Pan-African Journal of Education and Social Sciences (PAJES)
Vol 5, No. 2, 144-157, 2024

https://doi.org/10.56893/pajes2024v05i02.10

A Global Outlook into the Transformation of Education for the Fourth Industrial Revolution

Alfred Otara

Rongo University

Abstract

This study explores the current educational issue of the Fourth Industrial Revolution (4IR), shaped by a complex environment created by many approaches and difficulties. It explores international educational responses to 4IR using a systematic approach that includes literature review. This review highlights the crucial requirements of inclusivity and fair access to education. This has been achieved by emphasizing the transformative impact of technology, particularly artificial intelligence (AI), virtual reality (VR), and augmented reality (AR), in transforming learning experiences. The successful integration of 4IR education is highlighted by real-world case studies from Singapore, Finland, and Rwanda that provide insights into effective policy design, pedagogical innovation, and cross-sector collaboration. These findings highlight the multidimensional nature of 4IR education. They also underscore the significance of context-responsive teaching methods. Overall, this study promotes a comprehensive and inclusive approach that provides educators and policymakers with insights needed to successfully negotiate the benefits and challenges of the dynamic 4IR context.

Keywords: Fourth industrial revolution, education strategies, technology integration, inclusivity, systematic review

Introduction

Developments in the Fourth Industrial Revolution (4IR) have revolutionized the modern world. This remarkable shift is marked by unmatched technological innovations (Schwab, 2017). This revolution is characterized by automation and the Internet of Things (Shenkoya & Kim, 2023) are expected to transform jobs (Alam et al., 2021). It is fundamentally driven by breakthroughs in artificial intelligence, Internet of Things (IoT), robotics, nanotechnology, and biotechnology (Atmojo et al., 2022). These elements collectively redesign the way people and societies operate, economic functions, and commerce flourishes (World Economic Forum, 2020). The enormous effect can be seen in how it has disrupted established business models, given rise to unperceived sectors, and reconfigured human and corporate communication systems (World Economic Forum, 2018). It can be said that this sophisticated development has a double cutting edge as an empowering influence and disruptor at the same time. Accordingly, the need to improve education and training for relevance is unquestionable.

Future workers will require technical, cognitive, and interpersonal skills in the Fourth Industrial Revolution, which should be considered part of education standards (Bennett & McWhorter, 2021). In essence, the competencies expected of 4IR, such as decision-making, creativity, and imagination, cannot be delivered through current educational training and practices (Trilling & Fadel, 2009). Digitalization has greatly impacted global education systems (Bond et al., 2020). Digital education improves distance education and contributes to the Industrial Revolution through skills (Ronchi & Ronchi, 2019). This means that the education sector presents a significant opportunity to enhance communication conditions, appropriate knowledge, and understanding of deployment

*Contact author: aotara@rongoversity.ac.ke

(Jung, 2020). This revolution requires education to surpass customary instructive norms (Altinisik et al., 2023). It requires an extensive redesign of educational programs and pedagogies that can guarantee students' relevance in this period of rapid change (Jam et al., 2022). This underscores the need for educational frameworks that support the development of skills suitable for the 21st century, such as character-building, meta-learning, and active learning techniques (Tiemann & Annaggar, 2020).

Globally, education systems have experienced dramatic changes in all industrial revolutions, with the sole aim of responding to socioeconomic shifts (Zgraggen, 2021). For instance, agrarian civilizations were replaced by automated manufacturing during the First Industrial Revolution. This era led to the formation of fundamental education to train a labor force for the agriculture and mechanical industries (Innovationexcellence.com, 2016). The second industrial revolution saw that public education systems focused more on providing students with fundamental reading and numeracy skills. This period was marked by mass manufacturing and electricity supply (McCowan, 2018). The emergence of the Third Industrial Revolution was characterized by digitalization and automation, which led to the popularization of the service industry. This advancement has prompted the introduction of computer literacy programs within academic institutions to address technological demands (Wong & Shen, 2018). Although these educational changes represented significant advancements, they fell short of furnishing learners with the most needed analytical competencies. These competencies enable graduates to traverse swiftly changing job terrains (Tokareva et al., 2020). New digital machines and IT tools require new skills and competencies, posing challenges for the workforce (Alcácer & Cruz-Machado, 2019). The 4IR will require the integration of artificial intelligence, robotics, and blockchain in higher education institutions for personalized learning, teaching, and digital assessment (Bucea-Manea-Ţoniş et al., 2022). These historical developments give rise to one fundamental question- ''can the education as currently designed meet the demands of the (4IR)?'' Essentially, lessons learned from these historical attempts underscore the critical need for an educational paradigm shift.

