level. These vocational activities are prepared to support students' independence after graduation. This curriculum structure makes deep learning not only academically oriented but also directed toward fulfilling functional and vocational needs relevant to students' daily lives.

d. Policy in Inclusive Education

The findings also reveal that the implementation of deep learning is closely related to inclusive education policies. Deep learning is understood as an instructional strategy, whereas inclusive education is a philosophy that governs the acceptance and management of student diversity. Schools that accept children with special needs must be ready to adapt their instructional strategies, learning environments, and support systems.

The government has provided various forms of training for regular school teachers to enhance their competence in facilitating students with disabilities. Since 2020, training for Special Education Support Teachers has been conducted, which later developed into tiered inclusive education training with basic, intermediate, and advanced levels offered through the Ruang GTK platform.

Additionally, the government encourages the adoption of Universal Design for Learning as a framework to ensure equitable access to education for all learners (Meyer et al., 2014). Despite these efforts, the interview results indicate that the implementation of inclusive education in regular schools is still developing. Some schools still focus only on keeping students with special needs "calm in the classroom" without providing appropriate learning services. Therefore, a deeper understanding of inclusive education philosophy is needed to ensure that deep learning can be implemented meaningfully.

e. Technology Integration in Special Education with a Deep Learning Approach

In the context of the digital era, the findings of this study provide a realistic picture aligned with the Universal Design for Learning (UDL) framework. The utilization of technology found is selective and adaptive according to students' abilities, ranging from simple assistive technologies like "pencil grips" to "interactive digital learning media." This aptly reflects the UDL principle of providing variety in methods of representation, engagement, and expression (CAST, 2024; Kelly et al., 2022; Meyer et al., 2014). The finding that AI is currently used more by teachers for designing learning, rather than being applied directly to students, aligns with the literature on adaptive technology (Chahal et al., 2024; Şanal, 2023) which emphasizes adapting technology to student needs and readiness, not the other way around.

However, limited facilities and infrastructure pose challenges, as technology use often depends on teachers' personal devices such as laptops, tablets, or mobile phones. Physical limitations of the classroom are also a consideration. This reflects the challenges highlighted by Salvia et al. (2017) regarding the lack of accessible digital media. Artificial intelligence has not been used directly by students but is utilized by teachers to design lesson materials, find references, and develop appropriate learning

activities. If AI-based technologies are used by students in the future, adult guidance will be necessary to ensure proper understanding and safe device use.

f. The Importance of Initial Assessment in Special Education

One of the most significant practical implications of this study is the finding that a strong initial assessment functions as the starting point of deep learning design in special education contexts. Initial assessment is not merely an administrative or diagnostic procedure; rather, it constitutes the foundational stage upon which all subsequent pedagogical decisions are built. Without a comprehensive understanding of students' strengths, needs, and learning readiness, the selection of learning projects, technological tools, vocational pathways, and partnership models risks becoming misaligned and ineffective.

The findings reveal that teachers must gather holistic and detailed data on students' cognitive, social, emotional, and functional profiles before designing instruction. Such data directly inform critical learning design choices, including the type of project-based activities implemented, the degree of task complexity, the form of technological support provided, and the nature of family and community involvement. This aligns with previous research highlighting that initial assessments—such as learner readiness inventories and class profiling conducted at the beginning of the academic year—are essential because they provide the empirical basis for adaptive instructional planning (Abellana et al., 2025).

Furthermore, a strong initial assessment ensures that deep learning originates from students' authentic needs rather than from predetermined curricular expectations. When assessment data are used as the foundation, teachers can intentionally design deep learning frameworks that integrate adaptive pedagogical strategies, meaningful functional partnerships, contextual learning environments, and technology aligned with students' abilities. In this sense, initial assessment operates as the **anchor of inclusive deep learning**, ensuring that instructional practices remain responsive, purposeful, and capable of supporting students' functional and vocational development in real-life contexts.

4. CONCLUSION

Based on all the analyses conducted, this study concludes that the implementation of deep learning for children with special needs in the digital age is essentially a transformative process that integrates four fundamental pillars. First, a contextual pedagogical approach through the stages of understanding-applying-reflecting, which is packaged contextually with the real lives of students. Second, a functional partnership between schools, families, and communities acts as an essential support ecosystem for creating meaningful learning experiences. Third, a responsive

curriculum with an emphasis on functional and vocational skills is the foundation for preparing students for independence. Fourth, selective and adaptive technology integration, supported by substantive inclusive policies, enables personalized learning.

The findings confirm that the success of deep learning is not determined solely by technological complexity or policy perfection, but rather by educators' depth of understanding of each student's specific needs and their ability to design authentic learning experiences that are relevant to the students' life contexts. The practical implications of this study emphasize the need for various interventions from multiple angles, ranging from teacher competency development, the provision and development of technology relevant to needs, and the formulation of policies that encourage inclusive education and student equality.

This study has clear limitations. These insights were obtained from a single case study. The successful perspectives and strategies of these participants may not be generalizable to the context of new teachers or regular schools that are still struggling to understand the philosophy of inclusion. Therefore, future research needs to explore the implementation of deep learning in inclusive schools that are still in the developing stage. In addition, research and development (R&D) is urgently needed to create user-friendly and accessible “adaptive technology” and “digital teaching materials” to address the challenge of “limited inclusive interactive learning facilities” in the digital age.

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