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Transforming Junior High School Education in the Era of the Industrial Revolution 4.0 and Society 5.0

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Abstract. The rapid advancement of digital technologies in the era of Industrial Revolution 4.0 and Society 5.0 has significantly transformed the landscape of education. Junior high schools, as a critical stage in students' development, hold a strategic role in preparing a generation that is both technologically competent and strong in character. This study aims to analyze the challenges and strategies for integrating technology-based and character-oriented education in junior high schools to meet the demands of the digital age. Employing a library research methodology, the study reviews relevant academic literature, policy documents, and previous research findings. The results reveal a paradigm shift toward personalized and adaptive learning, the essential integration of digital literacy, and the development of 21st-century skills (4C + 1C: critical thinking, creativity, communication, collaboration, and computational thinking). Moreover, the role of teachers is transforming into facilitators and innovators. However, key challenges such as unequal infrastructure, limited ICT competencies among teachers, and disparities in access in underdeveloped regions remain prominent. The study concludes that cross-sector collaboration and adaptive educational policies are vital to building an inclusive and future-ready educational ecosystem. It recommends a holistic approach that balances technological advancement with character education to produce ethical, innovative, and resilient future citizens.

Keywords: junior high school; education; industry revolution 4.0; society 5.0; digital literacy; skill 21st century

INTRODUCTION

The development of digital technology in the 21st century has fundamentally transformed social, economic, and educational structures. The Industrial Revolution 4.0 is characterized by the emergence of Artificial Intelligence (AI), the Internet of Things (IoT), big data, and robotics, which have brought significant impacts across all sectors of life, including the education system (Schwab, 2016; Brynjolfsson & McAfee, 2014). Furthermore, the concept of Society 5.0, introduced by the Government of Japan, emphasizes the need to balance technological progress with human values by integrating advanced technologies into social life to create an inclusive and human-centered society (Fukuyama, 2018; Cabinet Office of Japan, 2018).

In this context, the junior high school education level holds a strategic position as the foundation for developing students' character, skills, and digital literacy. Junior high school represents a crucial transitional stage where students must be equipped not only with academic knowledge but also with 21st-century competencies, such as critical thinking, creativity, collaboration, and communication (OECD, 2018; Prensky, 2010). In addition, digital literacy, adaptability to technological changes, and digital ethics have become essential competencies that must be cultivated from an early age (Purnawati, 2021; Aoun, 2017).

However, implementing education in the 4.0 and 5.0 eras remains a complex challenge. Studies have shown that technological infrastructure disparities in underdeveloped regions, limited teacher competence in technology utilization, and low student readiness for digital learning are among the main obstacles (Suwardana, 2017; Yuwono & Susilowati, 2020). Moreover, rapid digital transformation may undermine moral and ethical values if it is not balanced with strong character education (Hermawan, 2019).

The Indonesian Government, through the Ministry of Education and Culture, has formulated the 2020–2024 Education Strategy, which emphasizes the integration of digital technology into the curriculum, enhancement of teacher competence through ICT training, and strengthening collaboration among educational stakeholders (Ministry of Education and Culture, 2020). Initiatives such as the development of e-learning platforms, the use of Learning Management Systems (LMS), and the provision of digital devices for schools reflect the government's commitment to promoting adaptive and technology-based education.

Given this background, this paper is structured based on the library research method, which involves analyzing various scientific sources, policy documents, and previous studies relevant to the topic. The purpose is to analyze how junior high school education in Indonesia can effectively adapt to the challenges and opportunities brought by the Industrial Revolution 4.0 and Society 5.0. The study focuses on structural challenges, curriculum and pedagogical development strategies, and the importance of balancing technological mastery with character education.

Through a comprehensive literature-based approach, this paper aims to provide both conceptual and practical contributions to the development of a junior high school education system that is relevant, resilient, and empowering in preparing students to face a digital yet humanistic future.

METHODS

This paper employs a library research method, which involves a systematic review of various written sources relevant to the topic under study. The literature research method aims to obtain data and information from existing documents such as scholarly books, academic journal articles, policy reports, and credible digital sources. In conducting this study, the author identified and selected various references related to education in the era of the Industrial Revolution 4.0 and Society 5.0, particularly those focusing on junior high school education. The sources were drawn from both national and international publications, including scientific journals, government policy documents issued by institutions such as the Ministry of Education and Culture and the Ministry of Communication and Information, as well as publications from global organizations such as the OECD and the World Economic Forum.

