Philosophical Foundations of Education Development in the Era of Industry 5.0

Oksana Yakymchuk

Ph.D. in Philosophy, Associated Professor,
Dragomanov Ukrainian State University (Kyiv, Ukraine)
E-mail: Yakimchyk1409@gmail.com
https://orcid.org/0000-0002-9729-8389

Yakymchuk, Oksana (2024) Philosophical Foundations of Education Development in the Era of Industry 5.0. *Philosophy and Cosmology*, Volume 33, 173-182. https://doi.org/10.29202/phil-cosm/33/8

The research solved the socio-philosophical explication of the problem of industrial revolutions in the history of the development of human civilization, focusing on the issues of education development. The content and socio-cultural prerequisites of the formation of Industry 1.0 – 3.0 have been conceptualized in connection with human civilization's corresponding economic and educational landscapes. The study showed that Industry 4.0 and Education 4.0 are subordinated to it and revolve around developing technologies (in particular, digital ones), focusing on developing scientific and technological progress. The education paradigm of Education 4.0 pragmatically concentrates on the real socio-cultural situation (information technologies expansion, flexibility for labor market challenges, hard and soft skills, etc.). It was demonstrated that the concept of Industry 5.0 is an attempt to deepen the achievements of Industry 4.0, bringing to the fore the idea of human-centeredness and sustainable development. It was shown that the humanization of civilizational progress and technological progress should occur through rethinking the education paradigm, which should act as an essential transit tool in the era of Industry 5.0. The dynamics of the formation of Industry 4.0 and the short-term perspective of the transition to Industry 5.0 naturally require the involvement of the philosophy of education as a tool for formulating modernization steps in the educational sphere, which should be characterized by systematicity and deep futuristic orientation. It was demonstrated that the basic principle for the philosophy of education for Industry 5.0 is the idea that Industry 5.0 successively deploys the technical and economic achievements and principles of Industry 4.0, with a particular emphasis on human-centeredness and the sustainable development of humanity. Education 5.0 is a holistic philosophical theory, educational policy, and a teacher who can implement in practice the principles of Industry 5.0.

Keywords: philosophy of education, Industry 5.0, Education 5.0, Industry 4.0, Education 4.0, industrial revolution, 21st century skills.

Received: 15 April 2024 / Accepted: 28 May 2024 / Published: 1 October 2024

Introduction

Modern philosophical and, in general, socio-humanitarian discourse actively debates the implementation of the ideas of the Fourth Industrial Revolution, which marked the transition of human civilization to a qualitatively new state. This state is described by the active development of digital technologies and their penetration into most spheres of human being and society. Industry 4.0, due to its scale, initiated the implementation and active development of several concepts subordinate to it – Society 4.0, Economy 4.0, Education 4.0, etc. Education 4.0 is based on expectations related to the support of scientific and technological progress with educational tools, and for most developed countries, Industry 4.0 is already an objective reality. In the case of Industry 4.0, educational theorists offer many educational strategies aimed at effective training of creative workers, responsible citizens, carriers of professional skills, able to be carriers of human potential in the conditions of transformation of labor market conditions, taking into account the comprehensive integration of information technologies.

At the same time, in recent years, the relatively new theory of Industry 5.0 has become the subject of controversy. This civilizational transit should appear due to the Fifth Industrial Revolution, which is expected to emerge in a ten-year perspective. Unlike Industry 4.0, Industry 5.0 actualizes the issue of reviewing the interaction of people and technology, deepening their close cooperation and increasing the personal contribution of a person to production processes. Industry 5.0 is aimed at overcoming the alienation of people of Industry 4.0, seeking active involvement of the individual's creative potential in production processes and social development based on the principles of sustainable development. Education 5.0 is an essential socio-cultural mechanism for the transition to Industry 5.0. Traditionally, the philosophy of education should offer an image of a new educational strategy, revise educational competencies, ask questions about a new image of an educator, etc.

In the study, we proceed from the hypothesis that it is heuristic to turn to the potential of social philosophy for clarifying the nature of civilizational changes (from Industry 1.0 to Industry 5.0). The very concept of "industrial revolution" has the status of a methodological framework in the study. In the next step, using the potential of the philosophy of education, we will try to outline the features of the theory of Education 5.0 as a futurological project for developing educational systems.

