

Research Article

# The Effect of Digital Literacy on Learning Outcomes and 21st Century Skills of High School Students: *Systematic Literature Review*

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**Abstract:** This study aims to systematically examine the influence of digital literacy on the learning outcomes and 21st-century skills of high school students. The method used is a Systematic Literature Review (SLR) following the PRISMA guidelines. Data sources were obtained from various academic databases, including Google Scholar, ERIC, ScienceDirect, and SpringerLink, with publications ranging from 2019 to 2025. A total of 30 articles were selected based on predetermined inclusion and exclusion criteria. The analysis was conducted using a thematic approach to identify patterns, relationships, and the contribution of digital literacy to learning outcomes and the development of 21st-century skills, such as critical thinking, collaboration, communication, and creativity. The synthesis results show that digital literacy has a significant influence on improving learning outcomes and strengthening 21st-century competencies. This study emphasizes the importance of integrating digital literacy into secondary school curricula and teacher training to support effective 21st-century learning.

**Keyword:** 21st Century Skills; Digital Literacy; High School Students; Learning Outcomes; Systematic Literature Review.

## 1. Introduction

The development of digital technology has had a significant impact on the world of education, particularly in efforts to improve learning outcomes and 21st-century skills. Digital literacy is now an essential competency for high school students to be able to think critically, collaborate, communicate, and innovate in the digital age. However, there is still a gap in the effective use of digital literacy in schools. Therefore, this study aims to conduct a systematic review of studies discussing the influence of digital literacy on learning outcomes and 21st-century skills. The rapid development of digital technology has driven a global paradigm shift, marked by the Industrial Revolution 4.0 era, which is now evolving towards Society 5.0. This shift places high demands on the quality of human resources, whose main assets are a balance between substantive knowledge and core 21st-century skills. Digital literacy has become an essential competency that underpins the success of students' education and careers, enabling them to think critically, collaborate, communicate, and innovate (4C skills) in a digital environment. For high school/vocational school graduates, digital literacy skills are not just academic abilities, but a strategic solution to overcome high unemployment rates. (N. M. Putri et al., 2025) By mastering digital literacy, the millennial generation, especially the new workforce, is believed to be able to seize business opportunities, utilize artificial intelligence (AI) technology, and reduce fierce competition in choosing types of work, which is ultimately very important to ensure improved welfare in the current era of economic digitalization. In general, national and regional education authorities have recognized the significance of strengthening digital literacy (LD), even reporting that the Digital Literacy Index (ILD) in several regions has exceeded the national average, with the hope that this improvement can encourage a more skilled and knowledgeable society. Despite these claims of success at the macro level, there is a fundamental contradiction reflected in internal policy documents, which explicitly note that the implementation of the digital literacy movement in the field is still considered "suboptimal." This suboptimal implementation is often triggered by

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persistent structural challenges, such as funding constraints, resistance from teachers to adopting transformative learning models, and an acute lack of technical support, especially in regions with limited infrastructure. Therefore, the macro digital index achievements need to be viewed critically, as there are strong indications that the index tends to measure only basic aspects of digital access and understanding, rather than the quality of critical and in-depth utilization in the school environment.

The gap in the effective use of digital literacy in schools stems from the failure of the education system to transfer basic digital knowledge into the higher-level cognitive and behavioral skills that are essential for the 21st century. Studies focusing on Generation Z and Millennials in population centers show that, despite adequate competence in basic digital understanding, scores on more complex dimensions of digital literacy are often in the “low” category. (Jaya et al., 2025) Specifically, the competency with the lowest index is Collaboration Skills, and other important competencies such as Analyzing, Verifying, and Evaluating also show alarming scores. This deep deficit, especially in collaboration and analysis skills, is particularly troubling because collaboration is a key pillar of the 4C skills framework. These findings indicate that the current focus of education may still be too limited to operational skills (accessing information), thereby failing to shape the Digital Culture and Digital Ethics necessary for active, ethical, and constructive participation in the global digital society (Society 5.0).

