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A Systematic Literature Review of Digital Skills and Human Resource Readiness for the Industrial Revolution Era 4.0 and 5.0

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Abstract: The Industrial Revolutions 4.0 and 5.0 have significantly transformed the workforce, demanding human resources (HR) to possess digital skills and adaptive readiness. This study aims to identify and analyze the necessary digital skills and HR readiness to address the challenges of these industrial revolutions through a literature review approach. This article analysis of 15 scientific articles published between 2020 and 2025, the research reveals that digital skills such as data literacy, information technology proficiency, and problem-solving abilities are key factors. The readiness of Human Resources (HR) to adopt advanced technologies and human-centric approaches in the Industrial Revolution 4.0 and 5.0 era depends on their willingness to acquire new skills and adapt to rapid transformations. Thus, the success of HR is greatly influenced by organizational readiness and access to technology-based training. The findings of this study provide strategic recommendations for policymakers and practitioners to design effective and relevant HR development programs in the era of Industrial Revolutions 4.0 and 5.0.

Keywords: Digitization, Digital Skills, Human Resources, Industrial Revolution

A. Introduction

The level of readiness of Human Resources (HR) in adopting advanced technology and adaptive readiness in the era of the Industrial Revolution 4.0 and 5.0 is an important thing that must be considered by companies. After knowing the level of readiness of Human Resources (HR) in its possession, the company can determine what effective strategies to improve HR skills and readiness amidst the changes triggered by the Industrial Revolution 4.0 and 5.0 to become better. By choosing the right strategy, it can improve company performance.

The Industrial Revolution 4.0 has introduced advanced technologies, which have fundamentally transformed work practices and business processes. Furthermore, the Industrial Revolution 5.0 reinforces the human-centric concept, where technology is

designed to align with human needs. This transformation requires human resources to possess high-level digital skills and adaptive readiness to remain relevant in the ever-evolving job market. Although many studies have discussed the impact of technology on human resources, research combining digital skills and human resource preparedness within the context of the Industrial Revolutions 4.0 and 5.0 remains limited.

Industry 4.0 is regarded as a technology that driven revolution aimed at achieving higher productivity and efficiency as a high - tech government strategy, enhancing competitiveness in the global market (Xu et al., 2021). Herman, (2015) outlines that Industry 4.0 is based on four design principles, primarily focusing on connectivity, which refers to the capacity of machines, humans, sensors and devices to interact with each other using the Internet of Things (IoT) or the Internet of People (IoP). Furthermore, Vogel-Heuser & Hess, (2016) elaborate on the key principles of Industry 4.0, which include flexibility and adaptability to changing requirements, service oriented reference architectures, intelligent and CPPS, interoperability between humans and CPPS, optimization equipment effectiveness, cross-disciplinary and lifecycle data integration, reliable and secure inter-business communication, and data security. While Industry 4.0 not always to be seen as a human centered initiative, operator - assistance technologies, work-life balance, aspects such as human machine collaboration, and socio approaches should not be neglected (Xu et al., 2021).

Industry 4.0 requires adaptation to changing precondition with a strong emphasis on adaptability. Then Industry 5.0 has emerged in recent years. Industry 5.0 more coordinated and compared to Industry 4.0 and emphasizing collaboration between machines and humans. With a strategy human - centered, Industry 5.0 builds upon Industry 4.0 to achieve greater resilience and sustainability (Ismail et al., 2023).

The phenomenon in Industry 5.0 shows that the implementation of a value network is needed to apply new technologies and become an integrated and highly integrated value chain, (Cillo et al., 2021). Therefore, businesses must possess the necessary competencies to apply and integrate Industry 5.0 technological components, such as blockchain, Cognitive Artificial Intelligence (CAI), digital twins or adaptive robots (Xu et al., 2021). Businesses need competency in developing functional principles in Industry 5.0, such as ecentralization, and vertical/ horizontal integration real-time capability. Digital transformation competencies (DTC) involve a range of digital skills (Ghobakhloo et al., 2023). Digitalization and adequacy of expertise in various disciplines related to information technology and operational technology can be used as a proposal for knowledge competency, such as user data science, interface design, software engineering, process automation, network architecture and robotics engineering (Ghobakhloo et al., 2023).

