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ANALYSIS OF THE IMPLEMENTATION OF THE DEEP LEARNING APPROACH IN STRENGTHENING ELEMENTARY SCHOOL STUDENTS' DIGITAL LITERACY

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ABSTRACT

This study aims to analyse the implementation of the deep learning approach in cultivating digital literacy among elementary school students, identify the challenges and solutions encountered during its implementation, and examine its impact on students' digital literacy competencies. A qualitative case study design was employed in two elementary schools with different digital literacy contexts. Data were collected through classroom observations, document analysis, and semi-structured interviews with principals, teachers, and students. Data analysis followed an iterative framework involving data condensation, data display, and conclusion drawing, while data trustworthiness was ensured through source triangulation, technique triangulation, and member checking. The findings reveal that the deep learning approach was implemented systematically through planning, implementation, evaluation, and reflection stages. Learning activities integrated digital technologies, collaborative inquiry, information exploration, and process-oriented assessment to support meaningful learning experiences. Several challenges were identified, including limited technological infrastructure, disparities in students' digital literacy skills, teachers' varying levels of digital competence, and restricted instructional time. These challenges were addressed through collaborative learning, peer tutoring, alternative learning resources, and continuous professional development for teachers. The implementation of deep learning cultivated students' abilities to access, understand, evaluate, and utilize digital information. Students demonstrated greater independence in technology use, stronger critical thinking skills in evaluating information, and increased creativity in producing digital-based learning products. The study implies that deep learning provides an effective pedagogical framework for cultivating digital literacy in elementary education by fostering active engagement, critical inquiry, collaboration, and reflective learning. Successful implementation requires adequate technological support, teacher readiness, and adaptive learning strategies that accommodate local school contexts.

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INTRODUCTION

The rapid development of digital technology in the era of the Fourth Industrial Revolution has transformed the way people learn, work, and interact. In the field of education, digital literacy has become one of the essential twenty-first-century competencies that students need to develop from the elementary level. Digital literacy is not limited to the ability to operate digital devices; it also encompasses the skills to access, understand, evaluate, utilize, and create digital content responsibly (Li, 2025). Mastery of twenty-first-century skills, including critical thinking, communication, collaboration, and creativity, serves as an important foundation for addressing global challenges (Baharuddin, 2025). These competencies play a significant role in shaping learners who can adapt to ongoing technological advancements. Therefore, digital literacy and twenty-first-century skills are essential components of modern education that should be cultivated from the elementary school level.

The rapid proliferation of digital technologies in the era of Industry 4.0 has transformed the ways individuals learn, work, and interact. Within educational contexts, digital literacy has emerged as a foundational competency that students need to develop from the elementary school level. Digital literacy extends beyond the ability to operate digital devices and encompasses the capacities to access, understand, evaluate, utilize, and create digital content responsibly (Li, 2025). Alongside digital literacy, twenty-first-century competencies, including critical thinking, communication, collaboration, and creativity, have become essential for preparing students to navigate increasingly complex technological and social environments (Baharuddin, 2025). Consequently, developing digital literacy and higher-order thinking skills has become a central objective of contemporary elementary education.

Empirical evidence reveals that students' digital literacy competencies remain unevenly developed, particularly at the elementary school level. Previous studies indicate that many students experience difficulties in understanding, evaluating, and utilizing digital information effectively (Maulana et al., 2025). Digital literacy development is influenced by multiple factors, including learning environments, instructional strategies, and the extent to which technology is integrated into educational practices (Atmojo & Wardana, 2025). The variation in students' competencies suggests persistent disparities in digital literacy attainment that require systematic educational interventions.

Challenges associated with digital literacy development are further intensified by suboptimal technology integration in elementary schools. Technology is often utilized for limited instructional purposes, while teachers frequently encounter difficulties in incorporating digital tools into meaningful learning experiences. Limited teacher competence in educational technology and insufficient development of digital learning media remain significant barriers to effective implementation (Tabina et al., 2025). School readiness to implement technology-enhanced learning also varies considerably, particularly in areas with limited infrastructure support (Norfika, 2025). These conditions highlight the need for innovative instructional approaches capable of integrating technology meaningfully while promoting students' active engagement in learning.