There are many challenges with the current education system, and the needs of the Fourth Industrial Revolution (4IR) cannot be appropriately addressed. An outdated curriculum and conventional teaching techniques cannot enable students to succeed in the fast-changing labor markets (UNESCO, 2019). There is a Mismatch between graduates' competencies and the demands of the labor market. This is due to the existing discrepancies between industry requirements and educational training (Economist Intelligence Unit, 2019). Furthermore, the situation is aggravated by the rapid evolution of technology, which has made some skills obsolete even before they are taught in school (Economist Intelligence Unit, 2019). Looking into the future, digital advancements will greatly transform higher education by incorporating game-based approaches, systematic data collection and evaluation, and use of artificial intelligence for effective reforms (Ji et al., 2022). These issues pose a great challenge for educational institutions in providing students with the crosscutting skills necessary to succeed in the 4IR age.

Although the literature has discussed issues within the Fourth Industrial Revolution (4IR) and the need for relevant education, there remains a significant research gap. There is a need to understand how educational systems in various countries respond to the challenges of the 4IRs. While some studies have focused on the skills needed for the 4IR workforce (Fataar, 2020), there has been no thorough examination of global variations. In addition, there is little information regarding educational policies, curriculum reforms, and implementation strategies used to prepare students for the rapidly shifting technological landscape. For instance, Jam et al. (2022)

and Daley and Cordell (2021) underscore the necessity of cross-country comparative research to understand the various educational approaches used by various nations in integrating 4IR. This study seeks to close this gap by analyzing various approaches used by different countries to incorporate 4IR-related competencies. This study highlights best practices and potential pitfalls. It also provides insights into the variables that affect the global adoption of 4IR-focused educational policies.

Methodology

The methodology was based on a systematic literature review that highlighted the steps taken to conduct the review to ensure systematic and rigorous data collection and analysis.

Search Strategy

The search strategy developed for this systematic review involved identifying online databases to locate the relevant literature (Lame, 2019). The search followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework (Moher et al., 2009). This approach was chosen for its effectiveness in guaranteeing transparent and comprehensive reporting. The PRISMA guidelines provide a checklist of items that should be included in systematic reviews and meta-analyses, such as search strategy, study selection criteria, data extraction process, and data analysis methods. The strategy focused on sources from databases and Google search engines including Google Scholar, ERIC, and Scopus. Publications and reports from reputable institutions, including the World Economic Forum and UNESCO, were also considered.

Selection Criteria (Inclusion/Exclusion Criteria)

Specific search terms relating to the Fourth Industrial Revolution and education were used to select articles. The search focused mainly on mapping the existing literature on 4IR and education. The search then narrowed to specific subject areas featuring cutting-edge teaching strategies, technology in education, inclusivity, and successful case studies from around the world. Other considerations included articles featuring global views, educational practices, and policies concerning 4IR. The search spanned 2019 to 2023, and any others outside this period were excluded. The following exclusion criteria were used to limit the papers to those published only in English. A total of 56 documents were extracted and screened for relevance. Furthermore, nine more articles were excluded from the study after filtering for duplicate records.