Digitalization of companies under Industry 5.0 is expected to require significant resources, involving substantial investment, implementation of digital capabilities

and foundational technologies, and development (Lamas, 2021). The transformation and digitalization of companies under Industry 5.0 will be ongoing and dynamic, as innovation cycles are becoming shorter (Maddikunta, 2022). Transition to Industry 5.0 requires companies to continuously allocate necessary resources, provide significant initial funding, and accept longer return periods, highlighting the opportunity and need to strategically shift from conventional expectations regarding payback periods and ROI (Ghobakhloo et al., 2023). Therefore, the capability and availability of resources (RAC) involve the availability of financial capital to support technology acquisition, Industry 5.0 development, research and acquiring or training digitalization expertise (Ghobakhloo et al., 2023).

In the era of Industry 5.0, recognizing the power of industry to achieve goals beyond growth and job creation aiming to become a resilient welfare provider by respecting boundaries, shaping production processes and placing the welfare of industrial workers at the heart of production (Xu et al., 2021). Furthermore, research by Xu et al., (2021) highlights that Industry 5.0 is centered around three interconnected core values: human - centeredness, sustainability, and resilience. Additionally, (Müller, 2020) identifies six key technologies in Industry 5.0: 1) AI to detect, for example, causality in dynamic and complex systems, producing actionable intelligence, 2) good materials that enable materials with recyclable features and embedded sensors and biologically inspired technologies and, 3) human - machine interaction technology that combines and connects the power of machines and humans. 4) simulations to model entire systems and digital twins 5) data transmission, storage, and analysis technologies capable of handling system interoperability and data 6) technologies for storage, energy efficiency, utonomy, and renewable energy. Industry 5.0 is not only an era of revolution driven by technological advancement, but also an initiative driven by values between technological transformation towards a specific goal (Xu et al., 2021). Taj & Jhanjhi, (2022) describe the relevance and importance of the impact of Industry 4.0 HR (Human Resource) development and consumer behavior. The authors discuss the context of digital transformation and automation, which are highly relevant to current global economic and social challenges. The research aims, which are to identify opportunities, challenges, and drivers in HR development and consumer behavior, are well defined. Industrial transformation has shifted from the Industry 4.0 paradigm to Industry 5.0, which introduces a new approach focused on human-centricity, sustainability, and resilience. While Industry 4.0 emphasizes digitalization and automation through technologies such as the AI (Artificial Intelligence), IoT (Internet of Things) and, Industry 5.0 highlights the integration of humans at the center of production with the goal of creating harmony between machines and humans. This article explores these fundamental changes and underscores the roles of humans, organizations, and technology as key pillars.

Although various studies have explored the impact of technology on human resource (HR) skills in the context of Industry 4.0 and 5.0, observations reveal that strategic efforts to enhance HR readiness through technology-based training remain limited.

This article aims to address the following research questions 1) What is the level of HR readiness in adopting advanced technology and a human-centric approach in Industrial Revolution era? 2) What are the effective strategies to improve HR skills and readiness amid the changes driven by Industry 4.0 and 5.0?

B. Methods

The method in this article combines literature review and qualitative approaches to analyze many researchs developments related to Digital Skills and Human Resource Readiness for the Industrial Revolution Era 4.0 and 5.0. The first step is to identify articles by searching from various sources such as Google Scolar, Emerald, Elsevier, Science Direct, Scopus and others. The data obtained and screened based on the title and abstract obtained 30 articles. After checking the full text, 15 eligible articles were obtained. A total of 15 journal articles, published between 2020 and 2025, were compiled and analyzed based on their relevance to the research topic. The data analysis process consisted of three stages: first, collecting articles relevant to Digital Skills and Human Resource Readiness for the Industrial Revolution Era 4.0 and 5.0; second, analyzing the selected articles by reviewing their methodology, results, and critical reviews; and third, drawing conclusions about future research opportunities. The complete analysis process is illustrated in Figure 1, as outlined by (Fitriastuti et al., 2019), (Vemberi et al., 2022), (Vemberi et al., 2024), (Herawati, 2024).