One pedagogical approach that addresses these challenges is deep learning. Deep learning emphasizes meaningful understanding, critical inquiry, problem-solving, and the connection between knowledge and real-life contexts (Sudarmono et al., 2025). Research has demonstrated that deep learning can enhance students' literacy competencies through contextualized and interactive learning experiences (Ismail et al., 2025). The approach also encourages active participation, collaboration, reflection, and sustained engagement, all of which are essential components of effective digital literacy development (Laksono, 2025). By positioning students as active constructors of knowledge, deep learning provides opportunities to holistically develop both digital literacy and higher-order thinking skills required in twenty-first-century education.

Recent studies have highlighted the positive contribution of deep learning to improving learning quality and literacy outcomes in elementary education (Ismail et al., 2025; Simamora et al., 2025; Sudarmono et al., 2025). Other studies have emphasized the importance of digital technologies and artificial intelligence in supporting students' digital literacy development (Maulana et al., 2025; Rahmawati et al., 2022; Saqjuddin et al., 2025). However, existing research tends to focus on either learning outcomes or technology utilization separately, providing limited insight into how deep learning strategies systematically cultivate digital literacy competencies. Furthermore, studies examining the implementation of deep learning in elementary schools often overlook the interconnected dimensions of digital literacy, namely accessing, understanding, evaluating, and utilizing digital information. Research addressing these dimensions simultaneously within authentic classroom settings remains limited.

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The novelty of this study lies in its comprehensive examination of how deep learning is contextualized to holistically develop digital literacy competencies among elementary school students. Unlike previous studies that focus primarily on learning achievement or technology use, this study investigates the integration of deep learning strategies with digital literacy development across four interconnected dimensions: accessing, understanding, evaluating, and utilizing digital information. Methodologically, the study employs a qualitative case study approach across two schools with different digital literacy implementation contexts, enabling a deeper understanding of instructional practices, implementation challenges, adaptive strategies, and learning outcomes within real educational settings.

Accordingly, this study aims to: (1) analyze the forms and strategies through which the deep learning approach is implemented to cultivate digital literacy among elementary school students; (2) identify the challenges and solutions associated with its implementation across different school contexts; and (3) examine how the implementation of deep learning influences students' abilities to access, understand, evaluate, and utilize digital information.

METHOD

This study employed a qualitative approach with a multiple-case study design to explore the implementation of the deep learning approach in cultivating digital literacy among elementary school students. The research was conducted at SD Negeri Sri Tanjung and SD Negeri Lubuk Harjo, two schools representing different contexts of digital literacy implementation. Participants were selected using purposive sampling and consisted of two principals, four teachers, and twelve students who were directly involved in digital literacy learning activities. Data collection was conducted over a three-month period through classroom observations, document analysis, and semi-structured interviews. Prior to data collection, participants received information regarding the research objectives, and informed consent was obtained from school authorities and participants to ensure ethical compliance.

Data collection focused on documenting instructional planning, classroom implementation, learning interactions, and students' digital literacy practices. Classroom observations were conducted during learning activities to capture the implementation of deep learning strategies, while semi-structured interviews were used to explore participants' experiences, perceptions, and challenges. Supporting documents, including teaching modules, student assignments, assessment records, and school policies related to digital literacy, were collected to strengthen data triangulation. The use of multiple data sources enabled a comprehensive understanding of instructional practices across both school contexts.

Data analysis followed the interactive model of Miles, Huberman, and Saldaña. The process began with data condensation through coding, categorization, and identification of emerging themes related to deep learning implementation and digital literacy development. Subsequently, the data were organized and displayed in matrices and thematic narratives to facilitate interpretation. The final stage involved drawing and verifying conclusions by comparing findings across data sources and participant groups. To enhance trustworthiness, the study employed source triangulation, technique triangulation, and member checking throughout the research process.

RESULT AND DISCUSSION

Results

Forms and Strategies of Deep Learning Implementation in Learning Planning

Documentation data revealed that lesson planning was developed through teaching modules integrating learning objectives, digital technology, collaborative activities, and assessment. The modules were designed to promote students' understanding of cultural heritage and local economic activities through contextual learning experiences. Digital resources such as YouTube videos, LCD projectors, and the Quizizz platform were incorporated to support information access, exploration, and interactive learning. Instructional approaches included discussion, presentation, game-based learning, and problem-based learning.