The collected literature was then critically reviewed and analyzed to identify the main ideas, trends, challenges, and strategies concerning educational transformation in the digital era. The analysis was carried out thematically by classifying information into key topics such as digital literacy, technology-based learning, character education, and educational access gaps. The reviewed materials were synthesized to construct an argumentative framework addressing the core issues discussed in this paper. This process enabled the author to integrate multiple perspectives from both scientific and policy viewpoints into a comprehensive and systematic understanding of the subject.

To ensure the validity and credibility of the arguments, all references used in this study were taken from verified academic and official sources, which are cited and listed in accordance with established scientific standards. Through this literature-based approach, the paper is expected to contribute conceptually to the development of ideas and the formulation of educational policies that respond effectively to the dynamics of the Industrial Revolution 4.0 and Society 5.0, particularly within the context of junior high school education in Indonesia.

RESULTS AND DISCUSSION

The transformation of education in the era of the Industrial Revolution 4.0 and Society 5.0 represents a fundamental paradigm shift that affects the philosophy, structure, and practice of learning across all levels, particularly in junior high school education. Based on an extensive review of academic studies and policy documents, it is evident that educational systems worldwide, including Indonesia, are undergoing rapid digitalization and pedagogical reform. This change encompasses not only the adoption of new learning technologies but also a shift in the roles of teachers, students, and institutions. The following discussion presents six major findings that highlight the dynamics, challenges, and opportunities of this educational transformation: the paradigm shift in learning, strengthening digital literacy and 21st-century skills, inequality in digital infrastructure, the evolving role of teachers, character education in a technology-based society, and the importance of collaboration and adaptive policy in education.

Shift in Learning Paradigms

The 21st-century learning environment has experienced a radical transition from conventional to adaptive, personalized, and technology-integrated approaches. The Industrial Revolution 4.0 and Society 5.0 have redefined learning as a dynamic, interactive, and continuous process that transcends physical classrooms. Digitalization has become the cornerstone of this transformation. Teaching and learning activities increasingly utilize online and blended learning platforms such as Google Classroom, Zoom, Moodle, and Ruangguru, allowing students and teachers to engage in flexible, location-independent learning (Schwab, 2016; OECD, 2018). These technologies not only provide accessibility but also promote collaboration, interactivity, and individualized

instruction.

Personalized learning represents another significant dimension of educational transformation. The emergence of Artificial Intelligence (AI) and Learning Analytics enables the customization of curriculum content and learning materials to suit students' needs, learning speeds, and interests (Aoun, 2017). This adaptive model enhances engagement, motivation, and retention by allowing students to progress according to their personal learning trajectories. Moreover, immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) have begun to enrich the learning experience by providing interactive and experiential environments, particularly in science, history, and technical subjects (Fukuyama, 2018; Yusof & Zulkepli, 2020).

Simultaneously, the roles of teachers and students are undergoing substantial transformation. Teachers are no longer mere transmitters of information but facilitators, mentors, and learning designers who guide students in digital exploration and problem-solving. Students, in turn, are expected to become active participants who engage critically with knowledge rather than passive recipients (Prensky, 2010; Kusuma, 2022). Furthermore, the expansion of digital access has democratized education by enabling students in different regions to access similar learning materials, provided that adequate infrastructure and internet connectivity are available (Ministry of Education and Culture, 2020). Collectively, these shifts illustrate how digital transformation has redefined pedagogy toward a more human-centered and adaptive framework aligned with the goals of Society 5.0.

Strengthening Digital Literacy and 21st-Century Skills

The literature review reveals that digital literacy and 21st-century skills constitute the two most critical competencies in preparing junior high school students for the challenges of the Industrial Revolution 4.0 and Society 5.0. Digital literacy is no longer limited to the ability to operate technological devices; it encompasses a broader set of competencies including information evaluation, cybersecurity awareness, and ethical online behavior (Purnawati, 2021; OECD, 2018). Junior high school students must be capable of navigating vast digital ecosystems responsibly, distinguishing between credible and false information, and understanding the implications of their online activities.

At the same time, 21st-century education demands the cultivation of the "4C" competencies—critical thinking, creativity, collaboration, and communication (Aoun, 2017; Prensky, 2010). These skills are essential for fostering problem-solving abilities, adaptability, and global citizenship. However, research indicates that many students and teachers in Indonesia still lack adequate digital competencies. The digital divide among schools remains high, and teacher training in digital pedagogy is often insufficient (Suwardana, 2017; Yuwono & Susilowati, 2020).

