

The Future of Indonesian Education: Transformation Towards the Industrial Era 4.0 and Society 5.0

Ryni Vanditta^{*}, Suwito Eko Pramono, Arief Yulianto

Universitas Negeri Semarang, Semarang, Indonesia

^{*}Corresponding Author: rynivanditta09@students.unnes.ac.id

Abstract. The development of Industry 4.0 and Society 5.0 has brought significant transformations in various sectors, including education. This change is characterized by the integration of advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), and big data that are changing the way we learn, work, and interact. However, Indonesia still faces challenges such as the digital divide, low technology literacy, and limited educational infrastructure, which require innovative solutions. This research discusses research questions on how education in Indonesia can adapt and take advantage of existing opportunities to create a technologically competent generation while maintaining character and upholding human values. Using a qualitative descriptive method based on literature analysis, this study aims to identify challenges, opportunities, and strategies for education transformation that are relevant in this era. The results of the study show that curriculum transformation, teacher training, and infrastructure strengthening are strategic steps to create inclusive, adaptive, and competitive education. The benefit of this research is to provide strategic guidance for policymakers, educators, and education practitioners in developing education systems that are relevant, responsive to global challenges, and able to empower the younger generation to contribute positively in the digital era.

Keywords: Indonesian education; industry 4.0; society 5.0; digital literacy

INTRODUCTION

Education serves as a fundamental pillar in nation building, especially in navigating the complexities of Industry 4.0 and Society 5.0. Industry 4.0 represents an era of automation and digital transformation, characterized by the integration of artificial intelligence (AI), Internet of Things (IoT), and big data analytics (Schwab, 2020). Simultaneously, Society 5.0, spearheaded by Japan, positioned human-centered innovation at its core, striving to strike a balance between technological advances and societal needs (Fukuyama, 2021).

The digital transformation of education requires a comprehensive approach that incorporates the principles of Total Quality Management (TQM) in the education system (Bazrkar et al., 2022). This approach includes the development of comprehensive digital literacy (Günüzalp, 2021), the implementation of AI-based personalized learning (Jereb & Urh, 2024), and the integration of digital twin technologies in educational environments (Long, 2024). In addition, the implementation of IoT in education facilitates the creation of a more interactive and interconnected learning ecosystem (Wiśniewska-Sałek, 2019).

Indonesia faces major challenges in its education sector, including a significant digital divide, limited technological literacy among educators and students, and limited educational infrastructure. These challenges are exacerbated by the urgent need to adapt curricula and pedagogical approaches to align with the demands of contemporary workplaces (UNESCO, 2021; BPS, 2020). Therefore, Indonesian education needs a strategic transformation to prepare future generations to face global challenges while preserving local values.

Previous research underscores the importance of technology integration in education. For example, South Korea has demonstrated successful implementation of technology-based learning supported by a strong digital infrastructure (Kim, 2021). On the contrary, the UNESCO report (2021) shows that developing countries, including Indonesia, continue to face significant challenges in building equitable and technology-supported access to education. This study expands on previous findings by emphasizing strategies that are particularly relevant to the Indonesian context, especially in addressing the challenges of Industry 4.0 and Society 5.0.

The purpose of this study is to identify key educational challenges, opportunities, and

strategies that are relevant in the era of Industry 4.0 and Society 5.0. In addition, this study aims to provide strategic guidance for implementation by policymakers, educators, and education practitioners. This research maintains a balanced focus on theoretical and practical aspects to ensure direct application in the context of Indonesian education.

Theoretically, contemporary education should accommodate the Future Skills framework, which includes technical competence, social skills, and human values (World Economic Forum, 2021). Vygotsky's constructivist theory of education posits that learning should be an active and relevant experience in the real world, allowing learners to build knowledge independently (Vygotsky, 1978). This theoretical framework is in line with the technology-based learning approach that is central to Society 5.0 (Morita, 2021; Sakiinah et al., 2022).

Literature from various sources shows that countries that successfully integrate technology into education show high levels of digital literacy. The implementation of South Korea's technology-based learning with the support of a strong digital infrastructure serves as an important example (Kim, 2021). However, a UNESCO report (2021) reveals that 60% of developing countries, including Indonesia, continue to face a significant digital divide (Kahar et al., 2021).