The modules also revealed a structured learning process that encouraged students to explore information independently. Students were assigned to observe digital learning materials, conduct interviews, investigate local cultural heritage, gather information from various sources, and prepare reports collaboratively. In the economic learning topic,

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students identified economic activities within their surroundings through observation and information collection before participating in role-playing activities. These learning tasks were organized within heterogeneous groups formed according to the results of an initial diagnostic assessment.

The findings further demonstrated that the learning process was organized into three interconnected stages: understanding, application, and reflection. During the understanding stage, students accessed information through digital learning media. The application stage involved information searching, interviews, report writing, worksheet completion, and collaborative learning activities. Reflection was facilitated through teacher feedback and individual reflection journals. Assessment practices included formative and summative evaluation, performance-based assignments, observation sheets, and presentation rubrics assessing communication and critical response skills.

Overall, the documentation revealed that lesson planning systematically integrated information exploration, collaboration, digital technology utilization, reflection, and authentic assessment. These elements constituted the foundational structure of deep learning implementation aimed at strengthening students' digital literacy.

Table 1. Forms and Strategies of Deep Learning Implementation for Digital Literacy Development in Elementary Schools

No.	Implementation Component	Strategy	Key Findings
1	Learning Planning	Integration of digital technology and inquiry-based activities	Teaching modules incorporated digital resources, collaborative tasks, information exploration, and authentic assessment to support meaningful learning.
2	Learning Implementation	Active and exploratory learning	Students independently accessed, processed, and presented digital information, while teachers functioned as facilitators.
3	Collaborative Learning	Group discussion and peer interaction	Students worked in heterogeneous groups to analyze information, solve problems, and construct shared understanding.
4	Assessment	Process-oriented and authentic assessment	Learning outcomes were evaluated through observations, performance tasks, digital products, presentations, and formative assessment.
5	Reflection	Individual and collaborative reflection	Reflection activities encouraged students to evaluate learning experiences and strengthen digital literacy awareness.

Source: Researcher's Data (2026)

The findings presented in Table 1 demonstrate that the implementation of deep learning for digital literacy development was organized through interconnected stages of planning, implementation, assessment, and reflection. The integration of digital technology, inquiry-based activities, collaborative learning, and authentic assessment created opportunities for students to actively construct knowledge rather than passively receive information. This process enabled students to engage in information exploration, critical analysis, and reflective thinking, which are essential dimensions of digital literacy. These findings suggest that the effectiveness of deep learning lies not merely in the use of digital tools but in its capacity to facilitate meaningful learning experiences that cultivate higher-order thinking and digital literacy competencies simultaneously.

Challenges and Solutions in Implementing the Deep Learning Model to Strengthen Digital Literacy in Elementary Schools

Documentation, observation, and interview data revealed that the implementation of deep learning for digital literacy development was influenced by contextual factors related to infrastructure, student readiness, teacher competence, and instructional time. The two participating schools implemented deep learning in different contexts—regular classroom instruction and extracurricular activities, resulting in variations in instructional practices and resource utilization. Despite these differences, similar challenges emerged across both settings, indicating that successful implementation depended on the ability of schools and teachers to adapt learning strategies to local conditions.

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The first challenge concerned limited technological infrastructure. Observations revealed insufficient availability of digital devices, requiring students to share equipment during learning activities. Internet connectivity was also unstable, restricting access to online learning resources. Interviews with teachers confirmed that these constraints occasionally disrupted planned digital learning activities, while document analysis demonstrated that several technology-based activities could not always be implemented as intended. To address these limitations, teachers organized collaborative group work, assigned specific responsibilities to group members, and incorporated offline learning resources. Schools also gradually improved technological facilities through phased procurement programs.

The second challenge involved disparities in students' digital literacy competencies. Observation data revealed considerable variation in students' abilities to operate digital devices, search for information, and process digital content. Interviews indicated that some students performed tasks independently, whereas others required substantial assistance from peers or teachers. Student work samples further demonstrated differences in accessing, understanding, and utilizing digital information. To reduce these disparities, teachers implemented gradual scaffolding strategies through peer tutoring and continuous instructional support. Students with stronger competencies assisted their peers, while teachers provided structured guidance during the initial stages of learning activities.