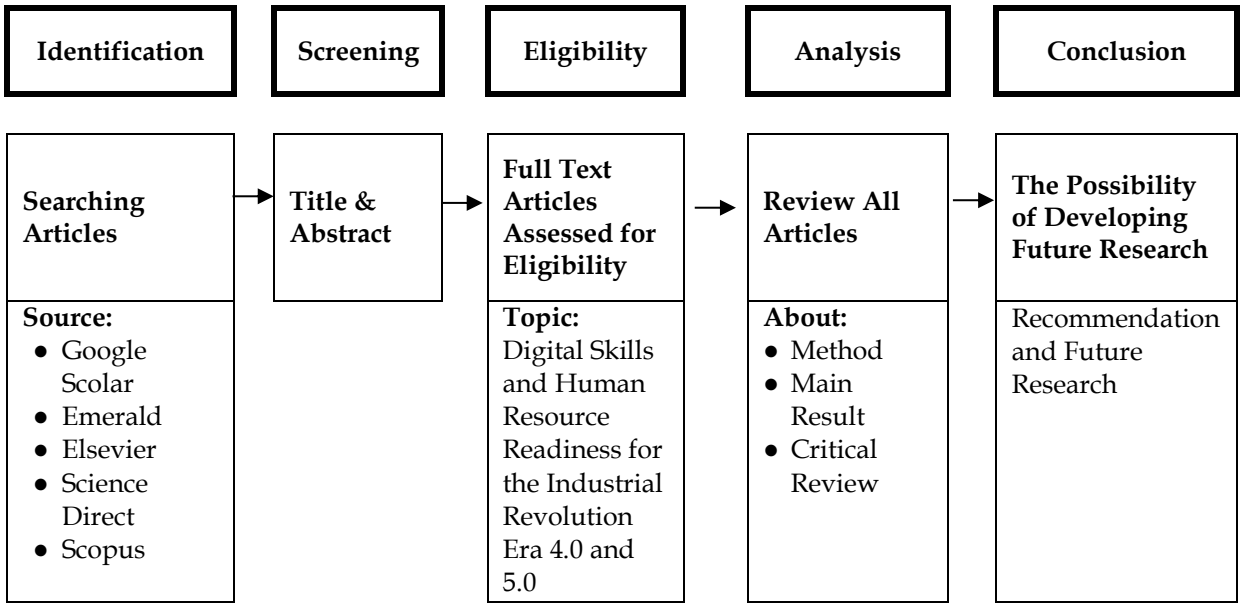

Figure 1. Review Method

C. Results and Discussion

Table 1 presents a summary of prior studies on Digital Skills and Human Resource Readiness in the context of the Industrial Revolution 4.0 and 5.0, highlighting the research methods, findings, and critical reviews.

Table 1. The Overview Summarizes the Studies Based on the Methods, Results, and Critical Reviews

