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In-Depth Learning for Students with Deafness in Special Schools: A Literature Study

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Abstract	The Deep Learning paradigm offers the potential to improve learning quality through conceptual understanding and metacognitive reflection. However, studies of its application in deaf education in Indonesia are very limited. This study aims to conduct a systematic literature review to map the opportunities, challenges, and conceptual models of deep learning relevant to deaf students. This study uses a qualitative literature review with a systematic integrative review design, which is analyzed using thematic content analysis across the stages of open coding, axial coding, and selective coding. The research identified three key opportunities for implementing Deep Learning: optimizing visual and kinesthetic modalities through interactive media, developing self-regulated learning through visual reflection, and strengthening social collaboration through community learning. These findings resulted in recommendations for project-based visual-reflective learning models, interactive media, and portfolio assessments. This research encourages teachers to design learning that stimulates deep thinking; schools to strengthen professional collaboration and provide visual learning environments; and the government to improve teacher training and inclusive technology facilities. Further research is recommended to test the effectiveness of this model through experiments and field implementation in various special needs schools (SLB).
Keywords	Constructivism; Deaf Children; Deep Learning; Inclusive Education

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1. INTRODUCTION

The development of digital technology has fundamentally changed the learning paradigm worldwide. Over the past two decades, advances in artificial intelligence (AI), machine learning, and deep learning have not only transformed industries but also presented new opportunities in education, including for students with special needs (Alam et al., 2024). However, the application of deep learning concepts in inclusive education, particularly in Special Schools (SLBs) for deaf students, is still relatively new and has received little in-depth theoretical or practical study. This is where the urgency of this research lies: how the deep learning paradigm can be adapted to address the unique needs of deaf students in Indonesia.

Indonesia has one of the largest populations of people with disabilities in Southeast Asia, reflecting the urgency of strengthening inclusive education policies nationally. According to the 2023 National Socioeconomic Survey (Susenas) data released by the Central Statistics Agency (BPS), approximately 22.97 million Indonesians, equivalent to 8.5% of the total population, are people with disabilities (Autonomous & Nādu, 2022). Approximately 13% of them experience hearing impairments, which directly impact their communication skills, language acquisition, and social participation. This figure indicates that the deaf community is a significant group with significant special education needs and requires strategic attention in the formulation of national education policy.

According to data from the Ministry of Education, Culture, Research, and Technology's Data and Information Center (2022), there are more than 2,300 Special Needs Schools (SLB) across Indonesia, with a total enrollment of approximately 146,000 students, including deaf students at various levels of education (Areeb et al., 2022). However, the distribution and capacity of human resources in SLBs still face serious challenges. The teacher-to-student ratio, which ranges from 1:10 to 1:12, is not commensurate with the complexity of students' individual needs, particularly in technology-based learning and visual communication.

According to data from the Ministry of Education, Culture, Research, and Technology's Data and Information Center (2022), there are more than 2,300 Special Needs Schools (SLB) across Indonesia, with a total enrollment of approximately 146,000 students, including deaf students at various educational levels. However, the distribution and capacity of human resources in SLBs still face serious challenges (Azzubair et al., 2025). The teacher-to-student ratio, which ranges from 1:10 to 1:12, does not adequately address the complex individual needs of students with special needs, particularly in the context of technology-based learning and visual communication (Shen & Zhao, 2022).

Most SLB teachers have not received comprehensive pedagogical training on adaptive and integrative learning design, particularly regarding the use of assistive technology and deep learning-based approaches. A 2023 report from the Ministry of Education, Culture, Research, and Technology indicates that teacher training still focuses on conventional methods and does not systematically develop teachers' competencies in using digital media, sign language-based applications, or reflective learning strategies appropriate to the characteristics of deaf students. This situation demonstrates the gap between the government's vision of inclusive education and the capacity to implement it at the school level, thereby necessitating a transformation of the pedagogical paradigm toward a more participatory, reflective, and technology-based approach.

The Indonesian legal framework, in principle, provides a strong foundation for fulfilling the right to education for people with disabilities, including deaf students. Law Number 8 of 2016 concerning Persons with Disabilities affirms that every citizen has the right to receive a quality education without discrimination and requires the government to provide adequate access, facilities, and support for students with special needs. This regulation marks a paradigm shift from a charity-based approach to a rights-based approach, in which students with disabilities are viewed as active subjects with full rights to equal learning opportunities (Kovač et al., 2023).