Teacher competence in integrating digital technology represented another challenge. Observations demonstrated that technology use was primarily limited to information retrieval activities rather than deeper forms of inquiry and knowledge construction. Interviews revealed that teachers were still developing their capacity to integrate digital tools within deep learning practices. Document analysis similarly indicated that technology integration had not yet fully supported extensive exploration and higher-order learning activities. In response, schools promoted professional development through training programs, collaborative lesson planning, and the exchange of instructional practices among teachers. These initiatives expanded teachers' technological and pedagogical capabilities and encouraged more innovative instructional approaches.

Limited instructional time was also identified as a constraint. Observation and interview data revealed that inquiry, discussion, project work, and reflection activities often required more time than was available within a single lesson period. Consequently, several learning activities had to be simplified or extended beyond regular classroom sessions. Teachers addressed this issue by integrating multiple learning activities into coherent instructional sequences, assigning project-based tasks as follow-up activities, and utilizing extracurricular programs to provide additional opportunities for digital literacy development.

The findings demonstrate that challenges associated with deep learning implementation were multidimensional and interconnected. Infrastructure limitations, differences in student competencies, teacher readiness, and time constraints collectively influenced the learning process. Nevertheless, the solutions adopted by teachers and schools reflected adaptive efforts to sustain deep learning practices and support digital literacy development within diverse educational contexts

Table 2. Challenges and Solutions in Implementing Deep Learning for Digital Literacy

No.	Challenge	Brief Description	Solution
1	Limited facilities and infrastructure	Insufficient devices and unstable internet connectivity	Group-based learning and the use of offline learning resources
2	Differences in students' abilities	Uneven levels of digital literacy among students	Peer tutoring and continuous guidance
3	Limited teacher competence	Technology use remains relatively basic	Teacher training and professional collaboration
4	Limited instructional time	Learning stages cannot be completed within a single session	Integration of learning activities and project-based assignments
5	Variations in student motivation	Not all students actively participate in learning activities	Collaborative learning approaches

Source: Researcher's Data (2026)

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Table 2 summarizes the major challenges and corresponding solutions identified during the implementation of deep learning for digital literacy development. The findings revealed that technological constraints, disparities in students' digital literacy competencies, limited teacher readiness, instructional time restrictions, and variations in student motivation influenced the learning process across both schools. Although these challenges differed in intensity and context, teachers and schools adopted adaptive strategies to maintain student participation and sustain deep learning practices throughout the implementation process.

The Impact of Deep Learning Implementation on Students' Digital Literacy

The findings revealed that the implementation of deep learning positively influenced elementary school students' digital literacy competencies. Classroom observations, interviews, and document analysis demonstrated changes in students' learning behaviors, characterized by greater independence, active participation, and increased engagement with digital resources. Students were no longer limited to receiving information from teachers but actively participated in searching, processing, evaluating, and utilizing digital information throughout the learning process.

Observation data indicated that students used smartphones and available classroom devices to access instructional videos through YouTube and search for information related to cultural heritage and local economic activities. Documentation of teaching modules further revealed that information-searching activities, video observation, and report preparation were systematically embedded within the learning process. Interviews with teachers demonstrated that students gradually became more confident in using search engines and digital learning resources independently. One teacher explained that students initially required guidance when searching for information but later demonstrated the ability to locate relevant information autonomously. These findings suggest an improvement in students' ability to access digital information effectively.

The findings also demonstrated improvements in students' ability to understand digital information. Observations revealed that students were able to explain information using their own words during group discussions and classroom presentations. Teachers reported that students showed stronger conceptual understanding when learning materials were delivered through interactive digital media. Documentation of students' work further indicated that learners could connect newly acquired information with prior knowledge and classroom experiences.

Another notable impact was observed in students' ability to evaluate digital information. Observation data revealed that students increasingly differentiated relevant information from irrelevant content when completing learning tasks. Interviews with teachers indicated that students became more cautious in selecting information sources and frequently sought clarification before using unfamiliar information. These behaviours reflected the emergence of critical evaluation skills during the learning process.