The Concept of Industrial Revolution as a Methodological Framework of Research

Our article aims to formulate the philosophical principles on how education should contribute to the Fifth Industrial Revolution, which brings a new social architecture called Society 5.0. For this purpose, it is crucial to understand the Industrial Revolution and the kind of revolutions we have in humanity's history. Every Industrial Revolution brings reconfiguration of the economy and labor market, creating tension in education systems. If the Fourth Industrial Revolution is a matter of extensive academic discussion, the fifth is only a horizon, and education should drive social transformation. Thus, it is vital to understand the nature of the Industrial Revolution as a social phenomenon before formulating the vision of "Education for Society 5.0".

When we use the "revolution" concept, we understand that we discuss rapid social, political, technological, and other changes, and any concept like the "Industrial Revolution" has its own academic discourse:

> "Revolution implies suddenness, as with the American and French revolutions which lasted a few years; but the Industrial Revolution was not a sudden event. However, other phenomena have been described as revolutions while occurring over a long period of time. The Scientific Revolution of the sixteenth and seventeenth centuries is a case in point. The fact is that the phrase 'Industrial Revolution' is now so ingrained that there is no point in trying to jettison it. What is important is to establish the different ways in which historians have conceptualized the 'revolutionary' nature of the changes" (More, 2000: 8).

Taking the Industrial Revolution as an emblematic case of a humanities theory allows educators to grasp better what sorts of social, cultural, and epistemological implications these technological transformations entailed can open up new ways not only into re-imagining the of education development.

The Industrial Revolution, a transformative part of human history, is of great interest to scholars across various fields, including the humanities and education disciplines. Its evolution from a mere technical advancement to a broader socio-cultural and epistemological phenomenon, as seen in the Fourth Industrial Revolution, underscores its profound impact. Leng's historical outline from Industry 1.0 to Industry 4.0 further highlights this transformative nature: "Industry 1.0 leads mankind into the "Steam Age" by using water steam to drive manufacturing equipment. As the market (one of the necessities of the Industrial Revolution) is detonated, mankind gains early material and the primitive accumulation of the economy, which leads to social change. Industry 2.0 leads mankind into the "Electric Age" by using energy as an intermediary to drive electricity. The division of labor in production throughout the whole society is clear, and the prelude to the mass-production assembly line model is opened. Industry 3.0 enables mass customization at the information technology (IT) level, while Industry 4.0 merges IT and Operational Technology (OT) in a cyber-physical system manner for mass customization/personalization with intelligence" (Leng, 2022: 280).

For the purposes of our research, it is worth analyzing the history of the first three industrial revolutions, which had a global impact, and gaining a deeper understanding of their historical, technological and cultural prerequisites. Each of these three revolutions was the evolution of the creation of goods and services, shaping human civilization on a universal scale. The fourth and fifth industrial revolutions, which we are particularly interested in, are determining the present and future development of human civilization.

So, the beginning of Industry 1.0 falls at the end of the 18th century, which is localized, mainly in Britain and is characterized by the introduction of the steam engine to implement innovations in the mechanization of production in the textile industry, laying the foundations for the development of transport, etc. It should be noted that the formation of the social structure of Industry 1.0 has the character of a process stretched over time, which serves as a period of accumulation of technological changes, changes in production and economic processes, everyday human practices, active transit from agrarian and industrial economy, etc. The Second Industrial Revolution was chronologically fixed in the 19th – 20th centuries, and its basis was the process of using electricity in production, which made it possible to realize the idea of mass (conveyor) production. The invention and mass introduction of the internal combustion engine made it possible to radically change the transport industry, rethink logistics processes, and contribute to the creation of large-scale industrial production: "The second Industrial Revolution was, in many ways, the continuation of the first. In many industries there was direct continuity… By changing the relation between knowledge of nature and how it

affected technological practices, it irreversibly changed the way technological change itself occurs. In so doing, what was learned in these years prepared the way for many more Industrial Revolutions to come" (Mokyr & Strotz, 1998: 14). Researchers have fixed Industry 3.0's beginning in the second half of the 20th century. Its driving force is the idea of automation of the production process, which is connected with the invention and introduction of microcircuits, microprocessors, and automated production systems built on them.