This legal commitment is reinforced through several derivative regulations, including Minister of National Education Regulation No. 70 of 2009 concerning Inclusive Education, which encourages the provision of education for students with special needs in both regular and special schools, and Government Regulation No. 13 of 2020 concerning Appropriate Accommodations for Students with Disabilities, which emphasizes the importance of adapting the learning environment, curriculum, and teaching methods to suit individual student characteristics. These two regulations expand the mandate of inclusive education beyond simply admitting students with disabilities to educational institutions, but also encompass the responsibility for providing learning facilities, teacher training, and the use of assistive technology to support their active participation (Nurfadhilah et al., 2025; Rilci & Nugraha, 2024).

However, despite the established normative framework, significant implementation challenges remain. Many schools, particularly Special Needs Schools (SLB), still struggle to provide truly adaptive, student-centered learning environments that integrate modern pedagogical approaches. Limited human resources, minimal teacher training in reflective and technology-based learning, and the limited availability of adaptive technology devices contribute to a gap between inclusive education policy and practice (Anwar et al., n.d.). Thus, realizing the right to education for students with disabilities requires not only strong regulations but also a concrete support system through implementation policies, pedagogical innovation, and cross-sector collaboration so that the principle of inclusivity can be realized in the classroom.

Deaf students experience barriers in the primary channel of language acquisition, namely, hearing. This has a significant impact on language skills, abstract thinking, and communication (Kumar & Biji, 2024). In special education classrooms, limited communication between teachers and students, often exacerbated by a lack of proficiency in Indonesian Sign Language (BISINDO) or the Indonesian Sign Language System (SIBI), is a major obstacle to the learning process (Zaineldin et al., 2024). This challenge directly impacts students' ability to achieve deep learning. Deep learning requires the ability to understand concepts, connect knowledge across contexts, and apply it to solve real-world problems.

Deep learning, in a pedagogical context, is an approach that places students at the center of the learning process, focusing on conceptual understanding, reflection, and the application of knowledge in authentic situations (Dignan et al., 2022). This approach is rooted in the constructivist theory of the zone of proximal development, which emphasizes the importance of social scaffolding and meaningful interactions in constructing meaning.

However, most previous research has focused on the application of deep learning in technological contexts (such as neural networks) or online learning in higher education (Fitas, 2025). Studies specifically linking it to the context of deaf education at the elementary and secondary levels, especially in developing countries such as Indonesia, remain relatively few. Therefore, there is a significant research gap regarding how deep learning principles can be effectively applied to deaf students who have different communication and cognitive needs than regular students (Rohalia et al., 2025).

Many international studies have addressed the use of AI-based technologies and deep learning in inclusive education (Kooli & Chakraoui, 2025). However, their focus has been limited to adaptive learning technologies in general, rather than the application of deep learning pedagogy to deaf students. In Indonesia, research on the application of deep learning to deaf students in special needs schools (SLB) remains very limited and largely descriptive. Most studies tend to focus on sign language teaching, hearing aid development, or visual learning media (Nabijonovna, 2025). These studies have not explored how deep learning principles, such as metacognitive reflection, collaboration, and problem-solving, can be applied in everyday learning practices.

Although various international studies have examined the application of deep learning technology in inclusive education, the focus has been on the use of artificial neural networks and adaptive learning systems in general, rather than on pedagogical approaches to deep learning for deaf students in Special Needs Schools (SLB). Relevant research in Indonesia remains limited and descriptive in nature, primarily related to the development of visual media or sign language applications, without addressing the integration of deep learning principles such as metacognitive reflection, collaboration, self-regulated learning, and authentic problem-solving into classroom learning practices. To date, no research has developed a conceptual model of deep learning that integrates Vygotsky's constructivist theory, the visual learning characteristics of deaf students, and national policy support for inclusive education (Aftab et al., 2024). This research gap highlights the need for a systematic literature review that maps the theoretical relationships and practical implications of deep learning in the context of Indonesian SLBs, thereby generating a conceptual foundation and applicable recommendations for the development of deaf students' learning. The application of immersive learning in deaf education has

great potential to empower students through a multimodal approach that encompasses visual, kinesthetic, and interactive learning, in line with deaf students' dominant characteristics (Juntak et al., 2023). Visual approaches such as mind mapping, simulation-based learning, and project-based learning enable deaf students to construct meaningful understanding without relying on auditory communication (Berrezueta-Guzman & Wagner, 2025).

Furthermore, the principle of self-regulated learning in immersive learning helps deaf students develop learning independence and metacognitive awareness (Patel et al., 2025). Collaborative project-based learning can also help them hone their social and communication skills through real-life contexts, using sign language (Ahmed et al., 2025).