The findings further demonstrated improvements in students' ability to utilize digital information productively. Students transformed information gathered from digital sources into reports, presentations, discussion outputs, and other learning products. Documentation showed that students produced more diverse and creative outputs using simple digital tools. Teachers also reported increased confidence among students when presenting and communicating digitally supported learning outcomes.

Overall, the findings revealed that deep learning facilitated the development of four interconnected dimensions of digital literacy: accessing, understanding, evaluating, and utilizing digital information. Evidence from observations, interviews, and documentation demonstrated that these competencies evolved progressively through activities involving information exploration, collaborative inquiry, presentation, and reflection. The results suggest that deep learning created learning experiences that encouraged students to engage more actively and meaningfully with digital information throughout the instructional process.

Discussion

Forms and Strategies of Deep Learning Implementation in Digital Literacy

The findings indicate that the implementation of deep learning in strengthening digital literacy was carried out through integrated stages of planning, implementation, assessment, and reflection. Teaching modules that incorporated inquiry-based activities, digital resources, collaborative tasks, and authentic assessment demonstrate that deep learning was systematically embedded within the instructional design. Rather than positioning technology merely as a learning aid, the instructional plans created opportunities for students to engage actively with information, construct knowledge, and reflect

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on their learning experiences. This mechanism aligns with the fundamental principles of deep learning, which emphasize meaningful learning, knowledge construction, and higher-order thinking processes (Sudarmono et al., 2025). Previous studies have similarly demonstrated that well-designed deep learning environments enhance student engagement and learning quality by connecting learning objectives with authentic learning experiences (Ismail et al., 2025).

The implementation stage revealed that students actively searched for, processed, discussed, and presented digital information. The effectiveness of these activities appears to stem from the shift in instructional roles, where teachers acted as facilitators rather than primary sources of knowledge. Such a learning environment encouraged students to become active participants in knowledge construction and information exploration. This finding corroborates previous studies showing that deep learning promotes student-centered, contextual, and exploratory learning experiences (Prayitno et al., 2025; Simamora et al., 2025). The present study extends these findings by demonstrating that exploratory activities also function as a mechanism for developing digital literacy because students repeatedly interact with digital resources while solving learning tasks. Through this process, technology becomes a medium for inquiry rather than simply a tool for content delivery (Maulana et al., 2025).

Collaborative learning further strengthened the implementation of deep learning. Students worked in heterogeneous groups to exchange ideas, compare information, and jointly solve problems. The collaborative structure appears to facilitate digital literacy development because students were exposed to multiple perspectives when interpreting and evaluating information. Knowledge construction therefore occurred not only through individual exploration but also through social interaction and collective reasoning. These findings align with studies reporting that collaborative learning enhances communication skills, critical thinking, and meaningful learning outcomes within deep learning environments (Baharuddin, 2025). Previous research has also demonstrated that discussion-based learning strengthens literacy development by encouraging students to articulate, justify, and refine their understanding of information (Mardi et al., 2025). The current findings suggest that collaboration serves as a bridge between information access and critical information evaluation.

Assessment and reflection emerged as equally important components of deep learning implementation. The findings indicate that students were continuously encouraged to evaluate their learning processes, receive feedback, and reflect on their experiences. Reflection appears to deepen students' understanding because it requires them to reconsider information, learning strategies, and outcomes. Consequently, learning extends beyond task completion and becomes a process of metacognitive development. These findings corroborate studies emphasizing reflection as a key element of deep learning that promotes deeper understanding and long-term knowledge retention (Relmasira & Donaldson, 2025). Similarly, process-oriented assessment cultivates critical awareness and supports the sustainable development of digital literacy competencies (Royani et al., 2024).

Recent developments in deep learning research demonstrate increasing attention to meaningful learning approaches within elementary education. Bibliometric analyses reveal a substantial growth in deep learning research under the Merdeka Curriculum framework, indicating a shift from content transmission toward active knowledge construction (Al-Qoyyim & Nabila, 2025). The implementation of deep learning across different subjects has also been shown to enhance student motivation, conceptual understanding, and academic achievement by encouraging learners to establish meaningful connections among concepts (Barokah & Mahmudah, 2025; Prayitno et al., 2025). Activity-based and experiential learning approaches similarly promote deeper conceptual understanding because students directly engage in learning processes rather than passively receiving information (Nababan et al., 2025).