The entire texts of the chosen publications were carefully examined to ascertain their applicability and relevance to the study. At this stage, 19 documents were eliminated, resulting in 28 papers for the analysis. The selected documents were analyzed using content analysis, following the guidelines presented by Pitchforth et al. (2017). Four characteristics were extracted from the reviewed articles and analyzed as themes: educational approaches, global perspectives on education for 4IR, technological enablers, inclusivity, and equity. It is worth noting that while a large number may initially appear ideal, the selection process prioritizes the most critical and high-quality documents to maintain focus and in-depth analysis. In addition, the excluded papers partially addressed the topic or contained low-quality evidence. In view of this, the inclusion and exclusion criteria focused on a few but more relevant articles to ensure the methodological soundness of the review.

Quality Assessment

This study was based only on original research articles, review papers, and conference papers. To maintain the quality of the review, all publications were thoroughly reviewed. A set of inclusion and exclusion criteria were devised to guarantee the validity and reliability of the selected articles. Articles addressing education for the Fourth Industrial Revolution were included if they met the inclusion criteria; articles of poor quality or with no direct connection to the subject matter were excluded. In addition, a*rticles judged to be poor in methodology or to*

have no direct relevance to the subject matter were not included in the review. This ensured that the conclusions related to the Fourth Industrial Revolution remained consistent. A quality assessment was performed to ensure rigor and reliability of the findings. Accordingly, high-quality studies were prioritized in the qualitative analyses.

Findings

Promising Educational Approaches

Nine articles were found to be relevant in this category, as shown in Table 1. Results from the reviewed literature indicate that there are critical skills for Industry 4.0, including technical, higher-order cognitive, and interpersonal skills (Mudzar & Chew, 2022). These findings also build a case for educational development driven by digital technologies, thus replacing traditional delivery modes (Qureshi et al., 2021). Education institutions should adopt an interdisciplinary approach, encouraging students to explore issues that transcend individual subjects (Haidir et al., 2021; Mudzar & Chew, 2022).

Table 1

Promising Educational Approaches

Authors	Title	Approaches
1. Mudzar, N. M., & Chew, K. W. (2022)	Change in labour force skillset for the fourth industrial revolution: A literature review.	There are three critical skills for Industry 4.0 which include technical skills, higher-order cognitive skills, and interpersonal skills.
2. Qureshi, M. I., Khan, N., Raza, H., Imran, A., & Ismail, F. (2021).	Digital technologies in education 4.0. Does it enhance the effectiveness of learning? A systematic literature review.	Digital education technologies are replacing traditional modes of delivery.
3. Haidir, H., Muhammad A., and Miftah F. (2021)	An innovation of Islamic religious education in the era of the industrial revolution 4.0 in elementary school.	Adoption of interdisciplinary approach.
4. Frank, P., & Stanszus, L. (2019)	Transforming consumer behavior: Introducing self-inquiry-based and self-experience-based learning for building personal competencies for sustainable consumption.	Approaches such as project-based learning, experiential learning, online learning, and customized learning have equipped students with multiple competencies.
5. Morris, T. H. (2020).	Experiential learning–A systematic review and revision of Kolb's model.	Project-based learning (PBL) has involved students in practical problem-solving exercises.
6. Alhloul, A., & Kiss, E. (2022).	Industry 4.0 as a challenge for the skills and competencies of the labor force: A bibliometric review and a survey.	Teachers need to master the 21st century skills including plus digital-based learning media.
7. Barbour et al. (2020).	Understanding pandemic pedagogy: Differences between emergency remote, remote, and online teaching. *State of the Nation: K-12 e-Learning in Canada.*	Open online courses, online simulations, and virtual classrooms all allow students to acquire requisite competencies