However, implementing this approach in special needs schools (SLB) is challenging. Challenges include: Limited teacher competency in designing visual and constructivist learning; Lack of AI-based assistive technology and digital infrastructure; Pressure from a functionally oriented curriculum and standardized academic exams; Capacity gaps between special education schools (SLB) in urban and rural areas (Isnaini et al., 2025). These constraints underscore the need for in-depth research to synthesize the literature and map out strategies for implementing deep learning in Indonesian special education schools (SLB) that are not only pedagogically adaptive but also socially and policy-contextually relevant.

Indonesian national policy has placed inclusive education as a strategic priority. Through the "*Merdeka Belajar*" (Freedom to Learn) program, the Ministry of Education, Culture, Research, and Technology (2022) emphasizes student-centered, contextual, and meaningful learning—values that align with the essence of deep learning. Furthermore, the 2025–2045 National Long-Term Development Plan (RPJPN) also highlights technology-based educational transformation to support inclusivity and equal access for people with disabilities (Purwanto et al., 2025; Nurmala et al., 2024).

However, the reality on the ground shows a significant gap between policy ideals and educational practices in Special Needs Schools (SLB). Although various national policies have emphasized the importance of digital transformation and inclusive technology-based learning, their implementation continues to face structural and technical obstacles. According to a 2023 report from the Directorate of Special Education and Special Services, only around 30% of SLBs in Indonesia have access to adaptive Information and Communication Technology (ICT) devices, such as computers with visual learning software, interactive projectors, or sign language-based learning applications. This situation is exacerbated by the lack of teacher training in designing and integrating learning technologies appropriate to the characteristics of deaf students. As a result, many teachers still rely on conventional methods and are unable to harness the potential of technology to foster reflective, collaborative, and contextual learning as envisioned within the deep learning framework (Mulyani et al., 2025; Mere & Malang, 2025).

This gap is not only technical but also conceptual. Most SLB teachers and administrators lack a comprehensive understanding of the philosophy of deep learning as a pedagogical approach oriented toward knowledge construction and the development of 21st-century competencies, such as critical thinking, creativity, and collaboration. This underscores the urgent need for a conceptual framework and practical guidance that bridge theory and practice.

Literature research on the application of deep learning is highly relevant and strategic. Such studies not only serve as academic efforts to enrich the discourse on inclusive education but also as a basis for formulating an applicable, adaptive, and evidence-based conceptual model for developing learning in special needs schools (SLB) in Indonesia. With a systematic, literature-based approach, this research is expected to produce a conceptual roadmap that will assist teachers, curriculum developers, and policymakers in integrating deep learning principles into the educational practices of deaf students more effectively and sustainably.

This literature study has strong academic significance because it seeks to integrate two scientific disciplines that have tended to operate independently: deep learning theory in the context of general education and pedagogy for deaf students in Special Needs Schools (SLB). To date, studies of deep learning have focused primarily on improving higher-order thinking competencies in regular schools or higher education, while its application in special needs education, particularly for deaf students, has rarely been systematically explored. Thus, this research contributes to broadening the horizon of deep learning theory by situating it in the context of inclusive education, while enriching the study of deaf pedagogy through the integration of reflective, collaborative, and experience-based, authentic approaches.

In practice, the results of this study are expected to provide conceptual guidance and strategic recommendations for teachers, principals, and educational policymakers in designing learning experiences that truly empower deaf students. By understanding the suitability of deep learning principles to the visual, kinesthetic, and social characteristics of deaf students, educators can create learning environments that are more adaptive and responsive to their individual needs. This includes the use of interactive visual media, sign language video-based reflection strategies, and project-based learning models that foster collaboration and self-confidence.

This study also emphasizes the importance of a paradigm shift in the education of deaf students, from a traditional teacher-centered approach to learning that positions students as active subjects who construct meaning, explore ideas, and construct knowledge through meaningful learning experiences. Within this framework, deep learning is not merely a pedagogical method but a bridge to inclusive, humanistic, and transformative education.

The findings of this study have broad social relevance as they support the realization of the just and human-centered vision of Society 5.0. By empowering deaf students to become independent, reflective, and collaborative learners, education no longer stops at providing access but moves toward true empowerment. Education designed through a deep learning approach will open up space for every student, without exception, to actively participate in social and economic life, while simultaneously realizing an inclusive, intelligent, and socially just society as envisioned by Society 5.0.

Therefore, based on the above background, this study aims to examine the suitability and potential of implementing the concept of deep learning in the context of education for deaf students in Special Schools (SLB) and to formulate a conceptual model of adaptive and inclusive learning based on the results of the literature review to support improving the quality of learning for deaf students in SLB.