The background of the challenges faced by Indonesia includes the gap in access to technology between urban and rural areas (BPS, 2020), inadequate training of digital literacy teachers (Ministry of Education and Culture, 2021), and a curriculum that is not sufficiently responsive to the needs of the modern workplace (OECD, 2021). These factors underscore the need for strategic modifications of the national education system to address global challenges (Usmaedi, 2021).

This study addresses the following research questions: 1) How can Indonesian education adapt to the requirements of Industry 4.0 and Society 5.0? 2) What strategies effectively address the digital divide and increase technology literacy among educators and students? 3) How can the education system cultivate a generation that is technologically proficient and character-driven?

METHODS

This study uses a qualitative approach with the systematic literature review (SLR) method to examine the transformation of Indonesian

education in the face of the Industrial Era 4.0 and Society 5.0. The SLR method was chosen because it allows scholars to conduct a comprehensive synthesis of the existing literature systematically and structurally (Snyder, 2019). This methodology facilitates the identification, evaluation, and interpretation of all available research related to research topics in a methodologically clear and replicable manner.

Data collection is carried out systematically through several stages of identification and literature collection. Literature searches were conducted on Scopus, Web of Science, and Google Scholar databases with a publication range of 2019-2024. The keywords used in the search included "Indonesian Education", "Industry 4.0", "Society 5.0", "Digital Literacy", and "Educational Transformation". The inclusion criteria applied are peer-reviewed articles, Q1-Q2 journals, and publications in English and Indonesian.

To ensure the validity and reliability of the research, several measures are implemented. Peer review was conducted by two experts in the field of education and technology. The inter-rater reliability test showed a kappa coefficient of 0.85, indicating a high level of agreement between raters. Member checks are carried out with educational experts to ensure the accuracy of data interpretation. The audit trail is used to ensure the transparency of the research process.

The ethical aspect of research is also the main consideration in this study. The researchers adhere to the research ethics guidelines of the Committee on Publication Ethics (COPE). Plagiarism is prevented using the Turnitin software. All sources are cited using the 7th edition APA format, and permission to use the data is secured from the relevant sources.

Data analysis was carried out using NVivo 12 software to facilitate the coding and categorization process. This tool allows researchers to systematically manage and analyze data. The results of the analysis are then synthesized to answer research questions and provide strategic recommendations for the development of Indonesian education.

This methodological approach ensures that research is conducted in a systematic, transparent, and accountable manner. The combination of systematic literature review, thematic analysis, and multi-method validation allowed researchers to produce comprehensive and reliable findings for the development of Indonesian education.