5.	Morris, T. H. (2020).	Experiential learning–A systematic review and revision of Kolb's model.	Project-based learning (PBL) has involved students in practical problem-solving exercises.
6.	Alhloul, A., & Kiss, E. (2022).	Industry 4.0 as a challenge for the skills and competencies of the labor force: A bibliometric review and a survey.	Teachers need to master the 21st century skills including plus digital-based learning media.
7.	Barbour et al. (2020).	Understanding pandemic pedagogy: Differences between emergency remote, remote, and online teaching. *State of the Nation: K-12 e-Learning in Canada.*	Open online courses, online simulations, and virtual classrooms all allow students to acquire requisite competencies
8.	Natarajan, U., Lim, K.Y.T., & Laxman, K. (2021).	A national vision for information and communication technologies in education: reflections on Singapore's ICT technologies Masterplans.	Supranational digital learning resources connect institutional digital learning across countries
9.	Mudzar, N. M., & Chew, K.W. (2022).	Change in labor force skillset for the fourth industrial revolution: A literature review.	Emphasizes interdisciplinary learning and critical thinking through project-based and phenomenon-based learning

Approaches such as project-based learning, experiential learning, online learning, and customized learning have shown promise in equipping students with multiple competencies needed for fast-changing 4IR (Frank & Stanszus, 2019). Project-based learning (PBL) has grown in popularity as a method of involving students in practical problem-solving exercises. It also encourages teamwork, critical thinking, and creativity (Morris, 2020). This implies that teachers need to master 21st century skills, including the ability to use digital learning media (Alhloul & Kiss, 2022). In addition, Massive open online courses (MOOCs), online simulations, and virtual classrooms are recommended because they allow students to acquire the competencies required for the new technological revolution (Barbour et al., 2020). Thus, the use of digital resources is important. The growth of supranational digital learning resources is expected to lead to the enhanced connectivity of institutional digital learning across countries (Natarajan et al., 2021).

Global Perspectives on Education for 4IR

Seven articles were scrutinized to determine the global perspectives on 4IR. Referring to Table 2, most educational institutions do not seem to have fully embraced the effect of 4IR. This was evident when most institutions were forced to stop their operations suddenly as a result of the COVID-19 pandemic (Chaka, 2022). It has also emerged that real-world education 4.0 is confined to certain countries and few higher education institutions (Chaka, 2022). Despite these limitations, some countries have made some strides. For example, South Korea has made remarkable attempts to incorporate technology into its education. This is evident in its 'Smart Education' project, which provides learners with digital learning tools and platforms (Lee et al., 2023). Finland, in contrast, has a strong affinity for a holistic approach to education that encourages creativity and adaptation and is interdisciplinary (Lozano et al., 2023).

Table 2

Global Perspectives

Authors	Title	Global experiences
1. Chaka, C. (2022).	Is education 4.0 a sufficient innovative and disruptive educational trend to promote sustainable open education for higher education institutions? A review of literature trends.	Most institutions have not fully embraced the effect of the 4IR. Real-world Education 4.0 is confined to a few countries
2. Lozano Rivas, F., Del Cerro Velázquez, F., & Morales Méndez, G. (2023).	Key competencies for sustainability: technical project supported by Ecodesign of educational spaces to achieve SDGs.	Finland focuses on creativity and adaptation and is interdisciplinary
3. Lee, S. E., Choi, N., & Kiaer, J. (2023).	The social perceptions of young children's use of smart devices in South Korea: Evidence from big data methodologies	South Korea's 'Smart Education' project
4. Cahapay, M. B. (2020).	Rethinking education in the new normal post-COVID-19 era: A curriculum studies perspective.	Singapore encourages continued learning
5. Ngenzi, J. L., Scott, R. E., & Mars, M. (2021	Information and communication technology to enhance continuing professional development (CPD) and continuing medical education (CME) for Rwanda: A scoping review of reviews.	One Laptop per Child (OLPC) project in Rwanda
6. Adnan, M. (2022).	Islamic education and character building in the 4.0 Industrial Revolution	United Arab Emirates gives priority to STEM
7. Aniyu, I.O., Oyedele, O.O., & Derera, E. (2021).	Disruptions of the Fourth Industrial Revolution: Implication for work-life balance strategies. In Future of Work, Work-Family Satisfaction, and Employee Well-Being in the Fourth Industrial Revolution	In South Africa, institutions have adopted virtual and contact artificial intelligence and the Internet of Things