The integration of deep learning with digital technology and artificial intelligence further strengthens its contribution to digital literacy development. Technology-supported learning environments provide students with opportunities to access diverse information sources, analyze information critically, and create digital products. At the same time, teacher readiness remains a determining factor in ensuring that technology use supports meaningful learning rather than superficial engagement. Studies have shown that AI-based learning programs can enhance analytical skills, while teacher training and mentoring programs improve the quality of technology integration in elementary education (Moon et al., 2024; Rahmawati et al., 2022; Warman et al., 2025). These findings indicate that the effectiveness of deep learning depends not solely on technological availability but on the interaction among instructional design, teacher competence, and student engagement within a supportive educational ecosystem

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Challenges and Solutions in Deep Learning Implementation

The findings reveal that the implementation of deep learning was influenced by multiple interconnected challenges, including technological infrastructure, student readiness, teacher competence, and instructional time. These factors did not operate independently; rather, they collectively shaped the extent to which deep learning principles could be implemented effectively. The findings suggest that successful deep learning requires not only pedagogical innovation but also adequate institutional support and adaptive instructional practices.

Limited technological facilities and unstable internet connectivity represented the most visible challenge. These constraints reduced students' access to digital learning resources and occasionally disrupted planned instructional activities. Previous studies similarly emphasize that infrastructure readiness is a prerequisite for successful technology integration in schools (Norfika, 2025). Research by Tabina et al. (2025) also highlights how limited technological resources can restrict opportunities for digital literacy development (Tabina et al., 2025). Unlike studies conducted in technology-rich educational environments, however, the present findings demonstrate that deep learning can remain effective despite infrastructural limitations when supported by collaborative and adaptive learning strategies.

Group-based learning emerged as an important solution to overcome technological constraints. By assigning specific responsibilities within groups, teachers ensured that all students remained engaged even when devices were limited. The effectiveness of this strategy appears to derive from the collaborative nature of deep learning, where knowledge construction occurs through interaction and shared responsibility rather than individual technology use alone. These findings align with Arianti et al. (2025), who reported that collaborative learning can compensate for resource limitations while maintaining meaningful learning experiences (Arianti et al., 2025). The use of offline learning materials further demonstrates that digital literacy development does not depend exclusively on continuous internet access but can also be supported through flexible instructional adaptation.

Differences in students' digital literacy competencies constituted another challenge. Variations in technological skills affected students' ability to access and process digital information independently. These findings corroborate previous studies indicating persistent disparities in elementary students' digital literacy competencies (Maulana et al., 2025). The implementation of peer tutoring and scaffolding strategies appears particularly effective because students often learn technological skills more comfortably from peers with similar learning experiences. This mechanism supports the development of inclusive learning environments in which students receive assistance according to their individual needs. Similar conclusions have been reported by Satyabuwana (2025), who emphasizes the importance of social support in technology-based learning contexts (Putri et al., 2025).

Teacher competence also influenced the quality of deep learning implementation. Although digital technologies were integrated into classroom activities, observations indicated that technology use frequently remained at the level of information retrieval rather than supporting deeper inquiry and knowledge creation. These findings suggest that technology alone does not automatically lead to meaningful learning. Instead, teachers require sufficient pedagogical and technological competence to design learning experiences that promote critical inquiry and reflection. This finding aligns with previous studies emphasizing the importance of continuous professional development in improving teachers' digital literacy and instructional innovation (Intan Safiah et al., 2025; Setyawan et al., 2025).