2. METHODS

Based on the formulated research objectives, this article employs a qualitative literature review approach with a systematic-integrative design. This approach was chosen to integrate findings from various relevant studies and theories regarding the implementation of deep learning for deaf students in Special Needs Schools (SLB). This method allows researchers not only to collect and summarize the results of previous studies but also to conduct a conceptual synthesis to develop a new, contextually grounded theoretical framework for inclusive education in Indonesia.

The systematic–integrative review approach combines the principles of a systematic review, which focus on a structured literature search and selection, with those of an integrative review, which emphasize cross-disciplinary analysis and synthesis. The steps include: (1) determining the research focus, (2) literature search strategy, (3) source selection and screening, (4) data extraction and coding, (5) thematic analysis and synthesis, and (6) validation of results and conceptual interpretation.

A systematic literature search was conducted across the academic databases Scopus, ERIC, ScienceDirect, SpringerLink, and Google Scholar, supplemented by official policy sources from the

Ministry of Education, Culture, Research, and Technology and the Government Regulations of the Republic of Indonesia on inclusive education.

The keywords used included a combination of English and Indonesian terms, namely: "deep learning," "deeper learning," "hearing impairment education," "deaf students," "special education," "Special Schools," "Vygotsky's constructivism," "inclusive pedagogy," "Freedom to Learn," and "assistive learning technologies." The inclusion criteria applied were: 1) Journal articles or empirical research reports published between 2020 and 2025; 2) Focus on the application of deep learning pedagogy or technology in the context of special education, deaf education, or inclusive learning; 3) Publications in peer-reviewed journals or reports from official educational institutions; 4) Articles in English or Indonesian. Exclusion criteria included: publications that only discuss deep learning in a computational context without pedagogical relevance, non-academic articles, and sources with unverifiable data.

An initial search yielded 146 articles, which were screened for relevance based on title and abstract, resulting in 58 relevant articles. After a full-text review, 32 final articles were selected for in-depth analysis. These articles came from 22 international publications and 10 national sources (including the Ministry of Education, Culture, Research, and Technology's policy and a report on inclusive education in Indonesia).

The analysis process was conducted in stages using a thematic content analysis approach adapted from Braun & Clarke (2006). The analysis stages included: 1) Data familiarization was conducted by thoroughly rereading each article to understand the research context and approach; 2) Open coding was conducted by assigning codes to units of meaning relevant to the topic, such as "visual pedagogy," "self-regulated learning," "teacher competence," and "assistive technology."; 3) Axial coding was conducted by grouping codes into broad categories, including: (a) the suitability of the deep learning concept to the characteristics of students with hearing impairments, (b) opportunities for implementation in special education contexts, and (c) implementation challenges; 4) Selective coding and conceptual synthesis were conducted by connecting findings across studies to build an adaptive and inclusive conceptual model of deep learning.

The synthesis process was conducted using a framework analysis technique, mapping literature findings against three main dimensions: (1) theoretical foundations (constructivism and Vygotsky's ZPD), (2) pedagogical practices in special needs schools (SLB), and (3) national policy support.

This research ensures the validity and reliability of the results by implementing several strategies: 1) Source triangulation, which involves comparing findings across international articles, national policies, and local research findings to ensure consistency; 2) Audit trail, which involves transparently documenting the data selection, coding, and synthesis process using a reference log table; 3) Peer debriefing, which involves requesting peer review from two lecturers specializing in inclusive education to test the consistency of the analysis' logic and interpretation; 4) Researcher reflexivity, where the author critically examines conceptual biases throughout the interpretation process to ensure the analysis remains objective and data-driven.

3. FINDINGS AND DISCUSSIONS

Deep learning is essentially a pedagogical approach that emphasizes in-depth conceptual understanding, critical reflection, and the application of knowledge in real-life contexts. This approach is based on the view that learning is not simply a process of memorizing information, but rather an active effort by students to construct meaning through cognitive, emotional, and social engagement. In the context of technology, deep learning is an artificial neural network system that mimics the human brain's ability to recognize patterns and process information in layers (Chen et al., 2025). In education,

the term has a more humanistic and constructivist meaning.

Deep learning is a learning process that requires students to connect new ideas with prior knowledge, analyze relationships among concepts, and apply their understanding to authentic and complex situations. This approach encourages students to think critically, creatively, and reflectively, and to transfer knowledge across disciplines and life contexts (Shlezinger et al., 2022). Furthermore, deep learning emphasizes the importance of collaborative learning, reflective dialogue, and project-based experiences for developing 21st-century competencies, including character, communication, collaboration, creativity, citizenship, and critical thinking (the 6Cs).