Another significant finding is that current curricula often remain overly content-heavy and do not provide sufficient opportunities for project-based, research-based, or collaborative learning (Ministry of Education and Culture, 2020). To address this gap, national and international initiatives have emerged, such as the National Digital Literacy Movement, Google for Education, and online training platforms like Kahoot, Edmodo, Moodle, and the Microsoft Education Center. Although these initiatives mark significant progress, their implementation remains uneven across regions. Strengthening digital literacy and 21st-century skills therefore requires systemic efforts, including curriculum reform, teacher professional development, and equitable resource distribution.

Inequality of Access and Digital Infrastructure

Despite substantial advancements in digital education, inequality in access and infrastructure continues to pose a major barrier to achieving inclusive and equitable education. The literature review indicates that many junior high schools in remote and underdeveloped regions (3T areas frontier, outermost, and underdeveloped) still lack stable internet connections, adequate ICT devices such as computers and projectors, and reliable electricity (Suwardana, 2017; Ministry of Education and Culture, 2020). Consequently, students in these areas are often excluded from digital learning opportunities.

The disparity between urban and rural schools remains significant. Urban students generally enjoy greater access to digital technology and online learning, while rural students still depend heavily on conventional methods due to infrastructural and economic constraints (Yuwono & Susilowati, 2020). Furthermore, teachers in underdeveloped schools often lack training in the effective use of digital tools, such as Learning Management Systems (LMS) or interactive media (Kusuma, 2022).

Although government programs like "School Digitalization" and "Learning from Home" aim to bridge these gaps, their implementation is hindered by logistical, geographical, and budgetary limitations (Ministry of Education and Culture, 2020; Ministry of Communication and Information, 2021). Socioeconomic inequalities also exacerbate the problem, as many students from low-income families cannot afford personal gadgets or internet subscriptions (OECD, 2018). These structural inequalities highlight the urgent need for comprehensive digital inclusion policies to ensure that the benefits of the digital revolution reach all levels of society, not just urban or privileged groups.

The Role of Teachers as Facilitators and Innovators

Teachers occupy a central role in educational transformation during the Industrial Revolution 4.0 and Society 5.0. The teacher's function has evolved from a knowledge transmitter to a facilitator, mentor, and innovator capable of designing active, collaborative, and problem-based learning environments. Teachers are now expected to facilitate and evaluate learning processes that promote student participation, both in physical and digital classrooms (Prensky, 2010; Kusuma, 2022).

Digital competence and innovative pedagogy have become essential attributes for modern educators. Teachers must be able to integrate technology pedagogically into learning activities, utilizing LMS platforms, interactive quizzes, simulations, and multimedia materials (Aoun, 2017; Ministry of Education and Culture, 2020). Moreover, in a world saturated with information and at risk of technological misuse, teachers play a vital role in instilling digital ethics, empathy, and social responsibility among students (Hermawan, 2019).

In the context of Society 5.0, teachers are also innovators who design contextual and adaptive learning experiences that align with students' individual needs. This includes project-based learning, cross-disciplinary collaboration, and real-world problem-solving (Yusof & Zulkepli, 2020). However, many teachers in Indonesia have not yet received adequate training in digital pedagogy. Most training programs still focus on technical skills rather than pedagogical innovation (Suwardana, 2017; Yuwono & Susilowati, 2020). Strengthening teacher capacity through continuous professional development, mentoring, and knowledge exchange therefore remains crucial for achieving effective educational reform.

Character Education in a Technology-Based Society

Character education remains a fundamental pillar of human development, even amid rapid technological advancement. The rise of AI, IoT, and robotics has transformed social patterns, learning methods, and interpersonal communication. Yet this digital transformation also creates value disruption, characterized by increased individualism, misinformation, and declining empathy and courtesy in online interactions. These challenges make character education more urgent than ever.

Integrating character values such as empathy, responsibility, integrity, cooperation, and tolerance into technology-based education serves as a moral counterbalance to the dominance of cognitive and technical skills. Character education should not be treated as a separate subject but rather integrated across all learning activities, both in physical and digital environments. Project-Based and Collaborative Learning methods can effectively instill values of responsibility, leadership, and teamwork, as students learn to solve real-world problems collaboratively.

Value-based technology implementation also enhances character formation. For instance, using AR simulations in history lessons can evoke nationalism and appreciation for cultural heritage. Likewise, Digital Ethics Education, covering issues like data privacy, cyber etiquette, and information filtering, helps students cultivate moral awareness in digital spaces. Extracurricular activities and community engagement, such as social media campaigns for environmental awareness or technology-based volunteering, also reinforce these values.