In Singapore, the government encourages people to continue learning throughout their lives to adapt to changing employment requirements (Cahapay, 2020). On the other hand, the "National Strategy for Higher Education 2030" of the United Arab Emirates gives priority to STEM (science, technology, engineering, and mathematics) education (Adnan, 2022). It is also observed that in South Africa, higher educational institutions have successfully adopted virtual and contact instruction technologies, such as artificial intelligence and the Internet of Things (Aniyu et al., 2021)

Technological Enablers of 4IR Education

Countries should adopt modern learning environments with mass network educational forums (González-Pérez & Ramirez-Montoya, 2022). Table 3 reveals that six articles found academics preferred virtual or hybrid classrooms, primarily utilizing different 4IR tools to send messages, schedule Zoom classes, and share feedback and educational resources (Nwosu et al., 2023). The results also show that the heart of technological innovation in 4IR education is artificial intelligence (AI). This is because the capacity of AI to customize learning streams based on specific student needs has made them popular (Grenčíková et al., 2021). AI-powered chatbots can now offer quick assistance to access learning materials thus boosting student engagement (Mijwil et al., 2023).

Similarly, learning environments are transformed as learners engage in virtual reality (VR) and augmented reality (AR). Virtual reality (VR) can expose students to real-world simulations that can afford them hands–on activities for experiential learning (Ziden et al., 2022). Supporting this assertion by way of an example is blockchain, which has the potential to utilize data in lifelong learning (Tran & Nguyen, 2021). Through real-time manipulation of data, Internet of Things (IoT) devices can facilitate personalized learning (Poszytek, 2021).

Table 3

Technological Enablers of 4IR Education

Authors	Title	Technologies
1. González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022).	Components of Education 4.0 in 21st century skills frameworks: Systematic review.	Learning environments with mass network educational forums.
2. Grenčíková, A., Kordoš, M., & Navickas, V. (2021).	The impact of industry 4.0 on education content.	Artificial intelligence (AI).
3. Nwosu, L. I., Bereng, M. C., Segotso, T., &Enebe, N. B. (2023).	Fourth Industrial Revolution tools to enhance the growth and development of teaching and learning in higher education institutions: A systematic literature review in South Africa.	Virtual or hybrid classrooms mainly by using different artificial intelligence tools
4. Mijwil, M. M., Ali, G., &Sadıkoğlu, E. (2023).	The Evolving Role of Artificial Intelligence in the Future of Distance Learning: Exploring the Next Frontier.	AI-powered chatbots to access learning materials
5. Ziden, A. A., Ziden, A. A. A., & Ifedayo, A. E. (2022).	Effectiveness of augmented reality (AR) on students' achievement and motivation in learning science.	Virtual reality (VR) and augmented reality (AR).
6. Poszytek, P. (2021).	The landscape of scientific discussions on the competencies 4.0 concept in the context of the 4th Industrial Revolution: A bibliometric review.	blockchain, in lifelong learning Internet of Things (IoT) devices to facilitate personalized learning

Inclusivity and Equity in 4IR Education

In many developing countries particularly in rural settings and among marginalized groups there is poor access to digital devices and internet connectivity (Ritzhaupt et al., 2020). According to Table 4, this disparity prevents 4IR education from empowering disadvantaged and vulnerable groups. In addition, there are varied learning limitations and experiences of content and digital skills for students who engage in digital curricula due to the contextual digital divide (Arek-Bawa & Reddy, 2022).