No	Authors and Title	Methods	Results	Critical Review
1	Sima, (2020).	This study employed a combination of qualitative and quantitative methods, utilizing a systematic review approach to identify the main themes. The Systematic Literature Review (SLR) was conducted following PRISMA-based guidelines.	This study highlighted that the worker must be highly skilled and capable of adapting to new technologies, which requires an updated educational curriculum. Furthermore, this study provided a comprehensive overview of the impact of Industry 4.0 on the labor market and consumer dynamics, illustrating a shift towards a more digitized and automated system.	This study includes only articles published since 2011, which may exclude earlier relevant research on Industry 4.0 and its implications. The sample consisted of 111 articles reviewed in detail, raising concerns about the representativeness and comprehensiveness of the findings. Lastly, the study only focuses on the Northern European region which may distort the understanding of the global impact of Industry 4.0.
2	Alaloul et al., (2020).	This study employed both quantitative and qualitative methods (survey and literature review). The consistency of the obtained data was measured using Cronbach's Alpha.	This study focuses on the implementation of Industry 4.0 (IR 4.0) in the construction industry, identifying key factors that influence its successful implementation. This study also highlights the importance of understanding technology and social dynamics during the integration of Industry 4.0 practices into the construction sector, paving the way for	This study reveals that the majority of the workers are unfamiliar with technologies associated with IR 4.0, highlighting the need for enhanced training and awareness. The findings outline the challenges and opportunities related to IR 4.0 implementation, emphasizing the importance of

			future advancements and efficiency.	strategic planning and consideration of macro-environmental factors.
3	Taj & Jhanjhi, (2022).	This article employed a qualitative method by collecting and evaluating existing studies related to IR 5.0 and AI, aiming to identify research challenges and opportunities.	This study demonstrates that human-machine collaboration within the framework of Industry 5.0 can improve productivity and efficiency by delegating physically demanding tasks to machines, allowing humans to focus on tasks that require specific skills. Additionally, the study identifies challenges and opportunities in addressing gaps in the implementation of Industry 5.0, highlighting the importance of developing a trusted, transparent, and unbiased AI system.	The critique of this study is the lack of supporting data related to future visions concerning legal, social, and ethical issues in human-robot collaboration. Additionally, the research is limited by its focus on specific sectors, such as IT and aviation, which may reduce the generalizability of its findings. The study also highlights the need for the development of new skills within the workforce to address the challenges of adapting to Industry 5.0, which has not yet been fully addressed.
4	Melnyk, (2023).	A conceptual study employing an in-depth literature analysis (theoretical framework). The modeling of digital twin systems is used to identify learning needs and new skill requirements.	This study emphasizes the humanization of production by improving the creative role of humans within the technology ecosystem. The digitalization of education is necessary to meet the demand for technology-based skills.	There is a lack of practical implementation of new technologies, such as digital twins. Harmonization occurs between the need for technological efficiency in Industry 4.0 and humanization in Industry 5.0.
5	Xu et al., (2021).	This study employs a literature review, combining data from various secondary sources to address	The findings of this study reveal that Industry 4.0 focuses on technology-driven efficiency and	This study does not provide a clear and detailed definition of what is meant by "Industrial

		the research questions.	productivity, such as the integration of cyber-physical systems and automation, while Industry 5.0 shifts its focus to human needs, emphasizing sustainability and social well-being.	Revolution," which could lead to confusion for readers and diminish their understanding of the context.
6	Akundi et al., (2022).	This study employed a literature review method based on text analysis. It analyzes 196 abstracts obtained from the IEEE, MDPI, and ScienceDirect databases using text mining techniques such as frequency analysis and topic modeling.	This study analyzes current research trends on Industry 5.0 using text mining techniques to identify patterns and future directions in the published literature. It also emphasizes the importance of further exploration to provide a better perspective on Industry 5.0 within the research community.	This study has a limitation in terms of the number of analyzed abstracts, with only 196 articles, which may affect the accuracy and generalizability of the results. Additionally, the study acknowledges that the findings could change as the amount of data increases and the digital libraries used are expanded.
7	Damayanti, (2021).	This study uses a qualitative approach as the basis for developing theory and knowledge regarding human resource competencies in the context of the Industry 4.0 revolution.	The findings of this study indicate that the Industry 4.0 revolution presents both opportunities and challenges for human resources, including the need for new competencies such as creativity, collaboration skills, and problem-solving. The study also emphasizes the importance of PESTEL analysis to understand the challenges faced in the implementation of Industry 4.0. Additionally, there is a need to enhance understanding of technology and sustainability in facing rapid changes.	This study lacks focus on the practical implementation of the identified competencies, as well as potential ambiguity in the definition and measurement of the required competencies. Furthermore, the study may not sufficiently consider the local context and industry-specific factors that could influence the application of competencies in the context of the Industry 4.0 revolution.