Striving to elucidate the role of the Industrial Revolution in shaping new social architectures (from Society 1.0 to Society 5.0), we align with the view that all revolutions have been underpinned by paradigmatic shifts driven by scientific progress. The advent of a new societal condition inevitably influences all traditional social institutions, fostering a dynamic tension between tradition and innovation: ""The Industrial Revolution" should be perceived as a radical and abrupt but also long-lasting ("secular") change at all levels of society… Industrial revolutions have always had a critical preceding phase in which traditional technologies and production methods depleted their potential for further improvements while new technologies were developed. In this phase, both radically new technical and social inventions entered the stage which lead in the course of the transformation to a radical "paradigm change" and afterwards enable a stable development over a longer period" (Long-Term Governance, 2013: 48).

Industry 4.0 is a social (mainly economic) theory that describes the content of the transformations of the era of digitalization, under the influence of which the existing models of the organization of production processes change; everyday practices (related to everyday life and not related to production) and communication patterns. Any industrial revolution is also a communication revolution by its very nature. The innovations of this revolution, such as the Internet of Things, formulate challenges of an anthropological nature, changing traditional ideas about human physicality and establishing a model of active integration of biotechnology, artificial intelligence, etc. So, Industry 4.0 offers new anthropological projects with corresponding challenges in many spheres of human and social beings.

In addition, the issue of dynamism and intensity of socio-cultural changes deserves attention because Society 4.0. has an unprecedented scale, which requires a fundamental and rapid reconfiguration of the activities of social systems and organizations, and the very anthropological project proposed by theorists of this social structure blurs the boundaries between everyday life and the world of digital technologies. This anthropological challenge creates enough grounds for alarmist theories because new rules and a particular social contract are being formed, which can provoke social (digital) inequality and excessive control by the state or transnational corporations. It is also clear the challenge of replacing hundreds of millions of job places with automated systems and artificial intelligence, but also the question of the readiness of educational systems to prepare personnel for the new realities of the new economic system, in which even the names of professions that will emerge in 5-10 years remain terra incognita when in practice the employee will have to implement the principles of lifelong learning and change many professions in one's life. As of today, according to Lase's vision, Education 4.0 has responded to societal challenges by working with knowledge, hard and soft skills in a following way:

- developing life skills, and the ability to live together and think critically and creatively;
- promoting soft skills and transversal skills, and invisible skills not related to specific technical and academic fields;

- cultivating critical and innovative thinking skills, interpersonal skills, global-minded citizens, and literacy of the media and information available;
- shaping students ready to face the industrial revolution era with an emphasis on the fields of Science, Technology, Engineering, and Mathematics (STEM);
- reorienting curricula on ICT-based learning, the Internet of Things, big data, and computerization, as well as entrepreneurship and internship for the development of literacy, technology literacy, and human literacy aspects (Lase, 2019: 58-59).

So, for more than two hundred years, humanity has lived through scenarios of Society 1.0, 2.0, and 3.0. In that case, the framework of Industry 4.0 theory has intensified the debate about the existential extinction of humanity when production has a maximum level of automation with minimal human involvement. In contrast to Industry 4.0, Industry 5.0 actualizes the issue of reviewing the interaction of people and technology, deepening their close cooperation and increasing the personal contribution of a person to production processes. In our opinion, in this context, it is even appropriate to use the metaphor that Industry 5.0 offers to overcome the alienation of people of Industry 4.0:

> "Society 5.0 emerged as a development of the industrial revolution 4.0 which was considered to have the potential to degrade the role of humans themselves. In society 5.0, humans will be the center (human centered) while remaining technology-based. The emergence of society 5.0 requires patented breakthroughs in an effort to face the challenges that will be posed by society 5.0. The existence of society 5.0 poses its own challenges in various fields of life, one of which is in the field of education, including learning" (Usmaedi, 2021: 63).