To address the identified gaps, a more focused and comprehensive synthesis of scientific evidence is needed. Although previous systematic reviews in Indonesia have confirmed the urgency of digital technology in education and examined certain components (such as the use of social media or ICT integration in general), these studies are often still general in nature at the national level, or recommend further research to fill the knowledge gaps. Furthermore, the literature suggests that commonly used research methods (such as descriptive qualitative) are not sufficient to measure true digital skills, thus necessitating a shift to performance-based research. Therefore, the novelty of this study lies in its Systematic Literature Review (SLR) approach, which will: (1) Explicitly link digital literacy with a broad spectrum of learning outcome variables (cognitive, affective, and psychomotor) and 4C skills in an integrated manner; (2) Provide a contextually relevant synthesis by highlighting pedagogical models that have been proven effective in improving the two weakest dimensions of collaboration and analysis in East Java; and (3) Identify recommended performance-based measurement instruments and methodologies to validate the progress of high school/vocational school students in East Java. Based on global urgency, regional contradictions, and apparent research gaps, this study aims primarily to conduct a systematic review of studies discussing the influence of digital literacy on learning outcomes and 21st-century skills. Specifically, this study aims to: (1) Map empirical evidence on the quantitative and qualitative effects of digital literacy on student learning outcomes (cognitive, affective) and 4C skills; (2) Synthesize pedagogical models and instructional media that have been proven effective in strengthening high-level digital literacy competencies in secondary education; and (3) Identify limitations in existing research to guide future studies focused on the specific context of senior high schools/vocational high schools in East Java. These comprehensive synthesis results are expected to provide strong and evidence-based policy recommendations to the East Java Education Office, enabling them to design curricula and teacher training programs that directly target the improvement of professional digital competencies and address critical deficits in collaboration and analysis skills, in order to prepare East Java graduates who are ready for the Society 5.0 era.

## 2. Literature Review

Digital literacy in the context of contemporary education is no longer understood as merely the technical ability to operate hardware or software (digital skills). Instead, digital literacy must be seen as an integrated competency, encompassing four main pillars necessary for safe and ethical interaction in the digital space: digital skills, digital ethics, digital culture, and digital safety. The ethical and cultural dimensions are crucial in high school education, especially in East Java, because regional research shows that although students may have basic skills in accessing and understanding, they lack the critical skills to analyze, verify, and most importantly, collaborate effectively. Deficits in these dimensions indicate that the focus of education must shift from merely mastering tools to mastering higher-level cognitive skills and behavioral ethics. 21st-century skills, summarized in the 4C framework (Critical Thinking, Communication, Collaboration, and Creativity/Innovation), are an absolute prerequisite for the quality of human resources required by the Industrial Revolution 4.0 (N. M. Putri et al., 2025). The application of these skills emphasizes student-centered learning, which is able to

accommodate various learning styles and demands effective collaboration and communication. Digital literacy is the foundation on which all these 4C skills are built. For example, Critical Thinking is highly dependent on the ability to Verify and Analyze digital information to combat hoaxes, while Collaboration requires the ability to Participate and Share digitally. The following table outlines the causal relationship between weak digital literacy in East Java and the demands of 4C skills. (Artha et al., 2025) A systematic literature review confirms that digital literacy has a significant influence, both directly and indirectly, on student learning outcomes (academic achievement). This influence is mediated by a key variable, namely learning motivation, especially intrinsic motivation, which serves to strengthen the impact of digital literacy on academic achievement. In the context of learning outcomes (LO), the analysis must cover all domains of learning. In addition to the Cognitive domain (traditional academic achievement), digital literacy has a substantial impact on the Affective domain (morality, character, and digital ethics) and Psychomotor domain (practical skills in the use of technology).

Failure to effectively integrate digital literacy will result in graduates who may achieve satisfactory cognitive outcomes, but are very weak in affective and behavioral skills (such as collaboration), which are essential for the world of work. Therefore, research synthesis should focus on the mechanisms of influence that occur through cognitive, affective, and behavioral pathways, identifying learning models that are specifically capable of improving motivation and 21st-century skills. The paradox in digital literacy arises when macro reports, which may be driven by high levels of access and basic digital awareness, do not reflect the mastery of critical skills at the individual level. Micro data focusing on the performance of high school students (Gen Z) in urban areas reveals this contradiction. Specifically, although the ability to Understand digital information is at a moderate level, most of the ten competencies tested are trapped in the low category. Most concerning is the ability to Collaborate, which recorded the lowest index score, reaching only 32.2%. This very weak level of digital collaboration directly indicates that students have difficulty building trust and interacting effectively in virtual spaces. It also shows an inability to adapt to the demands of future jobs that require adaptive and complex virtual teamwork, even though they theoretically have an understanding of digital media. The direct implication of these findings is that current educational efforts have fundamentally failed to prepare students for the demands of digital collaboration in the Society 5.0 era, where Digital Culture and Digital Ethics have not yet been optimally established.