8	Tyagi et al., (2024).	This study employs a qualitative method that highlights Industry 5.0, emphasizing the importance of integrating smart technologies and the human role in industrial processes.	The findings of this study indicate that Industry 5.0 emphasizes the importance of integrating smart technologies and the human role in industrial processes. The study highlights that Industry 5.0 aims to create more meaningful interactions between humans, machines, and robots, while also emphasizing sustainability as one of its key pillars.	This study may overly generalize the concept of Industry 5.0 without fully considering the variations in its implementation across different industrial sectors. Each sector may have unique challenges and needs that are not adequately addressed in the broader analysis. Furthermore, the study primarily focuses on the theoretical and conceptual aspects of the industrial transition.
9	Zizic et al., (2022).	This study uses a literature-based approach to analyze the paradigm shift between Industry 4.0 and Industry 5.0.	The findings of this study reveal a significant shift in research focus from sustainability in Industry 4.0 to human - centricity in Industry 5.0. This shift reflects the need for greater attention to human aspects in industrial processes, which were previously neglected. The study also highlights that Industry 5.0 is not solely focused on efficiency and technology but also emphasizes the social and ethical impacts of technological implementation.	The discussion on Industry 4.0 highlights its lack of focus on the human perspective. Criticism of this research also points out that, despite rapid technological advancements, human aspects are often neglected, which is one of the main weaknesses of the Industry 4.0 approach.
10	Saleh & Ijab, (2022).	This article uses the Literature Review methodology, which consists of five main activities: defining, extracting, searching, analyzing, and	There are various models of readiness for IR 4.0 that have been discussed in the literature, with a focus on the use of self-assessment tools by	The shortcomings of this study include the lack of analysis on additional aspects that indicate the level of internal and external readiness,

		assessing and combining data. The SLR process is divided into three major phases: planning, implementing, and reporting with an emphasis on reliability and validity. Exclusion and inclusion criteria are applied to ensure the relevance of articles included in the SLR process.	industry participants to measure their level of readiness. This study also identified that Malaysia has a low to moderate level of industry readiness for IR 4.0, and the importance of adopting new technologies such as AI and IoT to improve productivity. In addition, the IMPULS model is used to measure IR 4.0 readiness with six different dimensions.	such as willingness to share information and awareness of data security protocols. In addition, this study may not fully cover all factors that influence IR4.0 readiness, especially in the context of small and medium-sized enterprises (SMEs).
11	Ismail et al., (2023).	This study utilizes qualitative methods and literature-based research. It relies on a literature review to collect data and information from various relevant sources, which are then analyzed to explore new ideas and draw conclusions based on existing knowledge.	The findings of this study indicate that while Gen Z possesses strong technical skills, they often lack essential soft skills such as communication, critical thinking, collaboration, and creativity. The study also emphasizes that a combination of hard and soft skills is crucial for success in the modern job market.	This study highlights the importance of developing soft skills but does not provide enough emphasis on how these skills can be effectively measured and evaluated within the context of higher education. Additionally, the sample, which consists only of alumni from the Faculty of Economics at Universitas Terbuka, may not fully represent the entire Gen Z population in Indonesia.
12	Alojaiman, (2023). ,	This study uses a qualitative method by gathering information about Industry 5.0 from previously published works available in academic databases such as IEEE, ScienceDirect, and MDPI. The researchers used the keyword "Industry	The findings of this study indicate that Industry 5.0 represents a significant evolution from Industry 4.0, emphasizing a more human-centric approach in industrial practices. The study highlights that the transition to Industry 5.0 is not only about adopting advanced technologies	The critique of this study lies in its exploration of Industry 5.0 as an important development of Industry 4.0 with a focus on human-centered approaches. However, it highlights challenges in both technical and ethical aspects of this