It is a concept of Industry 5.0 and the social system corresponding to it that looks like an attempt not only to take into account the dynamics of technological changes and the introduction of innovations but also to propose a revision of the model of cooperation between man and machine, when automation and digitalization will also take into account the human needs for self-realization of each individual, strengthen the involvement of the individual in civilizational processes, offering a peculiar ecosystem of technological development based on the principles of orientation on human, sustainable development, etc.: "What should be strengthened is that Society 5.0 considers social capital as its key asset and it promotes globally targeted open innovation with human-centric priorities. In this concept, every citizen representing each generation has a role to play in innovation process. The Super Smart Society is built upon delivering the concrete, targeted and personalised, just on-/in-time solution to the people to provide a healthy and safe environment and promote people's well-being. It is still a vision, directive or goal and not the reality. Yet, it opens a new perspective to understanding and utilising the technological advancement and digital transformation for the benefit of society" (Carayannis & Morawska-Jancelewicz, 2022: 3449).

So, making the historical explication of the steps of civilization development using the concept of the Industrial Revolution, we can pass to the next steps of research trying to discover the issues of how education can be a driver of social and industrial innovations, how educators can deal with the current challenges of the Industry 4.0 and future challenges of Industry 5.0. The research steps will use the methodological achievements of the modern social philosophy and philosophy of education to formulate the principles of correlation between rapid social and economic transformations and education.

Education 5.0 as a Response on Industry 5.0 Challenges

As we demonstrated in the previous subsection of the research, due to the formation of societies of the era of Industry 1.0 and 2.0, fundamental transformations took place in society in the economic sphere and the system of industrial relations. These changes posed a challenge for education systems because the formation of new economic structures led to the emergence of new professions and, accordingly, the development of educational tools for their training. The chronology of the first industrial revolutions demonstrates their temporality and, accordingly, the ability of educational systems to respond to socio-economic demands. In the case of the third and especially the fourth industrial revolutions, we are talking about intensive social changes; in response, education should quickly and effectively offer approaches to provide learners with the appropriate knowledge, skills, and competencies (professional and general). The dynamic labor market, and rapid emergence of new professions are only part of the challenges that educational systems had to face in the late 20th and early 21st centuries: "Due to rapid economic and social change, schools/universities have to prepare students for jobs that have not yet been created, technologies that have not yet been invented and problems that we don't yet know will arise" (Shahroom & Hussin, 2018: 318). For our research, it is essential to clarify how Education 4.0 reflects the answers to society's challenges built in the conditions of the Fourth Industrial Revolution. This will give us grounds to propose a philosophical vision in which education can play an influential role in the transition to Industry 5.0, taking into account the idea of Hermawati when the crucial role will be delivered to "…imperative to re-imagine the role of humans in the manufacturing sector, alongside an exploration of ways in which humans and machines can coexist harmoniously and efficiently" (Hermawati et al., 2024: 1). We have reason to state that transit to Industry 5.0 vitalize the role of education due to the need of reskilling and upskilling of people to meet the challenges of societal transformation.

The dynamics of the formation of Industry 4.0 and the short-term perspective of the transition to Industry 5.0 naturally require the involvement of the philosophy of education as a tool for formulating modernization steps in the educational sphere, which should be characterized by systematicity and deep futuristic orientation. Education should not only respond to current challenges but also be a driver of changes in the turbulent modern world and lay effective opportunities for the evolutionary progress of humanity. In the case of Industry 4.0, the philosophy of education should offer educational strategies for training creative workers, responsible citizens, carriers of professional skills, and carriers of human potential in transforming labor market conditions, considering the comprehensive integration of information technologies. Education 4.0 is a complex response to the challenges produced by technology development and the mentioned concept cornerstones (nine key approaches) are explicated by Hussin in the following way, demonstrating the radical revision of the traditional didactics' rules: "First, learning can be taken place anytime anywhere. e-Learning tools offer great opportunities for remote, self-paced learning… Second, learning will be personalized to individual students. They will be introduced to harder tasks only after a certain mastery level is achieved…Third, students have a choice in determining how they want to learn. Although the learning outcomes of a course are preset by the institutions/bodies in charge of the curriculum, students are still free to choose the learning tools or techniques that they prefer…Fourth, students will be exposed to more project-based learning… Fifth, students will be exposed to more hands-on learning through field experience such as internships, mentoring projects and collaborative projects… Sixth, students will be exposed to data interpretation in which they are required to apply their theoretical knowledge to numbers and use their reasoning skills to make inferences based on logic and trends from given sets of data…Seventh, students will be