Table 4

Inclusivity and Equity in 4IR Education

Authors	Title	Issues with equity
1. Arek-Bawa, O., & Reddy, S. (2022).	Digital curricular transformation and fourth Industrial Revolution 4.0 (4IR): Deepening divides or building bridges.	learning limitations and experiences due to contextual digital divide
2. West, M., Kraut, R., & Ei Chew, H. (2019).	I'd blush if I could: Closing gender divides in digital skills through education.	Gender inequality affects participation and engagement in digital education
3. Ritzhaupt, A. D., Cheng, L., Luo, W., & Hohlfeld, T. N. (2020).	The digital divide in formal educational settings: The past, present, and future relevance.	Rural settings and among marginalized groups have poor access to digital devices and internet connectivity
4. Shenkoya, T., & Kim, E. (2023).	Sustainability in higher education: Digital transformation of the fourth Industrial Revolution and its impact on open knowledge.	Need culturally responsive content relevant to(4IR)
5. UNESCO. (2020	Education in a post-COVID world: Nine Ideas for public Action. United Nations Educational, Scientific and Cultural Organization	Need for subsidized devices and internet access in underserved communities
6. Gurumurthy, A., Bailur, S., Friederici, N., Heeks, R., & Morgan, S. L. (2019).	Gender, digital tech, and the global South: Women's inclusion in technology programs in Africa, Asia, and Latin America. Gender and Development.	Digital learning centers within community for navigating the digital landscape

Furthermore, gender inequality, specifically biases against women regarding technology, affects participation and engagement in digital education (West et al., 2019). To address this inequality, policies should be supported by deliberate governmental initiatives that provide subsidized devices and internet access to underserved communities (UNESCO, 2020). Moreover, creative ways of establishing digital learning centers within community spaces can be instrumental in imparting knowledge and skills to navigate the digital landscape (Gurumurthy et al., 2019). Curriculum developers can also design culturally responsive content relevant to the Fourth Industrial Revolution education targeting marginalized learners (Shenkoya & Kim, 2023).

Discussion

The reviewed literature reveals a multidimensional education landscape in the Fourth Industrial Revolution (4IR) with diverse strategies and challenges. The findings show varied and complicated scenarios, reflecting diverse approaches and difficulties in various countries and educational situations. A comparative analysis of educational policies and learning frameworks across various countries indicates varied approaches to 4IR education. Various countries are customizing their education to suit their cultural, economic, and technological contexts. However, there is a strong indication that technology-centric initiatives are prevalent in South Korea, and holistic, skills-focused models are prevalent in Finland.

Furthermore, insights from the literature reveal the motivations, challenges, and outcomes of 4IR-related educational initiatives. This review provides a deeper understanding of policies and program implementations. The examined works strongly highlight the critical role of technology as a facilitator of Fourth Industrial Revolution (4IR) education. The assimilation of artificial intelligence (AI), virtual reality (VR), and augmented reality (AR) by different education systems is being embraced to enrich the educational experience. Furthermore, the digital gap presents a substantial equity barrier, making it difficult for the underprivileged population to access these technologies. In this regard, the findings underscore the significance of inclusivity and fairness in bridging disparities in technology access. There is a necessity for collective initiatives aimed at bridging the digital gap. Artificial Intelligence, Virtual Reality, and Augmented Reality have been touted as game changers to improve learning experiences (Ziden et al., 2022).

It is significant that teachers master digital-based learning (Choudhury, 2020) and utilize psychological abilities such as creativity, critical thinking, collaboration, communication, innovation, problem-solving, ICT skills, and character (Rahmatullah et al., 2022). Remarkable examples from Singapore, Finland, and Rwanda (Tan, 2020; Sahlberg & Hargreaves, 2016) demonstrate how deliberate forward-thinking policies can benefit students from diverse backgrounds. It is imperative to develop scalable solutions and learning materials that are sensitive to cultural differences. A fully digitized curriculum aligns curricula and technology with pedagogy, thus promoting deep, active, and discovery-based curricula (Gagnon et al., 2019). The policies require that these learners be effectively equipped with the requisite skills to thrive in a dynamic 4IR environment. These benefits can be achieved through creative pedagogies and collaborative partnerships. Education should focus on teaching systemic and interdisciplinary thinking to meet the needs of Industry 4.0 (Cepelet al., 2019).