		5.0" to search for metadata and identify relevant publications.	but also about enhancing collaboration between humans and machines to improve sustainability and resilience in production systems.	transition. Additionally, there are limitations in the understanding and terminology of Industry 5.0, as it is still a relatively new concept.
13	Ghobakhloo et al., (2023).	The research method used in this study is a content-focused literature review, in which the researchers identified 11 actions and approaches that act as contributors to the transformation toward Industry 5.0.	This study identifies several key factors, including digital transformation competencies, proactive government support, ecological innovation, and sustainable value network reforms. The findings indicate that stakeholder collaboration and integration are essential elements for achieving the success of Industry 5.0.	The critique of this study is that the literature on Industry 5.0 is still limited and in its early stages, meaning the understanding of the drivers of transformation may not be comprehensive. Additionally, the study focuses solely on the European context, meaning the results may not be fully relevant or applicable to other regions.
14	Tavarez, (2023).	This study uses a systematic review method of the literature, which is carried out integrative to address the problem being analyzed. This review aims to critique and synthesize representative literature to produce a new framework and perspective on the topic being studied. This study also involves analyzing stakeholder perceptions in education and industry.	To face Society 5.0, an appropriate learning model is needed that focuses on complex problem solving, creativity and critical thinking. This study also emphasizes the importance of the role of "Educators 5.0" who can integrate human intelligence and computer thinking processes in a collaborative environment. In addition, innovation and creativity from the next generation will be key to overcoming challenges in the uncertain cyber-physical era.	Weaknesses of this research include limitations in the scope of the literature which may not cover all perspectives related to Society 5.0 and education. In addition, this study also does not include empirical data that can support the findings, thus reducing the strength of the evidence of the arguments put forward.

15	Aldrickzler et al., (2025)	The methodology used includes several learning methods, such as the Jigsaw method, problem-based learning, and case studies. In addition, this study also highlights the use of digital technology and competency-based approaches to support human capital transformation in the digital era. Gamification methods are also integrated to increase engagement and motivation in the learning process.	Transforming human capital for the digital age is leading to increased competitiveness, creativity and innovation across countries and industries. Investment in education and training is improving literacy, digital skills and numeracy outcomes. There is also recognition of the ethical and privacy challenges that emerge from technological developments, and the need for an ethical framework to address these issues.	This study lacks focus on the practical aspects of implementing an ethical framework in human resource development. In addition, this study may not sufficiently consider the differences in cultural and economic contexts that may affect the outcomes of human capital transformation across countries.

The following discussion is based on the findings from previous studies summarized in Table 1. The Industrial Revolution 4.0 presents significant challenges and opportunities for the workforce across various sectors. Previous studies highlight that workers need to acquire relevant skills to meet the demands of emerging technologies driven by digitalization and automation. In addition to technical skills, workers are also required to possess a high degree of adaptability in responding to the dynamic changes in the labor market. This condition emphasizes the need for an updated educational curriculum to produce a workforce capable of competing and supporting the sustainable development of technology.

In the context of the construction industry, the implementation of Industry 4.0 technologies provides valuable insights into success factors, such as understanding new technologies and social dynamics in the workplace environment. The process of integrating smart technologies into the construction sector requires a strategic approach to enhance operational efficiency and support innovation that can drive the overall progress of the industry.

Meanwhile, Industry 5.0 introduces the concept of collaboration between humans and machines. By delegating heavy physical tasks to machines, humans can focus more on tasks that require cognitive skills, creativity, and decision-making. However, the success of this collaboration hinges on the implementation of transparent, unbiased, and trustworthy artificial intelligence (AI) systems to bridge the gap in technology adoption. Industry 5.0 also emphasizes humanization in the production process, positioning humans at the center of creativity within the technological ecosystem. To

support this approach, the digitalization of education is essential in preparing a creative and competent workforce capable of navigating technological changes. This aligns with the core objective of Industry 5.0, which is to foster an inclusive work environment that prioritizes human well-being.