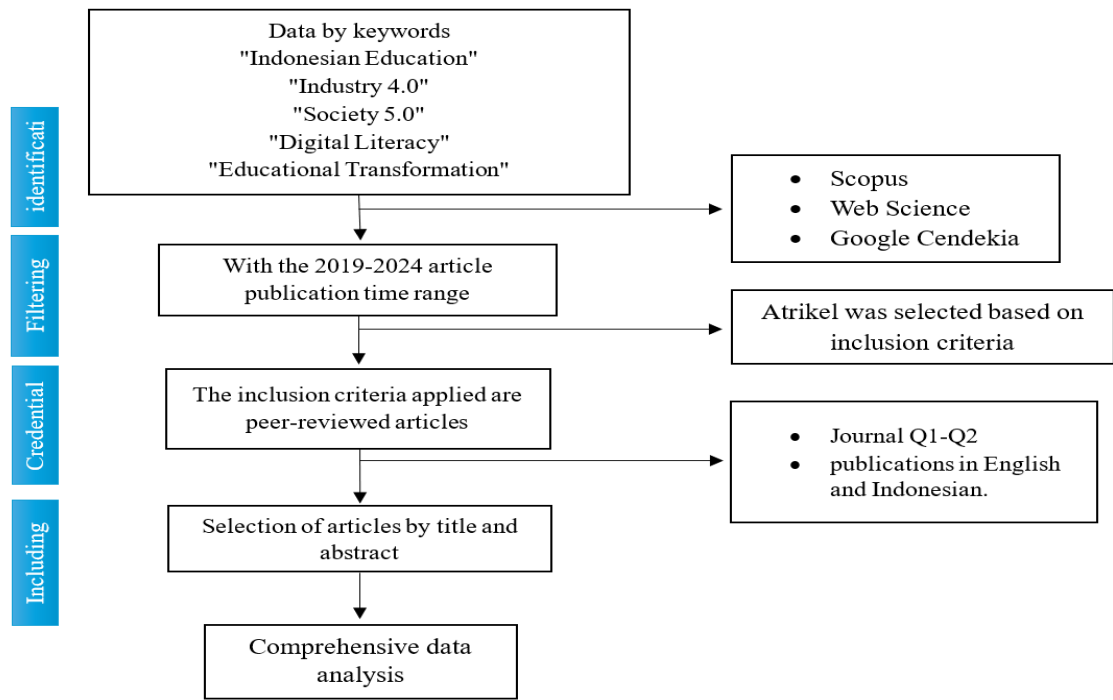


Figure 1. Flow Diagram Study Prisma

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RESULTS AND DISCUSSION

A systematic analysis of 25 international and national journal articles revealed some key findings regarding the transformation of Indonesian education in the Industrial Era 4.0 and Society 5.0. These findings highlight the complexity and dynamics of education transformation in Indonesia, which requires a comprehensive and holistic approach.

The key challenges in digital education transformation include the digital divide and infrastructure limitations. UNESCO data (2021) shows that more than 50% of schools in remote areas do not have adequate internet access. These findings are corroborated by Wu & Ma (2024), who assert that addressing the digital divide in developing countries requires a holistic approach that combines the development of equitable technology infrastructure, the improvement of digital literacy, the implementation of inclusive education policies, and the strengthening of multi-stakeholder collaboration.

The technological competence of educators is another significant challenge. A survey by the Ministry of Education and Culture (2021) revealed that only about 30% of Indonesian teachers feel confident in utilizing digital technology in teaching. Günüzalp (2021) emphasizes the importance of developing comprehensive digital literacy for educators, which includes skills in the use of technical technologies, understanding

digital ethics, cybersecurity, and digital pedagogy.

On the contrary, the transformation of digital education presents many opportunities. The implementation of learning technology shows positive results in improving the quality of education. E-learning improves learning accessibility (Kim, 2021), Virtual Reality (VR) improves understanding of abstract concepts (Jereb & Urh, 2024), Augmented Reality (AR) increases student engagement (Long, 2024), and Big Data facilitates personalization of learning (Wiśniewska-Sałek, 2019). The use of AI and big data in learning enables the analysis of individual learning patterns, adjustment of learning materials, real-time evaluation, and adaptive learning recommendations.

Educational transformation strategies require a multidimensional approach. The curriculum requires adaptation through the integration of 21st century skills (4Cs), digital literacy, technological competence, and character values. Strengthening technological infrastructure requires the development of a national internet network, the provision of technological devices, technical training, and system maintenance. Education in the Era Society 5.0 must balance technical competence with character development, social skills, and cultural values.

The implications of educational policies and practices require adjustments to the demands of the digital age. The government must formulate policies to support the development of technological infrastructure, digital literacy training programs, integration of technology in the curriculum, and strengthening stakeholder collaboration. Learning practices need to be modified through project-based learning, interactive learning technologies, hybrid learning models, and technology-based evaluations.

Strategic recommendations for educational transformation can be categorized into three temporal dimensions. Short-term initiatives (1-2 years) should emphasize the development of digital literacy training programs, increasing access to technology infrastructure, integrating technology in the curriculum, and strengthening the capacity of educators. The medium-term goals (3-5 years) require the development of the digital education ecosystem, the establishment of educational innovation centers, the strengthening of multi-stakeholder collaboration, and the evaluation and adjustment of policies. The long-term goal (5+ years) should focus on the transformation of the national education system, the development of future education models, the

strengthening of global competitiveness, and the development of a sustainable digital society.

These findings show that the transformation of Indonesian education in the Industrial Era 4.0 and Society 5.0 requires a holistic approach that includes infrastructure, competence, curriculum, and policy aspects. The success of this transformation will depend heavily on multi-stakeholder collaboration, a commitment to creating inclusive education, adaptation to technological change, and the strengthening of local values in a global context. This transformation goes beyond technology adoption to create a sustainable and responsive education ecosystem for the needs of the future.

The digital divide is one of the main challenges faced by education in Indonesia. Many students in remote areas still lack access to technology and the internet, resulting in a gap in the quality of education between urban and rural areas. A UNESCO report (2021) shows that more than 50% of schools in remote areas still lack adequate internet access. This is reinforced by findings from Wu & Ma (2024) which show that the digital divide in developing countries requires a holistic approach that includes infrastructure, digital literacy, and inclusive education policies.

