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Digital Literacy Learning Strategies in School Education: Challenges and Opportunities of the Industrial Revolution 5.0

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Abstract
The era of Industrial Revolution 5.0 demands a significant transformation in the education system, especially in the development of digital literacy. Digital literacy includes not only the technical ability to use technology, but also a critical understanding of the social, ethical and security impacts in the digital world. This study aims to explore digital literacy learning strategies in the school environment, identify the challenges faced, as well as the opportunities that arise in facing the demands of the Industrial Revolution 5.0. The research method used is a literature study and case analysis of various best practices in schools. The results showed that the integration of a digital literacy-based curriculum, teacher training and collaboration with external parties such as industry and communities are key strategies. Key challenges include gaps in technology access, lack of teacher readiness and the dynamics of rapid technological change. However, the Industrial Revolution 5.0 also opens up opportunities to create learning that is more personalized, collaborative and oriented towards developing 21st century skills. In conclusion, schools need to adopt a holistic and sustainable approach to integrating digital literacy to prepare students for an increasingly digitized future.

Keywords: *Learning Strategy, Digital Literacy, Industrial Revolution 5.0*

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Introduction
The development of digital technology has brought significant changes in various aspects of human life, including in the world of education. In the era of the Industrial Revolution 5.0, the integration between advanced technology and humanism is the main focus in building an adaptive and future-oriented education system. The Industrial Revolution 5.0 emphasizes the collaboration between artificial intelligence (AI), Internet of Things (IoT), Big Data, and other digital technologies with human values, creativity, and ethics (Taj, 2022). Therefore, the education system in schools needs to adapt to these changes, especially in equipping students with digital literacy skills. In the context of education, digital literacy is a fundamental aspect that determines the effectiveness of learning in the 21st century (Audrin, 2022). Strategic digital

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literacy learning not only allows learners to access information more broadly, but also shapes the ability to analyze, evaluate and create digital content responsibly.

The Industrial Revolution 5.0 presents a new paradigm in the integration of digital technology and human values (Gotama, 2024). In this era, technologies such as artificial intelligence (AI), Internet of Things (IoT), big data and robotics are rapidly evolving to create solutions that are not only efficient but also inclusive and centered on human needs. In the context of education, these developments demand fundamental changes, especially in preparing the younger generation with digital literacy skills. Digital literacy includes not only the technical ability to use digital tools but also critical, ethical and creative understanding in dealing with information and technology (Demmanggasa, 2023). Various studies have shown the importance of digital literacy in equipping students with 21st century skills, such as critical thinking, creativity, collaboration and communication. However, most studies tend to focus on the technical aspects of applying technology in education, while holistic approaches that consider the specific challenges and local needs in various school contexts are less explored. Many studies have focused on technology in the era of Industrial Revolution 4.0, but have not specifically highlighted the unique opportunities offered by Industrial Revolution 5.0, such as more personalized and collaborative learning approaches.

This research is made all the more apparent by the challenges faced by schools, including unequal access to technology, lack of teacher competence in utilizing digital technology, and resistance to curriculum innovation. On the other hand, the great opportunities offered by the Industrial Revolution 5.0, such as the use of AI for adaptive learning and collaboration between the education and industry sectors, have yet to be fully utilized (Sinaga, 2024; Winarno, 2023). This suggests the need for a more in-depth study to design digital literacy learning strategies that are not only relevant to the needs of the times but also adaptive to the challenges and opportunities that exist. First, this study integrates the digital literacy approach with the specific context of the Industrial Revolution 5.0, which emphasizes collaboration between humans and machines. Second, it identifies unique challenges and opportunities at the school level, paying particular attention to the local context and specific needs of students, teachers and educational institutions. Third, it offers innovative learning strategies by leveraging the latest technology to create personalized, inclusive and sustainable learning environments.