## 2. Method

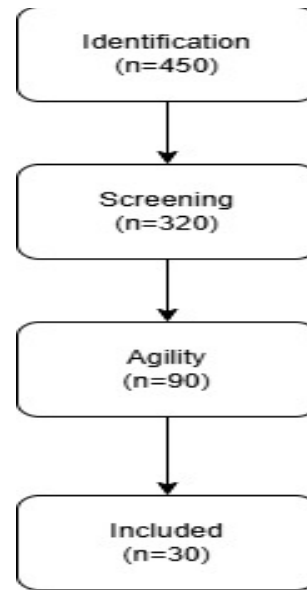
This study used the Systematic Literature Review (SLR) method based on the PRISMA guidelines. The SLR process was carried out in four main stages: identification, screening, eligibility, and inclusion. Data sources were taken from academic databases such as Google Scholar, ERIC, ScienceDirect, and SpringerLink with a range of years from 2019 to 2025. The inclusion criteria included: (1) articles focusing on high school students, (2) measuring learning outcomes or 21st-century skills, and (3) published in peer-reviewed journals. This study adopted a structured and transparent Systematic Literature Review (SLR) methodology, similar to the PRISMA approach, to ensure the reliability and validity of the findings. This process involved collecting, summarizing, analyzing, and synthesizing relevant research findings from leading academic databases (international and national) within the relevant time period. The main inclusion criteria focused on articles that explicitly discussed the relationship between digital literacy and student learning outcome variables and 21st-century skills (4Cs) at the secondary education level. The aim was to identify patterns, trends, and common themes across the literature to fill knowledge gaps.

## 3. Result

### Identification of Relevant Literature

The article selection process in this Systematic Literature Review (SLR) followed the PRISMA guidelines. The initial stage identified a total of 450 articles from various databases. Of these, 130 articles were identified as duplicates. After removing the duplicates, 320 articles remained to be screened. During the screening stage, 230 articles were excluded because they were not relevant to the topic or research criteria. Then, the remaining 90 articles were evaluated for full eligibility. In this full-text evaluation process, 60 articles were excluded

because they did not meet specific inclusion criteria. The final selection results showed that there were 30 articles that were fully relevant and passed to be included in the qualitative synthesis.



**Figure 1.** Literature Identification Through the Google Scholar Database.

**Table 1.** Summary of Research Articles Relevant to the Study.

No.	Author	Year	Title	Main Focus / Findings
1	Zakir S, et al.	2025	Digital literacy and academic achievement: the mediating role of informal digital learning, self-confidence, and students' digital competence.	Finding that digital literacy has a positive relationship with academic performance, mediated by informal digital learning, self-efficacy, and students' digital competence.
2	Saras Pratama, et al.	2025	The Importance of Digital Literacy in Education: Learning Transformation in the Digital Age.	Explaining the importance of digital literacy for educational transformation in Indonesia, improving access to information and critical thinking skills, despite facing challenges in infrastructure and teacher readiness.
3	Agus Minarto & Abdul Hobir	2024	Evaluation of the Role of Teachers in the Use of Digital Literature for Informatics Learning at SMP Negeri 2 Pademawu.	Teachers recognize the importance of digital literacy but face technical skill constraints. Teachers strive to overcome these with training and collaboration.
4	Shella Permatasari, et al.	2025	Literature Review on the Use of Android-Based Science Teaching Materials for the Period 2020-2025.	The use of Android applications as science teaching materials improves student understanding, creates an engaging learning experience, and enhances digital literacy and learning outcomes.
5	Siti Shofa Assyifa'ul Qulbi Barid, et al.	2025	Perceptions and Challenges of Coding Learning in Science Subjects as Strengthening 21st Century Skills.	Coding in science supports the development of 21st-century skills (computational thinking, critical thinking, problem solving), but challenges include curriculum development and infrastructure.