Teachers play a pivotal role as character builders. They act as facilitators who guide students in interpreting digital information wisely, as role models for ethical technology use, and as designers of integrated moral learning. Collaboration among government, schools, and industry is also vital. The government must embed character education into national curricula, schools must provide flexible platforms for its practice, and industries can contribute by creating digital learning tools that foster moral as well as technical development.

Collaboration and Adaptive Policy Design

The rapid technological development of the Industrial Revolution 4.0 and Society 5.0 necessitates flexible, dynamic, and responsive educational policies. Rigid and outdated regulations cannot keep pace with the continuous

evolution of digital learning ecosystems. Therefore, collaborative governance, involving government agencies, schools, industries, and communities is essential for maintaining educational relevance and inclusivity.

Collaboration between government and schools is vital in creating adaptive frameworks for curriculum design, infrastructure development, and teacher training. Governments must provide regulatory and financial support for STEAM-based and character education curricula, digital infrastructure procurement, and periodic teacher training. Partnerships with the private sector and industries are equally important, as these sectors possess the technological expertise and insight into future labor market needs. Programs such as mini-internships, industry visits, and co-created digital learning applications help bridge the gap between education and employment readiness.

Community and parental collaboration further strengthens the ecosystem of digital learning. Parents play an essential role in guiding students' study habits at home, while communities can promote positive digital content and online literacy campaigns. These partnerships collectively reinforce digital ethics, character education, and mentoring quality within home-based learning contexts.

Ultimately, adaptive education policies and cross-sector collaboration create the conditions for sustainable educational transformation. Flexible frameworks allow schools to innovate locally while aligning with national and global standards. Such synergy ensures that education remains human-centered, equitable, and future-oriented.

The Benefits of Digital Transformation in Education

Digital transformation in education not only addresses structural inequalities but also enhances quality, relevance, and sustainability in learning. The key benefits include expanding access and equity through e-learning platforms, promoting personalized and adaptive learning, strengthening digital literacy and cyber ethics, fostering 21st-century skills, and transforming teacher-student relationships. Hybrid and asynchronous learning models increase flexibility for students with diverse socioeconomic backgrounds or learning needs.

Furthermore, AI-driven analytics and immersive technologies improve learning effectiveness by providing real-time feedback, interactive simulations, and adaptive assessments. Students gain deeper engagement and autonomy, while teachers focus on mentorship and innovation. Digital education also cultivates future-ready learners equipped for digital careers, global collaboration, and ethical leadership.

In essence, digital transformation is not merely technological it represents a paradigm shift toward inclusive, adaptive, and character-driven education that prepares students for a rapidly changing world. Through strategic collaboration, strengthened literacy, and teacher innovation, junior high school education in Indonesia can evolve into a system that harmonizes technological advancement with humanity, fulfilling the true vision of Society 5.0: technology for people and sustainable well-being.

CONCLUSION

Education at the level School Intermediate First (SMP) is located in position strategic in prepare generation young people who don't only intelligent in a way academic, but also tough in a way character and adaptive to development technology. Integration between education digital characters and technology is need urge in answer challenge Revolution Industry 4.0 and vision Humanistic Society 5.0. First, transformation paradigm learning require education shift from approach conventional towards a model that is adaptive, personal, digital, and oriented towards future competencies. Second, literacy and skills 21st century (4C+1C) become foundation main in print ready generation face disruption technology and the complexity of the global workplace. Next**,** inequality access digital technology and infrastructure still become challenge serious, especially in the area left behind, and potentially widen gap education. Than, the role of teachers is experiencing shift significant, from just transmitter information become facilitator, mentor character, and innovator in design contextual and transformative learning. Character building still crucial**,** especially in face risk disruption values brought about by the digital era. Character like empathy, integrity, and responsibility digital answer must become part intact in the learning process. Finally, collaboration cross adaptive sectors and policies is factor important in realize ecosystem relevant, inclusive and sustainable education.

To support effective digital transformation in education, strategic efforts are needed across sectors. The government should expand digital infrastructure in remote areas, implement flexible and future-oriented curricula, and provide continuous training for teachers. Schools and educators are encouraged to apply project-based

and character-driven learning while fostering a healthy and ethical digital culture. The private sector can collaborate by offering training, digital content, and internship opportunities, while parents play a vital role in guiding children to use technology wisely and promoting independent learning at home. Through these combined efforts, Indonesia's education system especially at the junior high school level can nurture a tech-savvy, morally grounded, and collaborative generation ready to contribute to a digital-humanistic society.

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