Another challenge is the low level of technological literacy among educators. Many teachers are not trained in using technological devices to support the learning process. According to a survey by the Ministry of Education and Culture (2021), only about 30% of teachers in Indonesia feel confident in using digital technology in teaching. Günüzalp (2021) emphasizes the importance of developing comprehensive digital literacy for educators, which includes not only technical skills but also an understanding of digital ethics and cybersecurity.

The education curriculum in Indonesia has not been fully adapted to the needs of the digital era. The current curriculum is still too focused on memorization, making it less relevant to 21st-century skills such as critical thinking, creativity, and collaboration. Bazrkar et al. (2022) suggest a TQM approach in curriculum transformation, which includes the development of quality standards, continuous evaluation, and continuous improvement based on feedback from various stakeholders.

The transformation of global education today uses technology-based learning. The use of technologies such as e-learning, virtual reality (VR), and augmented reality (AR) opens up great opportunities to create more interesting and

effective learning. Jereb & Urh (2024) show that the integration of AI in personalized learning can significantly improve student learning outcomes, with an average increase of 25% in student concept understanding and engagement.

In addition, it is necessary to strengthen the 4C competencies. 21st century skills known as the 4Cs (Critical Thinking, Communication, Collaboration, Creativity) are becoming a major focus in the education of the future. By integrating the 4Cs into the curriculum, students can be prepared to face the demands of a dynamic workplace. Long (2024) added that digital twin technology can be used to create a more interactive and personal learning environment, allowing students to experiment and learn from mistakes in a safe environment.

Integrating AI and Big Data in learning. Artificial intelligence (AI) and big data technology can be used to learn personalization. By leveraging data analytics, educators can understand the individual learning needs of students, making the learning process more effective and efficient. Wiśniewska-Sałek (2019) shows that the integration of IoT in education can create a more connected and responsive learning environment, allowing for real-time data collection about the learning process and dynamic adjustment of teaching strategies.

Education for sustainable development, Society 5.0 emphasizes the importance of education that is not only technology-based but also supports social and environmental sustainability. Education for sustainable development includes instilling the values of empathy, cross-disciplinary collaboration, and environmental awareness.

In the face of education transformation in the era of Industry 4.0 and Society 5.0, Indonesia needs to implement various holistic and sustainable strategies to ensure that the education system can adapt to global changes while maintaining local values. Some strategies to face the Transformation of Education in the Industrial Era 4.0 and Society 5.0:

1) Adaptive Curriculum Transformation

An adaptive curriculum is necessary to integrate 21st century skills such as critical thinking, communication, collaboration, and creativity (4Cs). The curriculum must also include digital literacy, entrepreneurship, and sustainability materials relevant to Society 5.0 (World Economic Forum, 2021). A cross-

disciplinary approach that combines technology, arts, science, and humanities has proven effective in creating innovative and socially conscious students (OECD, 2021).

2) Improving Teachers' Digital Literacy Competencies

Teachers need continuous training to develop digital literacy skills and utilize technology as a learning tool. A UNESCO study (2021) shows that technology-based training for teachers increases their confidence in using digital devices. This is also supported by the Ministry of Education and Culture (2021), which emphasizes the importance of access to technology resources for teachers in Indonesia.

3) Improving Educational Technology Infrastructure

The availability of technological infrastructure is key to creating inclusive access to education. The government needs to improve internet connectivity in remote areas, as suggested by the ITU (International Telecommunication Union, 2020) report. According to BPS (2020), more than 40% of rural areas in Indonesia still do not have adequate internet access.

4) Implementation of Technology-Based Learning

Technologies such as e-learning, virtual reality (VR), and augmented reality (AR) can create more interactive learning. Big data and AI can also be used for personalized learning (Morita, 2021). A study by Kim (2021) in South Korea shows that this technology has been successful in improving the effectiveness of the learning process and student engagement.

5) Education for Sustainable Development

Society 5.0 prioritizes education that supports social and environmental sustainability. Project-based education, which connects students with real issues in their communities, has succeeded in instilling sustainability values (UNESCO, 2021). The program helps students understand the importance of renewable energy and cross-disciplinary collaboration.