assessed differently and the conventional platforms to assess students may become irrelevant or insufficient… Eighth, students' opinion will be considered in designing and updating the curriculum... Lastly, students will become more independent in their own learning, thus forcing teachers to assume a new role as facilitators who will guide the students through their learning process" (Hussin, 2018: 92-93). As we can see, the education strategy (or even education paradigm) of Education 4.0 pragmatically concentrated around the real socio-cultural situation (information technologies expansion, flexibility for labor market challenges, hard and soft skills, etc.). This list is evidence of the vision that teachers become mentors or colleagues instead of rigid controllers of education results. The student is not an "empty container" for the pre-defined knowledge. At the same time, some researchers underline that social dynamics and pressure of technological changes do not mean that Education 4.0 also pays fundamental attention to the creative component of every personality involved in the education process. It is mainly an attempt to deal with the expansion of information technologies, creating the possibilities to "fit" the current social and cultural situations and be involved in them.

The Education 4.0 theory and practice demonstrate that multidisciplinary (transdisciplinary) approaches actively involve the students' cognitive and skills dimensions and should be under the educators' attention, considering the high complexity of the labor and everyday problems of the Society 4.0 citizen. Considering the need to deal with technical and social innovations, labor market needs, etc., the students should be advanced in understanding the civilization perspectives balancing between hard and soft skills in professional and private life. However, staying optimistic on evaluating the Education 4.0 concept, can we say that it also deals positively with the fundamentals of personality being? Is it a strategy for the preservation and development of Humanity? According to our vision, the current education strategy responds to the challenges of Industry 4.0 on a pragmatic level. However, the next step of economic development should provide a new dimension of humans, new values, and a new social contract where a person will be the provider of this future social architecture. According to our vision, Industry 5.0 is a possibility to change the education status from "fit and survive" to "be prepared and contribute" using the philosophical vision of the re-defined education strategy: "Education plays a role, in shaping the future, and Education 5.0 revolutionizes the core of learning in today's age through advancements in technology teaching methods, student empowerment, and societal impacts. Essentially Education 5.0 embraces a human-centered approach, by leveraging technology to offer education and nurture thinking skills. This discussion offers an overview of Education 5.0 exploring its foundations, practical implementations, obstacles, and opportunities to enhance our understanding of how education evolves in an increasingly complex and interconnected world" (Mobo, 2024: 269).

For the theorists of Education 5.0, the core problem is the reorientation of knowledge and skills of a person in order to provide a vision in which a person should be the critical element in the cooperation of "man-machine," which will require him to have a wide range of skills for the 21st century –from technical and scientific literacy to the ability to operate in the conditions of complex multi-level systems, from flexibility in production and life circumstances to developed communication skills, from emotional intelligence and creativity to critical thinking, etc.

> "Industry 5.0 complements the existing Industry 4.0 paradigm by highlighting research and innovation as drivers for a transition to a sustainable, human-centric and resilient European industry. It moves focus from shareholder to stakeholder value, with benefits for all concerned. Industry 5.0 attempts to capture the value of new technologies, providing prosperity beyond jobs and growth, while respecting planetary boundaries,

and placing the well-being of the industry worker at the centre of the production process" (European Commission, 2021).