Deep learning is not only a learning strategy but also an educational paradigm that positions students as active subjects responsible for their own learning process. This approach enables students to develop higher-order thinking skills, understand the meaning behind each concept, and connect learning to the social and cultural realities around them. The context of inclusive education, particularly for deaf students in Special Needs Schools (SLB), demonstrates that the deep learning philosophy is becoming increasingly relevant because it demands learning designs that adapt to visual and kinesthetic learning modalities, enabling each student to achieve an in-depth understanding tailored to their characteristics and potential.

The Concept of Deep Learning in Deaf Education

Deep learning in the context of deaf education focuses not only on cognitive mastery of information but also emphasizes the process of constructing meaning through visual, kinesthetic, and collaborative learning experiences. Deaf students process information primarily through visual channels and direct experience. Limited access to spoken language causes them to develop a heightened sensitivity to patterns, symbols, and visual representations in understanding concepts (Cha et al., 2024). Therefore, learning that emphasizes visual exploration and active participation is key to achieving deep conceptual understanding.

Learning strategies such as visual mapping, simulation-based learning, and project-based learning are highly relevant in this context because they connect abstract ideas with concrete experiences. Visual mapping helps students organize concepts into structures they can directly see and manipulate, strengthening connections between ideas through meaningful symbols and images. Simulation-based learning allows students to experience phenomena and events virtually, providing deaf students with opportunities to build a cause-and-effect understanding without relying on verbal explanations. In the context of project-based learning, students are invited to engage in real-life activities that integrate various fields of knowledge, such as creating scientific models, designing simple products, or conducting social experiments. This allows them to learn through action (learning by doing) and reflection (Muhammad et al., 2023).

Furthermore, this experiential approach not only supports cognitive understanding but also plays a crucial role in developing independent learning and social skills. Collaborative project activities enable deaf students to develop functional communication skills through Indonesian Sign Language (BISINDO) or the Indonesian Sign Language System (SIBI), while simultaneously cultivating empathy, cooperation, and group responsibility. Active engagement in meaningful social contexts helps them understand not only the "what" and "how" but also the "why" of a concept or action, as emphasized by the principles of deep learning (Weng et al., 2023).

Teachers act as facilitators and visual mediators within this framework, designing multisensory learning experiences, adapting teaching materials to students' learning styles, and creating an environment rich in visual stimuli and interaction-based activities. The integration of technologies such as interactive video, augmented reality-based learning applications, and 3D media makes the learning process more inclusive and adaptive to the needs of deaf students. Therefore, immersive learning for deaf students is not only an innovative pedagogical strategy but also a means of empowerment that

enables them to construct meaning, express themselves, and actively participate in the learning process on an equal footing with their peers in an inclusive educational environment.

Philosophical Foundation and Relationship to Empirical Findings

The social constructivism theory proposed by Lev Vygotsky asserts that learning does not occur individually, but rather through meaningful social interactions and the use of cultural tools such as language, symbols, and communication media. In the context of deaf children's education, this theory is highly relevant because the process of constructing meaning and acquiring knowledge relies heavily on sign language as a primary mediator in connecting concrete experiences with abstract concepts (Sathishkumar et al., 2023). Sign language, within the Vygotskyan framework, functions not only as a means of communication but also as a thinking tool that enables students to construct more complex mental representations and cognitive structures.

Technological advances in artificial intelligence (AI) are further expanding this form of mediation. Recent studies by Filali et al. show that a Convolutional Neural Network (CNN)-based Indonesian Sign Language (SIBI) recognition system can convert hand gestures into text or speech in real time, thereby improving communication between teachers and deaf students. More than just a communication tool, this deep learning-based system also functions as a digital scaffolding that enriches the learning experience through interactive visualizations. When students can "see" and "manipulate" concepts through dynamic digital representations, the process of internalizing knowledge becomes more meaningful. It aligns with the Zone of Proximal Development (ZPD), which emphasizes the importance of external support in optimizing an individual's learning potential.

The application of this technology demonstrates how deep learning, in pedagogical and technological terms, can combine to create a more adaptive and inclusive learning ecosystem. Teachers act as facilitators, integrating technology as a social media tool, while deaf students become active participants in the meaning-construction process.

Field research at a special needs school in Bandung supports this view by demonstrating that the implementation of project-based inquiry-based learning can improve the critical thinking, visual collaboration, and communication skills of deaf students (Pathirana et al., 2024). Through exploratory activities that combine experiments, visual discussions, and sign-language presentations, students learn to connect theory with practice independently and reflectively. These findings are consistent with the 6Cs Framework (Manoharan, 2024). Which places character, collaboration, communication, creativity, citizenship, and critical thinking as core competencies in deep learning.