6	Eti Susanti & Rian Vebrianto	2025	Systematic Literature Review: Development of Interactive Learning Media with the Help of the Educaplay Platform in SKI Learning.	Educaplay-based interactive learning media promises to improve the effectiveness of Islamic Cultural History (SKI) learning through SLR reviews.
7	Najma Ulya, et al.	2025	The Role of Digital Learning Media in Mathematics Learning in the Era of Independent Learning: Systematic Literature Review.	Digital learning media plays an important role in supporting Mathematics learning in line with the Merdeka Curriculum, improving students' critical thinking and digital literacy skills.
8	Amri Saputra	2025	Interactive Learning in Elementary Schools in Indonesia: A Systematic Review of Literature from 2010-2025.	Interactive media (educational games, videos, AR/VR) contribute positively to learning outcomes (cognitive, affective, psychomotor) and support the strengthening of digital literacy in elementary schools.
9	Mohamad Syarief Abdullah	2025	Encouraging Student Motivation through the Use of Multimedia in the Flipped Learning Approach: A Systematic Review of Literature.	Multimedia-based flipped learning effectively increases students' intrinsic motivation through personalized experiences, but the challenges are the technology access gap and low digital literacy.
10	I N. Widya Artha, et al.	2025	Literature Review on the Implementation of Meaningful Learning in Senior High Schools.	Meaningful Instructional Design (PjBL, CTL) strategies are effective in improving learning outcomes, active engagement, and character building in high schools.
11	Amilusholihah, et al.	2024	Systematic Literature Review: The Effectiveness of the Merdeka Curriculum Problem-Based Learning Model in Senior High School Economics Learning	The Problem-Based Learning (PBL) model in the Merdeka Curriculum has proven to be effective and relevant in improving learning outcomes and 21st-century skills in high school economics.
12	Najma Ulya, et al.	2025	The Role of Digital Learning Media in Mathematics Learning in the Era of Independent Learning: A Systematic Literature Review	Digital learning media play an important role in supporting Mathematics learning in accordance with the Merdeka Curriculum, improving students' critical thinking and digital literacy skills.
13	Abdul Rosyid & Fatkhul Mubin	2024	21st Century Learning: A Closer Look at Innovation and Its Implementation in the Context of Indonesian Education	21st century learning innovations (including Blended Learning) aim to develop the potential and shape the character of students. Digitalization is a key marker of the transition to an information society.
14	Rina Nurhidayati	2024	Digital Technology Innovation in Improving Learning Quality: A Systematic Literature Review	Various types of digital media (videos, simulations, interactive games) are effectively used in Science/IPA learning. Their use has been proven to improve student learning outcomes, motivation, and digital literacy.

15	Erlavianda Tarita Putri	2025	Learning Motivation as the Key to Improving Indonesian Literacy	Learning motivation plays a fundamental role as an internal driver that influences cognitive engagement, autonomy, and effective use of technology. Motivation must be prioritized in literacy policies.
16	Irham Thufani Anshori & Udjang Pairin M. Bashir	2024	Gamification: The Effectiveness of Interactive Games in Improving Student Digital Literacy	Gamification and interactive games are effective in improving the digital literacy of high school students because they can increase motivation and skills in accessing and analyzing technology-based information.
17	Yinma Dewita Talaen, et al.	2025	Analysis of the Application and Development of the Independent Learning Curriculum on the Characteristics of 4C (Communication, Collaboration, Critical Thinking, and Creativity) in 21st Century Learning at the High School Level (A Systematic Literature Review)	The implementation of the Merdeka Curriculum improves 4C skills, with communication, collaboration, and creativity showing significant improvement, while critical thinking still requires specific strategies (e.g., Project/Problem-Based Learning and technology integration).
18	Andri Nur Cahyo & Tsania Nur Diyana	2025	The Application of Problem-Based Learning Models in Physics Education to Improve Student Science Literacy: A Literature Review	The Problem-Based Learning (PBL) model is effectively applied in Physics learning to overcome low Science Literacy among students, as PBL stimulates problem-solving and critical thinking.
19	Syafira Raka Putri & Farid Ahmadi	2023	The Effect of Educational Video Media on Digital Literacy, Reading Interest, and Learning Outcomes of Elementary School Students	The use of educational videos has been proven to have a positive effect on improving digital literacy, reading interest, and student learning outcomes in elementary schools.
20	Muliana, Mutia Fonna, & Hayatun Nufus	2024	The Effect of Problem-Based Learning (PBL) on 21st Century Skills	The implementation of the Problem-Based Learning (PBL) model is an effective solution for improving 21st-century skills (4Cs: Critical Thinking, Communication, Creativity, and Collaboration).
21	Muh Rafi Nur Ramadhan Ali	2025	The Role of Digital Literacy in Promoting High School Students' Thinking Skills: A Recent Literature Review	Digital literacy is significant in shaping students' thinking skills (especially critical thinking, analysis, and evaluation of online content) in high school.
22	Armina Sari Harahap, et al.	2025	The Role of Digital Leadership in the Era of Education 4.0 in Managing Vocational Schools: A Systematic Literature Review of Opportunities and Challenges	Digital leadership is important in vocational schools to improve graduate quality and innovation. The main challenges are limited infrastructure and digital literacy.