Although digital literacy has become a widely discussed topic in education, there are some research gaps that still need to be explored further, especially in the context of the Industrial Revolution 5.0. Most previous studies have focused on digital learning strategies in the context of the Industrial Revolution 4.0, which emphasizes automation and digitalization. However, studies on how the integration of humans with smart technology can be applied in the learning process are still limited. In addition, although many studies highlight the importance of digital literacy, there are still few empirical studies that specifically analyze the effectiveness of digital literacy learning strategies in improving students' digital skills in accordance with the demands of the Industrial Revolution 5.0. Furthermore, research on the readiness of educators and school infrastructure in supporting digital-based learning is also still rare. Most studies focus more on students' readiness to face the digital era, while factors such as teachers' readiness, access to technological devices, and relevant education policies have not been explored. In addition, aspects of digital ethics and cybersecurity in digital literacy learning have also not received enough attention. In fact, in an increasingly complex digital era, understanding the ethics of using technology, the threat of misinformation, and data security are important factors that must be taught early on.

This research offers novelty by filling the identified gaps. Different from previous research, this study will examine digital literacy learning strategies in the context of the Industrial Revolution 5.0, which emphasizes the collaboration between humans and smart technology in learning. In addition, this study will provide an empirical analysis of the

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effectiveness of various digital literacy learning strategies in schools, taking into account the readiness of educators, access to technology, and their impact on students' mastery of digital skills. The study will also adopt a holistic approach by not only focusing on student readiness but also exploring how educators' readiness, the availability of technology infrastructure and existing education policies can influence the effectiveness of digital literacy implementation in schools. Another novelty offered in this research is the integration of digital ethics and cybersecurity aspects in digital literacy learning strategies, so that students not only have technical skills, but are also able to use technology ethically, safely and responsibly. With these contributions, this research is expected to provide new insights and become a reference for the world of education in developing more effective, inclusive and sustainable digital literacy learning strategies in the era of the Industrial Revolution 5.0.

Methodology

This research uses the literature study method, which is a research method conducted by collecting, reviewing and analyzing various relevant literature sources to understand digital literacy learning strategies in school education in facing the challenges and opportunities of the Industrial Revolution 5.0. The literature study was chosen because this approach allows researchers to gain an in-depth understanding of the concepts, theories and practices that have been applied in digital literacy learning. The literature sources used in this study include scientific journals, academic books, conference proceedings, research reports, and education policies related to digital literacy and technology-based education transformation. The data collection process was carried out by searching various academic databases such as Google Scholar, ScienceDirect, Springer, and Scopus to obtain relevant literature. The criteria for literature selection were based on relevance to the research topic, novelty (especially within the last five years), and source credibility. The data obtained from the literature study was analyzed using content analysis techniques, which involved the process of data reduction, thematic categorization, and interpretation of the reviewed findings. The first step in this analysis was to identify and select the literature that was in line with the research focus, namely digital literacy learning strategies, implementation challenges in schools, and opportunities offered by the Industrial Revolution 5.0 in education. Next, the data obtained was classified into main themes, such as pedagogical approaches in digital literacy, the role of technology in learning, educators' readiness, and digital education policies. After that, the findings are interpreted to draw conclusions that can contribute to the development of digital literacy learning strategies in schools.

Results and Discussion

This research identified a number of key challenges in implementing digital literacy in schools in the era of the Industrial Revolution 5.0. One of the biggest challenges is inequality in access to technology. In many rural areas, technology infrastructure is very limited, with some schools lacking adequate hardware, such as computers or tablets, and stable internet connections (Nazira, 2024; Rumondor, 2024). This inability to access technology hinders teachers and students from using digital tools for learning, creating a divide between urban and remote schools. This exacerbates inequalities in the quality of education, where students in urban areas have an advantage in accessing digital resources and online learning materials, but despite the proliferation of technology, many teachers feel they lack the skills to integrate technology effectively in the learning process (Zhao, 2022). Only a small percentage of teachers have received specialized training in the use of technology for education. This is a big problem because technology can only be effectively used if teachers understand how to utilize digital tools to improve teaching quality. Without adequate understanding, teachers struggle to

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effectively teach digital literacy to students, which in turn affects students' ability to master these skills.