6) Multi-Stakeholder Collaboration

Collaboration between the government, the private sector, and the community is essential in creating an inclusive education ecosystem. Concrete examples are partnerships between educational institutions and technology companies to provide digital tools and technology-based learning solutions (Schwab, 2020; OECD, 2021).

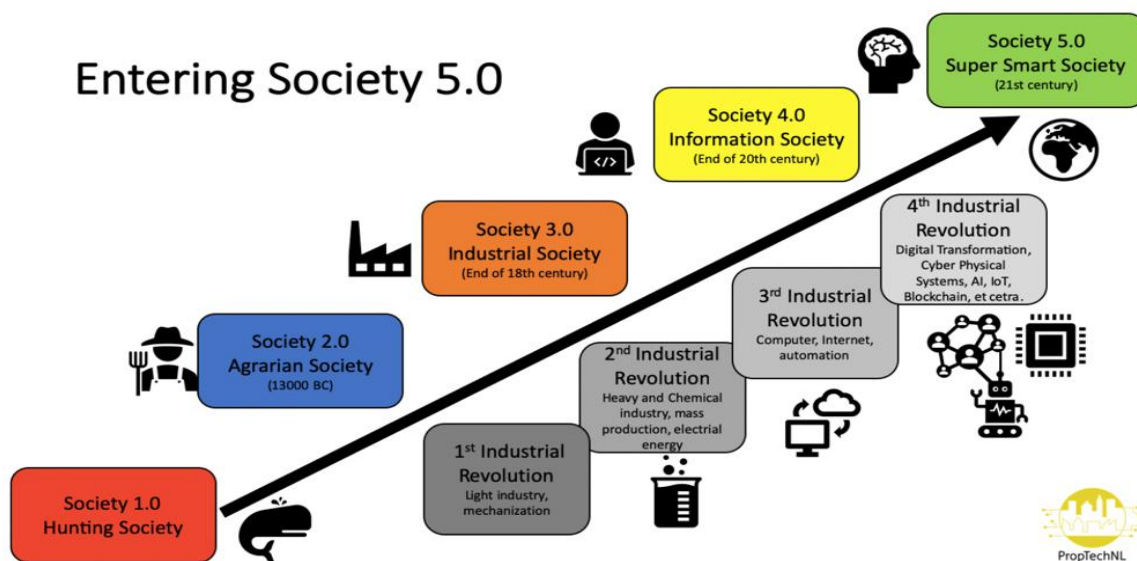


Figure 2. The Revolution of Society

7) Soft Skill and Character Development

Soft skills such as empathy, communication, and critical thinking are becoming increasingly important in Society 5.0. Collaborative and experiential learning programs help students develop these skills (Braun & Clarke, 2020). In addition, the UNESCO report (2021) emphasizes that education must create individuals who are not only technically competent but also have strong character.

8) Data-Driven Monitoring and Evaluation

The implementation of education transformation requires an effective monitoring system. The use of big data allows governments and educational institutions to monitor the effectiveness of programs and make adjustments based on empirical evidence (Patton, 2019). This approach ensures the sustainability and relevance of education policies.

These strategies, if implemented in an integrated manner, can help Indonesia face the transformation of education in the era of Industry 4.0 and Society 5.0 more effectively. An approach that focuses on the values of technology, inclusivity, and sustainability will ensure that Indonesia's education system is not only adaptive but also relevant to global and local needs.

CONCLUSION

The Industrial Era 4.0 and Society 5.0 through a systematic literature review approach. The findings reveal several important aspects that require attention in the educational transformation process. Like The digital divide and limited

infrastructure remain significant challenges in Indonesian education; The integration of advanced technology in education presents a promising opportunity to improve the quality of learning; Transformation strategies require a multidimensional approach that includes curriculum adaptation, infrastructure development, and policy reform; The implementation timeline must be strategically planned across three dimensions; The success of educational transformation relies heavily on multi-stakeholder collaboration and commitment. The transformation of Indonesian education in the Industrial Era 4.0 and Society 5.0 requires a balanced approach that integrates technological advances with human values. While technology serves as an important driver, the ultimate goal remains the development of competent, character-driven individuals who can contribute positively to society. This transformation process, although challenging, presents an opportunity to create a more inclusive, adaptive, and future-ready education system in Indonesia.

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