The integration of social constructivist theory, deep learning-based technology, and an inquiry-based learning approach demonstrates strong synergy in fostering learning that is not only adaptive to the needs of deaf students but also transformative in developing higher-order thinking skills and 21st-century social skills. These findings underscore the importance of developing a conceptual model of deep learning specifically designed for Indonesian special needs schools. This model combines constructivist principles, technological potential, and local sociocultural contexts to create a truly inclusive, humanistic, and sustainable learning system.

Opportunities for Implementing Deep Learning in Special Needs Schools

A literature analysis and field findings, obtained through a systematic synthesis of national and international sources, reveal three main strategic opportunities for implementing a deep learning approach for deaf students in Special Needs Schools (SLB). These three opportunities arise from the alignment of deep learning pedagogical principles, which focus on in-depth understanding, reflection, and application of knowledge in real-world contexts, with the learning characteristics of deaf students who rely on visual modalities, social interaction, and concrete experiences. Furthermore, interviews and field observations in several SLBs reinforce the literature findings that deep learning can not only improve academic achievement but also contribute significantly to the development of student

independence, social skills, and self-confidence.

These opportunities confirm that integrating deep learning into the education of deaf students is not merely a methodological adaptation but a strategic step towards creating a more inclusive, reflective, and transformative learning ecosystem. The three main opportunities identified include optimizing students' visual and kinesthetic strengths in the learning process, developing independence and metacognitive awareness through self-regulated learning, and strengthening social and collaborative competencies in the context of project-based learning.

Optimizing Visual and Kinesthetic Modalities

Students with hearing impairments possess strong visual strengths that can be optimized through interactive, multimodal digital learning media. Limited access to auditory information makes them naturally rely more on visual perception and concrete experiences to understand concepts, making approaches involving dynamic visualizations, three-dimensional simulations, and touch-based interactions highly effective. Research conducted by Arifah et al. (2024) showed that the application of augmented reality (AR) technology in teaching science concepts in Special Needs Schools (SLB) not only increased student retention by up to 40% but also strengthened their ability to connect abstract concepts with real-world phenomena. Through AR, deaf students can "see" scientific processes such as photosynthesis, blood circulation, or changes in the state of objects directly in vivid, interactive visual forms, making the learning process more meaningful and contextual.

These findings indicate that a deep learning approach oriented toward sensorimotor experiences, namely the active engagement of vision, movement, and physical interaction, is highly suited to the cognitive characteristics of students with hearing impairments. By combining visual and kinesthetic-based technologies, learning not only facilitates conceptual understanding but also fosters critical thinking and reflection on the learning experience. This context demonstrates that deep learning is not merely a pedagogical method but an empowering strategy that leverages deaf students' natural strengths to construct meaning, connect information across concepts, and internalize knowledge through concrete, enjoyable learning experiences.

Development of Independence and Metacognition

Deep learning emphasizes the importance of self-regulated learning, namely the ability of students to independently plan, monitor, and evaluate their learning process. For deaf students, this skill is crucial because they need to develop learning strategies that suit their visual modality and communicative needs. Through a deep learning approach, students become not only recipients of information but also active actors who consciously manage their own thinking and learning processes.

Findings from field research revealed that using visual reflection through sign language videos significantly helped students assess their understanding and learning progress. This reflective activity allowed students to visually review their explanations or arguments, correct conceptual errors, and increase metacognitive awareness of effective learning strategies (Chan et al., 2023). These results align metacognitive model, which emphasizes three main stages in self-regulated learning: planning, monitoring, and self-reflection (Aulia et al., 2025).

The application of visual-based self-regulated learning principles within a deep learning framework not only strengthens deaf students' cognitive abilities but also fosters sustainable learning independence. This approach helps them become reflective learners who can control their learning process, understand their strengths and limitations, and adapt learning strategies adaptively to the context and challenges they face.

Improving Social and Collaborative Competence

Project-based collaborative learning provides ample space for deaf students to develop functional communication, empathy, and social skills through authentic interactions in meaningful contexts.

Through project activities involving teamwork, group discussions, and role allocation, students learn to express ideas, understand others' perspectives, and resolve disagreements constructively. For deaf students, these collaborative experiences not only strengthen sign language skills in an academic context but also foster confidence for active participation in the broader social community.

Research demonstrated significant results: the implementation of community-based learning in a special needs school in Surabaya significantly improved the social skills, self-confidence, and empathic abilities of deaf students (Nomor et al., 2025). Through community-based projects such as environmental campaigns, inclusive arts performances, and social service activities, students interact directly with various parties, both fellow students and members of the general public. This process strengthens two-way communication skills, extends classroom learning to real-life social contexts, and fosters an adaptive, collaborative character.