Resistance to curriculum change is also a significant barrier to the implementation of digital literacy in schools (Hasna, 2024; Anam, 2024; Munir, 2024). Many schools still rely on traditional curricula that were designed before the advent of rapid technological developments and are therefore less responsive to changes and advances in technology. The existing curriculum in Indonesia, despite some updates, remains inadequate to prepare students with the digital skills needed to face an increasingly connected and technology-dominated world. The ICT curriculum taught often seems separate from other subjects and does not cover all aspects of digital literacy needed by students. In many cases, ICT is only taught as a standalone subject without clear links to teaching in other areas such as math, science, language or art. In fact, digital literacy should include more than just technical skills in using devices or applications (Nugraha, 2022; Sutrisna, 2020; Djafar, 2023). Students also need to understand how technology can be applied in the context of everyday life and how it can support critical thinking, creativity and collaboration. Without deeper integration with other subjects, digital literacy remains a separate concept and is not fully utilized in students' learning experiences. Many schools face major challenges in adapting the curriculum to the rapidly evolving world of technology and the increasingly digitized world of work. Conventional curricula find it difficult to respond quickly to changes in the industry, where the digital skills required by workers are evolving along with technological advances. Most schools still focus on teaching basic skills, while in the professional world, digital skills such as coding, data management and information analysis are becoming increasingly important. This creates a gap between what is learned in school and the skills needed in the workforce.

The absence of close collaboration between educational institutions often hinders curriculum updates that can accommodate digital needs in various sectors. In fact, this collaboration is essential to create a curriculum that fits the needs of an increasingly digitalized world of work and prepares students to enter a highly technologically connected labor market. To overcome this obstacle, greater efforts are needed from relevant parties to update and adapt the curriculum to be more relevant to technological developments. One way is to include digital literacy as an essential component in all subjects, not just in ICT subjects. This approach will enable students to not only master technical skills but also understand how technology can be used to enhance learning and problem-solving processes across a range of disciplines. A curriculum that is responsive to technological developments should include skills that match the needs of the world of work, such as skills in data analysis, programming and digital information management, all of which are basic competencies required in many industry sectors. Without significant changes to the existing curriculum, schools will struggle to prepare students for the challenges and opportunities of an increasingly digital world (Fricticarani, 2023; Maskur, 2023; Muliawan, 2024).

The research also identified some great opportunities in improving digital literacy in schools. One of them is the use of artificial intelligence (AI) in more personalized learning. AI can be integrated into the learning process to create a learning experience that is tailored to the needs and characteristics of each student. AI-based systems are able to analyze students' performance data in real-time, such as their ability to do problems or complete tasks, as well as the speed and way they learn. Based on this analysis, AI can suggest appropriate subject matter, introduce relevant topics, or provide additional practice on areas where students are struggling. The use of AI technology in learning allows students to have a more interactive and adaptive learning experience (Liriwati, 2023; Hartono, 2024; Nurahayati, 2024). For example, if a student struggles to understand a concept in math, the AI system can provide additional, more in-depth exercises or explain the concept in a different way, according to the student's learning style. Conversely, if the student shows a good understanding of the material, the AI system can direct the student to study more advanced material. This approach not only makes learning more

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efficient but also allows students to progress according to their abilities, without having to follow the same pace as the rest of the class.

A great advantage of AI-based learning is the ability to provide immediate feedback which is very useful for students (Labobar, 2024; Nirwani, 2024; Rohmawaty, 2024). Most students may feel shy or hesitant to ask teachers for help directly when they encounter difficulties. However, with the help of AI, students can get instant feedback on their work, which can help students correct mistakes quickly and without pressure. It also allows students to continue learning in a more independent way, developing problem-solving and critical thinking skills more efficiently. The use of AI in learning provides an opportunity to introduce new concepts that are more relevant to technological developments. AI can be used to teach students the basics of algorithms, programming, or even data processing, skills that are in high demand in an increasingly digitized professional world. By introducing students to these tools early on, they not only develop academic skills, but also digital skills that will be very useful in the students' future careers.