23	Gildan Jaya Muhammad Ramadhan, et al.	2025	The Impact of the Blended Learning Model on Improving Digital Literacy among Junior High School Students	Blended learning is effective in improving junior high school students' digital literacy (accessing, evaluating, utilizing information). Success is highly dependent on infrastructure and teacher competence.
24	M. Ichwan Al Hafidz, et al.	2025	The Use of Gamification in Learning to Improve Students' Digital Literacy	Gamification is effective in improving students' digital literacy, motivation, and engagement. Gamification is an innovative approach in the 21st century.
25	Marsha Nabila Putri, et al.	2025	The Future of Education 4.0: Digital Literacy as the Key to Character Building in Students	Digital literacy is important in Education 4.0, not only to improve information skills but also to strengthen character (integrity, responsibility, creativity) and 4C skills.
26	Annisa Azzahra Dewi, et al.	2025	A Systematic Literature Review: The Relationship Between Digital Literacy Skills and Independent Learning in Madrasah Ibtidaiyah Students	There is a positive relationship between digital literacy and MI students' learning independence. Digital literacy includes students' skills in managing information and using digital media.
27	Ilyas Adi Saputra, et al.	2025	The Effect of Digital Literacy on the Academic Achievement of High School Students	High digital literacy is strongly correlated with better academic achievement in high school students, as it supports critical thinking, analysis, and problem solving.
28	Tri Suryanti & Retno Utari	2025	Integration of Digital Technology in 21st Century Learning: A Literature Review on the Application of Learning Management Systems (LMS) in Secondary Schools	The implementation of LMS in secondary schools significantly contributes to improving students' digital competence and the effectiveness of online learning.
29	Wienda Gusta & Asma Alhusna Pinta Medina	2024	The Influence of Digital Literacy on the Problem-Solving Skills of High School Students	Digital literacy has a significant influence on the critical thinking and problem-solving abilities of vocational school students. Students with high digital literacy are better at analyzing information and making logical decisions.
30	Ainia Asfiya'i, et al.	2024	The Impact of Digital Literacy on the Professionalism of High School Teachers: A Literature Review	Digital literacy has an important impact on improving teacher professionalism because it allows teachers to be more productive in creating digital learning media.

The results of a systematic literature review (SLR) carefully compiled using the PRISMA methodology consistently point to the key finding that Digital Literacy (DL) has a strong, positive, and significant impact on improving academic achievement (learning outcomes) among high school students. Digital Literacy, in this context, serves as a key enabler that allows students to adapt and achieve optimal performance amid the rapid development of the Education 4.0 ecosystem. Specifically, high mastery of DL is closely correlated with better academic grades. This is supported by improved cognitive abilities, particularly in terms of analyzing and evaluating information sourced from digital platforms, which enables students to independently filter the validity of materials. Furthermore, LD encourages student independence in learning, as evidenced by the effective use of various digital learning media, such as interactive videos, simulations, or Android-based e-modules, which not only deepen

understanding of the material but also significantly increase students' intrinsic motivation in the learning process.