Industry 4.0 focuses on efficiency and productivity through automation and the integration of cyber-physical systems, while Industry 5.0 prioritizes sustainability and social well-being with a human-centric approach. This difference reflects a shift in the industrial development paradigm from mere technological efficiency to a balance between technology and humans. To understand the direction and research trends in Industry 5.0, text mining techniques have been used to identify key patterns and explore the concept in greater depth. The Industrial Revolution 4.0 also presents challenges in meeting the demand for new competencies. Creativity, collaboration skills, and problem-solving have become essential abilities in this era. Approaches through the analysis of Political, Economic, Social, Technological, Environmental, and Legal (PESTEL) factors help to understand the challenges of implementing Industry 4.0 while providing strategic insights to address these barriers. Industry 5.0 emphasizes the importance of meaningful integration between humans, machines, and robots, with sustainability as a core pillar. The smart technologies used are not only aimed at improving efficiency but also at enhancing the quality of human life across various aspects of industry. This shift reflects a change in focus from the sustainability characteristic of Industry 4.0 to the human-based approach of Industry 5.0. It also highlights the importance of considering social and ethical aspects in the application of technology.

Overall, Industry 5.0 is considered a significant evolution of Industry 4.0, with a focus on sustainability, human-machine collaboration, and a human-centered approach. The success of implementing Industry 5.0 is determined by several key factors, such as digital transformation competencies, government support, ecological innovation, and sustainable value network reforms. Collaboration among stakeholders becomes a crucial element in creating a broader positive impact on society and the environment, while ensuring sustainability in the future development of industries.

D. Conclusions

The readiness of Human Resources (HR) to adopt advanced technologies and human-centric approaches in the Industrial Revolution 4.0 and 5.0 era depends on their willingness to acquire new skills and adapt to rapid transformations. Industrial Revolution 4.0 requires technical expertise, including programming, data analysis, and automation system operations. In contrast, Industrial Revolution 5.0 emphasizes the importance of human-centric abilities, such as creativity, collaboration, and problem-solving, alongside the ability to integrate with technology. Thus, although HR professionals worldwide are increasingly inclined toward technology, significant challenges remain in ensuring their readiness to adapt to changes that require

interdisciplinary expertise and an understanding of the social and ethical dimensions of these technologies.

There are several effective strategies to enhance HR skills and readiness in this era. First, updating the education curriculum. The curriculum should be aligned to meet the demands of the labor market in the context of Industry 4.0 and 5.0, focusing on the development of both technical and non-technical skills, such as digital literacy, creativity, adaptability, and the ability to collaborate effectively with technology. Second, implementing training and certification programs. Practical skill-based training programs, such as those related to artificial intelligence, the Internet of Things (IoT), and robotics, can help the workforce improve their technical abilities. Third, focusing on the development of human-centric skills. Considering the significance of collaboration between humans and machines in Industry 5.0, developing interpersonal skills, problem-solving capabilities, and creativity is important. Fourth, fostering collaboration among government, industry, and academia. Strong partnerships between these sectors are vital to provide relevant training opportunities and establish policies that support the transition to Industry 4.0 and 5.0. Finally, utilizing technology for remote learning. Using digital platforms for remote learning and skill development allows for wider access to education and enables workers to continue their training without having to leave their jobs.

By implementing these strategies, HR will be better equipped to face the changes brought by Industry 4.0 and 5.0, and able to take advantage of the opportunities offered by advanced technology while maintaining a balance with a human-centric approach that focuses on human well-being. Additionally, further research remains necessary to explore in depth the topic of effective strategies for enhancing HR skills and readiness in response to the transformations driven by Industry 4.0 and 5.0, as highlighted and identified in this study.

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