The basic principle for the philosophy of education for Industry 5.0 is the idea that Industry 5.0 successively deploys the technical and economic achievements and principles of Industry 4.0, with a particular emphasis on human-centeredness and the sustainable development of humanity: if the critical value for Industry 4.0 is the maximum promotion of technological development, then Industry 5.0 returns man as a value to the center of socio-cultural transformations. For the philosophy of education, the teacher's competence in sharing the ideology of Industry 5.0 should not be left aside. For us, the scheme looks logical when the theoretical provisions of the philosophy of education become elements of modern educational policy and direct educational practice. So, Education 5.0 is a holistic philosophical theory, educational policy, and a teacher who is able to implement it in practice. That is why the training models of modern teachers should provide practical answers regarding the teacher's professional readiness to be an active transmitter of the principles of Industry 5.0: "While Industry 5.0 brings many potential benefits, it also presents several challenges for the education sector… Industry 5.0 technologies are rapidly evolving, and it is difficult to predict exactly which skills and knowledge will be required in the future. This makes it difficult for educators to prepare students for the job market and ensure they can compete in a rapidly changing economy… One of the main challenges of Industry 5.0 in education is the need to adapt teaching and learning methods to accommodate Industry 5.0 technologies" (Al-Emran & Al-Sharafi, 2022: 4).

Conclusions

As a result of the research, we solved the task of socio-philosophical and historical explanations of the problem of industrial revolutions in the history of the development of human civilization. It was possible to demonstrate the content and socio-cultural prerequisites of the formation of Industry 1.0 (characterized by the introduction of the steam engine to implement innovations in the mechanization of production), 2.0 (using electricity in production, mass (conveyor) production), 3.0 (automation of the production process connected with the invention and introduction into production of microcircuits and microprocessors) as fundamental phenomena in the transformation of the economic and educational landscapes of human civilization. Industry 4.0 (fusion of cyber-physical technologies, Internet of Things, etc.), as a modern phenomenon, was considered using the potential of social philosophy and philosophy of education, which allowed the explication of modern theories of Education 4.0. The study showed that Industry 4.0 and Education 4.0 are subordinated to it and revolve around developing technologies (in particular, digital ones), focusing on developing scientific and technological progress. The education paradigm of Education 4.0 pragmatically concentrates on the real socio-cultural situation (information technologies expansion, flexibility for labor market challenges, hard and soft skills, etc.).

The concept of Industry 5.0 is an attempt to deepen the achievements of Industry 4.0, bringing to the fore the idea of human-centeredness and sustainable development. It was shown that the humanization of civilizational progress and technological progress should occur through rethinking the education paradigm, which should act as an important transit tool in the era of Industry 5.0. The new image of education will provide those who study with both professional and 21st-century skills. The dynamics of the formation of Industry 4.0 and the short-term perspective of the transition to Industry 5.0 naturally require the involvement of the philosophy of education as a tool for formulating modernization steps in the educational sphere,

which should be characterized by systematicity and deep futuristic orientation. Education should not only respond to current challenges but also be a driver of changes in the turbulent modern world and lay effective opportunities for the evolutionary progress of humanity. The basic principle for the philosophy of education for Industry 5.0 is the idea that Industry 5.0 successively deploys the technical and economic achievements and principles of Industry 4.0, with a particular emphasis on human-centeredness and the sustainable development of humanity. For the philosophy of education, the teacher's competence in sharing the ideology of Industry 5.0 should not be left aside. For us, the scheme looks logical when the theoretical provisions of the philosophy of education become elements of modern educational policy and direct educational practice. So, Education 5.0 is a holistic philosophical theory, educational policy, and a teacher who is able to implement in practice the principles of Industry 5.0.

🕮 References

Al-Emran, M., and Al-Sharafi, M.A. (2022) Revolutionizing Education with Industry 5.0: challenges and future research agendas. *International Journal of Information Technology*, 6(3), 1-5. Available online: https://www.researchgate.net/profile/Mostafa-Al-Emran/publication/367077900_Revolutionizing_Education_with_Industry_50_Challenges_and_Future_Research_Agendas/links/63c08f5d4c7e7c4e5123120b/Revolutionizing-Education-with-Industry-50-Challenges-and-Future-Research-Agendas.pdf

Ashton, T.S. (1997) *The Industrial Revolution 1760-1830*. NY: Oxford University Press. https://doi.org/10.1093/oso/9780192892898.001.0001

Carayannis, E.G., and Morawska, J. (2023) University and Education 5.0 for Emerging Trends, Policies and Practices in the Concept of Industry 5.0 and Society 5.0. In *Machado, C.F., Davim, J.P. (eds) Industry 5.0*. Springer, Cham. https://doi.org/10.1007/978-3-031-26232-6_1