Limited instructional time represented another challenge because inquiry, discussion, project work, and reflection require extended learning opportunities. Deep learning inherently demands more time than traditional instructional approaches because students engage in exploration, analysis, and knowledge construction processes. Similar observations have been reported in previous studies highlighting the time-intensive nature of project-based and inquiry-oriented learning (Waruwu, 2025). The integration of learning activities and the use of extracurricular programs therefore functioned as practical solutions that allowed students to continue learning beyond conventional classroom schedules. These adaptive strategies indicate that flexibility in instructional planning is essential for sustaining deep learning implementation

The Impact of Deep Learning on Students' Digital Literacy

The findings demonstrate that deep learning positively influenced all four dimensions of digital literacy: accessing, understanding, evaluating, and utilizing digital information. The improvement appears to result from learning experiences that required students to interact continuously with digital information throughout the learning process. Rather than learning

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about technology in isolation, students developed digital literacy through authentic tasks that involved information searching, analysis, discussion, presentation, and reflection.

Students' ability to access digital information improved as they became increasingly independent in using digital devices and online learning resources. Repeated exposure to information-searching activities enabled students to develop familiarity with search strategies and digital platforms. These findings align with Li (2025), who argues that technology integration strengthens foundational digital literacy competencies. The present study extends this perspective by showing that access skills develop most effectively when digital tools are embedded within meaningful inquiry activities rather than used solely for information delivery (Li, 2025).

Improvements in understanding digital information were evident in students' ability to explain information using their own words and connect it with prior knowledge. This outcome suggests that deep learning facilitates meaningful cognitive processing rather than superficial information acquisition. Exploration, discussion, and collaborative inquiry encouraged students to interpret information actively and construct personal understanding. These findings corroborate previous studies demonstrating that deep learning promotes deeper conceptual understanding through meaningful learning experiences (Ismail et al., 2025).

The development of information evaluation skills represents one of the most significant findings of this study. Students increasingly demonstrated the ability to distinguish relevant information from irrelevant content and to question the credibility of information sources. Such skills emerged because students were repeatedly exposed to situations requiring comparison, discussion, and justification of information. This finding aligns with Sudarmono (2025), who reports that deep learning contributes to the development of critical thinking. The current study further indicates that critical evaluation develops not through direct instruction alone but through sustained engagement in inquiry-based learning processes (Sudarmono et al., 2025).

Students also demonstrated greater ability to utilize digital information productively. Information obtained from digital sources was transformed into presentations, reports, and other learning products, reflecting the practical application of knowledge. This transformation process appears to be a key mechanism through which digital literacy develops because students move beyond information consumption toward information production. Similar findings have been reported by Rahmayantis et al. (2025) and Saqjuddin et al. (2025), who found that technology-supported learning enhances students' creativity and productivity (Rahmayantis et al., 2025; Saqjuddin et al., 2025).

Overall, the findings indicate that deep learning cultivates digital literacy through interconnected processes of exploration, collaboration, reflection, and authentic application. The simultaneous development of accessing, understanding, evaluating, and utilizing information suggests that digital literacy is best fostered through meaningful learning experiences rather than isolated technology training. These findings extend previous research by demonstrating that deep learning functions not only as an instructional approach but also as a pedagogical mechanism for developing comprehensive digital literacy competencies in elementary education

CONCLUSION

This study demonstrates that the implementation of the deep learning approach provides a meaningful pedagogical framework for cultivating digital literacy among elementary school students. Through the integration of inquiry-based learning, collaborative activities, digital technology utilization, reflection, and authentic assessment, students were encouraged to actively access, understand, evaluate, and utilize digital information. The findings indicate that deep learning supports not only technological engagement but also the development of critical thinking, independent learning, and meaningful knowledge construction. The study also revealed several challenges, including limited technological infrastructure, disparities in students' digital literacy competencies, variations in teachers' digital readiness, and restricted instructional time. Nevertheless, adaptive strategies such as collaborative learning, peer tutoring, alternative learning resources, and continuous professional development enabled schools to sustain the implementation of deep learning within diverse educational contexts.

The primary contribution of this study lies in providing empirical evidence on how deep learning can be contextualized to holistically develop digital literacy in elementary education, particularly in schools with varying levels of

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technological readiness. These findings suggest that schools should strengthen teacher capacity, improve access to digital resources, and adopt flexible instructional designs that support active and reflective learning. This study is limited to two elementary schools and focuses on a qualitative exploration of implementation processes. Future research may involve larger samples, mixed-methods designs, or longitudinal investigations to examine the long-term effects of deep learning on students' digital literacy development across different educational contexts.

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