AI-powered personalized learning also reduces the teaching burden for teachers (Anas, 2024; Yahya, 2023; Oktavianus, 2023). With AI systems capable of assessing student performance and providing appropriate learning materials, teachers can focus more on their role as facilitators and coaches, instead of spending a lot of time providing individualized instruction. It also gives teachers more time to work with students who need special attention, while AI can handle most of the administrative work and material customization automatically. The application of AI in learning has the potential to address the learning gap that occurs between students with different backgrounds. By customizing course materials and providing support that is more in line with each student's ability level and needs, AI enables more inclusive education. Lower-ability students can get material that is easier to understand, while faster students can explore more challenging topics. This reduces inequalities in academic achievement and provides opportunities for all students to develop according to their potential. While there are many opportunities offered by AI in education, the main challenges in its implementation are the availability of adequate infrastructure and sufficient training for teachers. AI requires sophisticated hardware and software, as well as accurate data to function optimally. Therefore, the implementation of AI-based learning systems requires considerable investment in technology and training for teachers (Mustoip, 2023; Harahap, 2023; Cahyanto, 2024). For this reason, there needs to be strong support from the government, private sector, and educational institutions in ensuring that all schools can utilize the full potential of AI.

With all these potentials, AI-based learning can be a very promising solution in improving students' digital literacy. To maximize the benefits, it is important for educational institutions to carefully plan the integration of this technology, taking into account the availability of resources, the readiness of teachers, as well as the readiness of students to face major changes in the way students learn. Along with the development of technology, education is expected to continue to adapt and provide learning experiences that are relevant to the needs of today's digital world (Haleem, 2022). collaboration between the education sector and industry is a great opportunity that can be utilized to improve digital literacy in schools (Sari, 2024). Along with the rapid development of technology, many leading technology companies, such as Google, Microsoft, and Apple, have offered training programs as well as various resources that are very useful for the development of digital skills of students and teachers. These programs include not only software and digital learning tools, but also professional training designed to help teachers master how to integrate technology into their teaching.

The training programs conducted by these technology companies also allow students and teachers to adapt to rapid changes, improving students' skills in programming, data processing, artificial intelligence, and other technology fields that are highly relevant to the demands of industry 4.0 and 5.0. This collaboration can introduce students to the industrial world early on, providing students with insights and practical experience that can be highly

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beneficial in students' future careers. For example, some technology companies have developed project-based curricula that allow students to work with mentors from industry, working on assignments or projects that relate directly to real-world challenges. This gives students the opportunity to learn from practitioners who have hands-on experience in technology and related industries, and helps students understand how the digital skills they are learning can be applied in a professional context. By involving industry in education, students not only master technical skills, but also develop a deeper understanding of how technology plays a role in various industry sectors.

Collaboration between the education and industry sectors also has the potential to help address the issue of unequal access to technology (Rahayu, 2023; Andrea, 2024; Fathullah, 2025). Many technology companies have corporate social responsibility (CSR) programs that aim to provide support to under-resourced schools. For example, companies such as Intel and Cisco have launched various initiatives that provide hardware and software to schools in remote or underprivileged areas, so that schools can enjoy the benefits of more advanced technology on par with their urban counterparts. As such, these collaborations are instrumental in ensuring that all students, regardless of socio-economic background, can have equal access to quality digital learning. These partnerships can also accelerate the adoption of technology in education, especially in terms of curriculum development that is more relevant to future needs. Close collaboration between the education and industry sectors can result in curricula that are more responsive to the demands of a labor market that increasingly relies on digital skills. With direct input from companies working in the technology sector, education curricula can be customized to prepare students with the skills needed in an increasingly digital and connected world of work.

In the long term, strong links between the education sector and industry can also create employment opportunities for students who have been trained with digital skills (Khan, 2022). By facilitating internships and co-op opportunities between students and companies, this collaboration opens the door for students to gain valuable practical experience. Many tech companies offer internship opportunities for students, giving students the chance to work directly with professionals in the field, broadening students' horizons about the industry, and even increasing students' chances of getting hired after graduation. This creates a clear pathway from education to the increasingly tech-based world of work, preparing students for successful careers within the ever-evolving tech sector. Overall, collaboration between the education and industry sectors offers tremendous opportunities to improve digital literacy in schools, not only by providing access to the necessary tools and training but also by introducing students to work-relevant technologies and providing hands-on industry experience. This collaboration has the potential to reduce the digital skills gap, create better job opportunities and help students develop the skills they will need to succeed in an increasingly digital world. With support from the industry sector, education can transform to better respond to the emerging needs and challenges of the Industrial Revolution 5.0.