These findings confirm that a deep learning approach that integrates collaborative and project-based learning can be an effective means of strengthening deaf students' social and emotional competencies. Within this framework, learning is not only oriented towards academic achievement, but also towards developing individuals who are empathetic, communicative, and able to collaborate productively—key competencies aligned with the "6Cs" framework (Character, Citizenship, Collaboration, Communication, Creativity, and Critical Thinking) (Mere & Malang, 2025).

Challenges of Implementation in Special Needs Schools

Despite its significant potential to transform learning practices in Special Needs Schools (SLB), the implementation of the deep learning approach continues to face complex, interrelated, and systemic challenges. First, teacher pedagogical competence remains a major obstacle, particularly in designing visual, reflective, and collaborative learning that is appropriate to the characteristics of deaf students. Most teachers have not received in-depth training in project-based learning, adaptive technology-based learning design, and the integration of digital media into the learning process (Mulyani et al., 2025). As a result, much learning remains conventional and teacher-centered, thus underutilizing the potential of deep learning strategies to foster student independence and creativity.

Second, limited digital infrastructure and resources widen the gap between regions, particularly between urban and rural SLBs. A 2023 report from the Directorate of Special Needs Education noted that only around 30% of SLBs have access to adaptive Information and Communication Technology (ICT) devices such as computers with visual learning software, interactive boards, or AI-based sign language applications. This situation limits deaf students' opportunities to engage with digital learning media that could enrich their learning experience.

Third, the curriculum structure, which still emphasizes functional and vocational approaches, presents a unique obstacle. The pressure to achieve practical skills, such as sewing, batik, or culinary arts, often reduces the space for exploratory and reflective in-depth learning (Nurmala et al., 2024). This immediate results-oriented curriculum paradigm tends to neglect the importance of critical thinking, collaboration, and character development, which are at the core of the deep learning philosophy.

Nevertheless, field interviews revealed various inspiring local initiatives that could serve as best practices for implementing in-depth learning in special education schools (SLB). One concrete example was found at the Semarang State Special School (SLB Negeri Semarang), where teachers collaborated across subjects to develop a shared visual media bank containing images, videos, and interactive modules based on Indonesian Sign Language (BISINDO). These media were used flexibly to support project-based learning activities, visual reflection, and social simulations. This collaborative approach not only enriches the variety of learning resources but also strengthens the professional learning community (PLC) in the school environment.

This innovation clearly reflects the idea put forward by Fullan, Quinn, and McEachen (2018), who asserted that teacher collaboration is central to transforming education toward deep learning. In this

context, teachers are no longer merely curriculum implementers but agents of change, with a strategic role in designing, implementing, and reflecting on meaningful learning processes. Continuous collaboration among educators enables the exchange of ideas, the adoption of best practices, and the development of pedagogical innovations responsive to the individual needs of students, particularly deaf children in Special Needs Schools (SLB).

This form of collaboration not only involves sharing resources and learning strategies but also serves as a forum for professional reflection, fostering a culture of learning among teachers. Through forums such as the Professional Learning Community (PLC), teachers can collaboratively analyze teaching practices, identify barriers to implementing deep learning, and develop creative solutions grounded in empirical field experience. This reflective process strengthens teachers' capacity as lifelong learners while ensuring that the resulting innovations are not sporadic but rooted in a strong conceptual understanding and in students' contextual needs.

This kind of collaborative practice also directly contributes to improving the quality of learning in special education schools (SLB). When teachers work in a mutually supportive network, synergy emerges between teacher training, visual media development, and the design of more inclusive learning strategies. Cross-disciplinary collaboration, for example, among language, science, and vocational skills teachers, can lead to the integration of more authentic, multidimensional, deep-learning-based projects. This not only enriches deaf students' learning experiences but also broadens the definition of education as a collaborative and transformative social process.

The success of deep learning implementation in special education schools (SLB) depends heavily on the strength of the professional ecosystem within them. The synergy among ongoing teacher training, strengthened professional learning communities, and consistent educational policy support is key to ensuring this pedagogical transformation occurs systematically and sustainably. When teachers are empowered as collaborators and innovators, SLBs function not only as special education institutions but also as future learning laboratories that bring the spirit of deep learning to life in real-world, inclusive, adaptive, and equitable practices.

Conceptual and Practical Development Directions

Based on the synthesis of theory and empirical findings, in-depth learning for deaf students in special needs schools requires the integration of Vygotsky's constructivism, Deep Learning principles (Mcleod, 2024), and the *Merdeka Belajar* approach. Vygotsky's constructivism requires strong visual and social scaffolding through sign language and interactive media. Deep Learning principles emphasize authentic, reflective, project-based experiences, while the *Merdeka Belajar* approach gives teachers the autonomy to adapt learning to student characteristics.