Carayannis, E.G., and Morawska-Jancelewicz, J. (2022) The Futures of Europe: Society 5.0 and Industry 5.0 as Driving Forces of Future Universities. *Journal of the Knowledge Economy*,13, 3445–3471. https://doi.org/10.1007/s13132-021-00854-2

Clark, G. (2010) Industrial Revolution. In *Durlauf, S.N., Blume, L.E. (eds) Economic Growth. The New Palgrave Economics Collection*, 148-160. Palgrave Macmillan, London. https://doi.org/10.1057/9780230280823_22

European Commission (2021) *Industry 5.0 – Towards a sustainable, human-centric and resilient European industry*. Available online: https://ec.europa.eu/info/publications/industry-50_de

Hermawati, S., Correa, R., Mohan, M., Lawson, G., & Houghton, R. (2024) Defining human-centricity in Industry 5.0 and assessing the readiness of ergonomics/human factors communities in UK. *Ergonomics*, 1–20. https://doi.org/10.1080/00140139.2024.2343947

Hussin, A.A. (2018) Education 4.0 made simple: Ideas for teaching. *International Journal of Education and Literacy Studies*, 6(3), 92-98. https://doi.org/10.7575/aiac.ijels.v.6n.3p.92

Ivanov, D. (2022) The Industry 5.0 framework: viability-based integration of the resilience, sustainability, and human-centricity perspectives. *International Journal of Production Research*, 61(5), 1683–1695. https://doi.org/10.1080/00207543.2022.2118892

Lase, D. (2019) Education and Industrial Revolution 4.0. *Jurnal Handayani*, Vol 10 (1), 48-62.

Legi, H., Damanik, D., and Giban, Y. (2023) Transforming Education Through Technological Innovation In The Face Of The Era Of Society 5.0. *Educenter: Jurnal Ilmiah Pendidikan*, 2(2), 102–108. https://doi.org/10.55904/educenter.v2i2.822

Leng, J., Sha, W., Wang, B., Zheng, P., Zhuang, C., Liu, Q., Wuest, T., Mourtzis, D. and Wang, L. (2022) Industry 5.0: Prospect and retrospect. *Journal of Manufacturing Systems*, Vol. 65, 279-295. https://doi.org/10.1016/j.jmsy.2022.09.017.

Long-Term Governance for Social-Ecological Change (2013) Bernd Siebenhüner, Marlen Arnold, Klaus Eisenack, Klaus H. Jacob (Eds.). London: Routledge. https://doi.org/10.4324/9780203556160

Mokyr, J., and Strotz, R.H. (1998) *The Second Industrial Revolution, 1870-1914*. Northwestern University. Available online: https://www.studeersnel.nl/nl/document/maastricht-university/international-business-history/session-3-the-2nd-industrial-revolution-mokyr/1160374

Mobo, F.D. (2024) Education 5.0: Navigating the Future of Learning. In *Preconceptions of Policies, Strategies, and Challenges in Education 5.0.*, 268-274. https://doi.org/10.4018/979-8-3693-3041-8.ch015

More, D.C., and More, C. (2000) *Understanding the Industrial Revolution (1st ed.)*. Routledge. https://doi.org/10.4324/9780203136973

Shahroom, A. A., & Hussin, N. (2018) Industrial Revolution 4.0 and Education. *International Journal of Academic Research in Business and Social Sciences*, 8(9), 314–319. http://dx.doi.org/10.6007/IJARBSS/v8-i9/4593

Stearns, P.N. (2020) *The Industrial Revolution in World History*. NY: Routladge. https://doi.org/10.4324/9781003050186

Usmaedi, U. (2021) Education curriculum for Society 5.0 in the next decade. *Jurnal Pendidikan Dasar Setiabudhi*, 4(2), 63-79. Available online: https://jurnal.usbr.ac.id/jpds/article/view/94

Xu, X., Lu, Y., Vogel-Heuser, B. and Wang, L. (2021) Industry 4.0 and Industry 5.0 – Inception, conception and perception. *Journal of Manufacturing Systems*, Vol. 61, 530-535. https://doi.org/10.1016/j.jmsy.2021.10.006.