The increase in online learning is also a very significant opportunity in implementing digital literacy. Online learning platforms such as Google Classroom, Moodle and Zoom give students access to learning materials that students can access anytime and anywhere (Malik, 2021). In terms of learning strategies, this study recommends some important steps to improve digital literacy. One of them is the improvement of technology infrastructure in schools, both from the government and the private sector. Investment in hardware, software and internet connectivity is crucial to ensure all students, especially those in remote areas, have equal access to technology. The government needs to strengthen device distribution programs, as well as support the provision of wider and more stable internet access, so that all schools can utilize technology for learning.

Continuous training for teachers is also indispensable. Teachers should be trained not only to use technological devices, but also to integrate technology into their teaching

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effectively. This training should include the use of digital tools, learning applications, as well as teaching methods that enable interactive and collaborative learning. The education curriculum should be reformed to make digital literacy an integral part of all subjects (Fatiroh, 2024; Mashuri, 2024). This ensures that students not only learn technology as a separate subject, but also use it to explore various disciplines. Project-based and collaborative learning supported by technology is also a highly relevant strategy. Technology allows students to work together virtually, both inside and outside the classroom. Project-based collaborative learning gives students the opportunity to develop skills that are highly needed in the world of work, such as teamwork, communication, and problem solving (Rofiudin, 2024; Surojudin, 2024; Susanti, 2023). In addition, project-based learning allows students to use digital tools to create real solutions to problems that students face, so students can develop more in-depth practical skills.

The implementation of digital literacy in schools should prioritize the involvement of all parties, including students, teachers, parents and communities (Bouaamri, 2024). The government needs to formulate policies that facilitate the procurement of technological devices in schools, provide continuous training to teachers and reform the curriculum to make it more relevant to technological developments. Schools, in turn, should develop internal strategies that ensure all teachers have the necessary skills to integrate technology in their learning and that students are given equal opportunities to master digital literacy. This research shows that to optimize the implementation of digital literacy, a more holistic and systematic approach is needed. Technology has great potential to transform the way we teach and learn, but to make the most of it, there needs to be collaboration between the education sector, industry and society (Aithal, 2024). Only with an inclusive, adaptive and sustainable approach can schools meet the challenges of the Industrial Revolution 5.0 era and provide students with the digital skills needed to thrive in an increasingly digitalized world.

Conclusion

The Industrial Revolution 5.0 brings great challenges and opportunities for school education, especially in developing digital literacy. Digital literacy includes not only mastery of technology but also critical, ethical and creative thinking abilities that support 21st century skills. This research identified challenges such as gaps in access to technology, lack of teacher competence and resistance to curriculum change. However, the opportunities offered, including the application of technologies based on artificial intelligence, the Internet of Things and big data, can support more personalized, inclusive and sustainable learning. Digital literacy learning strategies in schools are becoming increasingly important in the face of the challenges and opportunities offered by the Industrial Revolution 5.0. Rapid changes in technology require the education system to adapt in more innovative ways, not only in mastering digital skills, but also in building ethical understanding and responsibility in the use of technology. However, the implementation of digital literacy strategies still faces various obstacles, including the readiness of educators, limited infrastructure, and disparities in access to technology in various schools. However, the Industrial Revolution 5.0 era also brings great opportunities for education. By utilizing artificial intelligence, Internet of Things (IoT), and other digital technologies, learning can become more interactive, personalized, and effective. In addition, the integration of digital ethics and cybersecurity aspects in education is crucial to ensure that students are not only proficient in technology, but also able to use it responsibly. This study contributes to filling the gap of previous research by highlighting digital literacy strategies in the context of the Industrial Revolution 5.0 and examining the effectiveness of the approaches implemented in schools

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