Digital literacy is not merely a technical competency, but a fundamental prerequisite for mastering 21st Century Skills (K-21), particularly the 4C dimensions (Critical Thinking, Collaboration, Communication, and Creativity). This review shows the substantial contribution of DL in shaping students' critical thinking, which is manifested through their ability to evaluate the credibility of online content and formulate solutions to complex problems in the digital environment. In addition, the aspects of collaboration and communication are effectively enhanced through interactions in the digital environment, such as the use of Learning Management Systems (LMS) and other online collaboration tools. The application of innovative learning models—such as Problem-Based Learning (PBL) and Flipped Learning—has proven effective in facilitating the development of 4C skills. These models explicitly require a solid foundation in digital literacy, as the success of problem solving (PBL) and multimedia-based independent study (Flipped Learning) is highly dependent on students' ability to access, manage, and utilize digital information resources. Although digital literacy has a significant potential impact on high school student performance, the SLR findings simultaneously highlight several structural challenges that need to be addressed to ensure equitable implementation. The main obstacles include the digital divide between regions and, equally important, teachers' limited technical competence in optimally and pedagogically integrating digital literacy tools and concepts into the curriculum. Studies show that many teachers still face difficulties in developing interactive digital content or effectively managing technology-based classrooms. Therefore, the success of LD's influence on improving student learning outcomes and K-21 is highly conditional and cannot stand alone. It is entirely dependent on the support of an integrated school ecosystem, which requires continuous investment in the provision of adequate infrastructure, as well as programmed and ongoing professional training for teachers to ensure that all components of education are ready to face the demands of the digital revolution.

## 5. Conclusion

major catalyst for success in the era of Education 4.0. The impact of DL is twofold: first, it has been proven to improve students' academic learning outcomes by sharpening their critical analysis skills, improving their ability to evaluate complex digital information, and fostering greater independence and motivation to learn. Second, LD serves as an integral foundation for strengthening 21st Century Skills (K-21), particularly the 4C dimensions (Critical Thinking, Collaboration, and Communication), as mastery of digital platforms enables more effective interaction and problem solving. This is evident in the successful implementation of innovative technology-based learning models such as Problem-Based Learning (PBL) and Flipped Learning. However, this SLR also provides a critical note that the success of LD integration is highly dependent on adequate school ecosystem support, which includes serious efforts to address digital infrastructure gaps between regions and, most crucially, improving teachers' professional competencies so that they are able to manage and integrate technology in a pedagogical. Thus, the main emphasis of this conclusion is the urgency to implement a holistic, equitable, and sustainable Digital Literacy strengthening program as a fundamental strategy in preparing high school students to be truly ready to face global competition and the demands of the ever-evolving future world of work.

## 6. Implication

A systematic analysis of Digital Literacy (DL) conditions has identified a significant digital literacy paradox: although macro indicators often show high levels of digital access and understanding among students, more in-depth data reveals a critical deficit in higher-level functional skills, such as collaboration and analysis at the micro level of students. To bridge this gap and fundamentally improve the quality of Senior High School/Vocational School (SMA/SMK) education, this study produced three strategic policy recommendations. To address the bias of indices that only measure access or basic understanding, relevant education authorities are urged to shift from conventional descriptive evaluation methodologies to Performance-Based Assessment. This new instrument is designed to verify the application of real skills, particularly the ability to Analyze and Consult (collaboration), which will ultimately provide a more accurate picture of the readiness of high school graduates to face the demands of Society 5.0. Considering that teacher incompetence is a major obstacle to effective digital media integration, investment in professional training must be significantly increased. This training must go beyond basic digital skills and focus on improving teachers' professional digital competence, with an emphasis on Digital Ethics, Digital Culture, and Digital Pedagogy, namely the ability to facilitate 4C learning based on digital projects. This program aims to empower teachers to be able to assist students, guide the wise use of devices, and detect and overcome potentially negative changes in digital behavior. Sustainable Infrastructure Investment is Needed to Create Equity across all educational units. Although many schools have made efforts to digitize, challenges related to funding, device availability, and technical support still limit the success of implementation, especially in underserved areas.

Therefore, continuous investment is crucial to ensure the availability and reliability of infrastructure and adequate technical support, so that access gaps no longer become barriers to the development of students' digital literacy and the creation of an inclusive, dynamic, and adaptive learning environment for all learners.

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