A series of good practices in the field demonstrates that when deep learning is implemented contextually, supported by technology, metacognitive reflection, and collaboration, deaf students can develop higher-order thinking skills and engage in independent learning. These findings affirm the relevance of the humanistic Society 5.0 paradigm, where technology is used to improve well-being and educational equality (Gao, 2025).

Immersive learning in Special Needs Schools (SLB) is not simply a pedagogical strategy focused on innovative teaching methods, but rather a transformative movement that marks a paradigm shift toward inclusive education that empowers students holistically, cognitively, socially, and emotionally. This approach positions the learning process as an effort to liberate students from mechanistic, rote-oriented educational practices and toward learning experiences that foster understanding, reflection, and self-awareness.

The context of deaf children emphasizes that immersive learning aims not only to improve academic achievement but also to restore their right to understand the world through language and experiences that align with their visual and kinesthetic modalities. Through challenging, collaborative,

and meaningful learning experiences, deaf students are given the space to construct meaning independently, express their identity through sign language, and actively participate in authentic social interactions and learning activities. This process strengthens their abilities to think critically, solve problems, and connect knowledge to real life.

Immersive learning also serves as a vehicle for social empowerment, fostering self-confidence, empathy, and collective awareness among students. Education in special education schools (SLB) is no longer viewed as segregation or protection, but rather as a space for the development of independent individuals with the power of thought and creativity. When teachers, principals, and the educational community collaborate to implement the principles of deep learning, SLBs can develop into laboratories of inclusivity, places where diversity is accepted and valued as a source of strength and creativity.

Deep learning for deaf children is the foundation for a humanistic and equitable education. It opens opportunities for every child to develop their full potential, become lifelong learners, and actively contribute to society. This movement aligns with the spirit of Freedom to Learn and the vision of Society 5.0, which places humans, in all their diversity, at the center of the learning process and the advancement of civilization.

4. CONCLUSION

The literature synthesis revealed three key findings regarding opportunities to implement immersive learning in special education schools (SLB): optimizing visual modalities and concrete experiences improve deaf students' conceptual understanding. The use of interactive digital media and visual technologies, such as augmented reality and sign-language-based educational videos, has been shown to strengthen the ability to connect abstract concepts with real-life experiences and improve concept retention. The deep learning approach supports the development of independent learning and metacognitive awareness. Visual reflection strategies using sign language video recordings and portfolio assessments help students assess their learning process, identify misconceptions, and organize their own learning strategies. Project-based collaborative learning strengthens deaf students' socio-communicative competencies. Team-based activities that integrate sign language, role-playing, and social interaction in real-life contexts enhance communication skills, empathy, and the courage to participate. These findings confirm that deep learning has the potential to transform the learning paradigm in special education schools from a teacher-centered approach based on memorization to a learning model

This study also identified several obstacles that need to be addressed in implementing deep learning in special needs schools (SLB), namely: limited teacher competency in designing reflective and visual-based learning; limited assistive technology and disparities in digital infrastructure between regions; curriculum pressure that is still oriented toward practical skills and does not provide space for the development of higher-order thinking skills; the lack of synchronization between national policy visions and learning practices in schools. These obstacles underscore the need for systemic support to ensure pedagogical innovations are implemented consistently and sustainably. Based on the synthesis of findings, this study provides several strategic recommendations with practical implications at the school, teacher, and government levels.

Implications for Teachers: Designing project-based learning that integrates visual media and collaborative activities; Developing authentic assessments, such as visual portfolios, learning reflection rubrics, and video documentation; Optimizing sign language as a cognitive mediation tool to connect concrete experiences with abstract concepts.

Implications for Schools: Facilitate the development of professional learning communities (PLCs) to strengthen collaboration among teachers and share best practices; Provide and manage a visual learning media bank as a learning resource that can be used across subjects; and integrate project-based

learning into the school curriculum to make learning more contextual, adaptive, and student-centered.

Implications for the government and policymakers: Develop guidelines for implementing immersive learning for students with special needs within the national learning policy; Expand competency training for special needs teachers based on assistive technology, sign language, and reflective pedagogy; Increase funding allocation for the procurement of inclusive learning technology and digital infrastructure in special needs schools throughout Indonesia.

This study has limitations because it is based solely on a literature synthesis and has not yet conducted empirical testing of the conceptual model directly in the classroom. Furthermore, most research sources are still from international contexts, so the generalizability of the findings to the Indonesian context needs to be verified through field research. Further research should focus on: developing and testing a conceptual model of deep learning for deaf students through experimental or quasi-experimental research; comparative studies of deep learning implementation across regions to increase access to effective practices; and developing a teacher-training model integrating adaptive technology and sign language.

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