In addition, a comprehensive and inclusive approach that ensures a complicated interplay between technological improvements and fair access is needed. These results support the notion that there is no one-size-fits-all answer due to the unique demands and goals of different countries. The findings also reflect the interpretive character of the educational responses of different countries to 4IR. For instance, Finland's comprehensive and multi-disciplinary skills-focused paradigm (Sahlberg & Hargreaves, 2016) contrasts with South Korea's technology-focused, by extension the "Smart Education" approach (Lee & Lee, 2018). Despite shortcomings in the future, the results highlight the urgent need for a comprehensive approach to 4IR education. This approach should combine technical skills with transversal talents to ensure that students are ready to take advantage of the possibilities and tackle the problems of 4IR.

It is expected that there will be considerable progress in higher education, particularly involving the integration of highly sophisticated tools and technology, a concept known as 'Education 4.0' (Weber, 2016). Countries are encouraged to create effective policies and resolve the practical difficulties hindering their implementation. The interpretations, consistencies, and contrasts noted in these findings shed light on the intricacies of the 4IR education. They also

serve as a basis for developing comprehensive and flexible approaches that equip learners to excel in the dynamic 4IR era.

Conclusion and Recommendations

This study has looked at many different features, issues, and potential solutions concerning schooling in the Fourth Industrial Revolution (4IR). The findings have shown the significance of including everyone in designing educational processes. A multifaceted approach is required to ensure the efficacy and inclusivity of the 4IR education. To prepare for the Fourth Industrial Revolution (4IR), we must adopt new approaches such as project-oriented instruction, hands-on learning, virtual instruction, and individualized education to develop multifaceted skills. In today's technologically advanced society, nations must rethink their educational systems to equip students with transferable skills, analytical capabilities, and an awareness of the wider world. It, therefore, calls for policymakers, educators, and others to adopt a diversified approach to address the challenges of the 4IR age.

Educational institutions should prioritize the establishment of in-depth, adaptable learning plans that cultivate both technical and non-technical capabilities. This can be achieved by creating pathways to secure access to technology in partnership with each other while developing students' imaginative thinking and solution-oriented skills. Educators should promote engaging learning environments that support tailored learning plans to stimulate interest beyond conventional classroom instruction.

Limitation

The researcher would like to state that the small number of data sources in this review could be a limitation. It is also possible that some prospective studies were omitted from the search. However, an endeavor was made to select credible and substantially recognized databases in the subject domain. Thus, the limitations of this study were considerably minimized. In view of this, future studies can address this by including a wide range of databases for a comprehensive systematic review.

References

Adnan, M. (2022). Islamic education and character building in the 4.0 Industrial Revolution.*Nazhruna: JurnalPendidikan Islam*, *5*(1), 11-21. https://doi.org/10.31538/nzh.v5i1.1771

Alam, G. M., Parvin, M., Rahman, M.M. (2021). Contribution of Informal and Institutional Skills Provisions on Business Inception and Growth: Evidence from Manufacturing and Service Industries. *Business Process Management Journal*, 27(4), 1335– 1352

Alcacer, V. and Cruz-Machado, V. (2019). Scanning the Industry 4.0: A Literature Review on Technologies for Manufacturing Systems. Engineering Science and Technology, an International Journal, 22, 899-919. https://doi.org/10.1016/j.jestch.2019.01.006

Alhloul, A., & Kiss, E. (2022). Industry 4.0 as a challenge for the skills and competencies of the labor force: A bibliometric review and a survey. *Sci*, *4*(3), 34 https://doi.org/10.3390/sci4030034

Altinişik, H. Z., Adigüzel, T., & Gençer, Y. G. (2023, January 31). Adaptation of Youth Innovational Skills Measurement Tool for Turkish Usage. https://scite.ai/reports/10.24106/kefdergi.1246467

Aniyu, I. O., Oyedele, O.O., & Derera, E. (2021). Disruptions of the Fourth Industrial Revolution: Implication for work-life balance strategies. In Future of Work, Work-Family Satisfaction, and Employee Well-Being in the Fourth Industrial Revolution (pp. 189- 199). IGI Global.

Arek-Bawa, O., & Reddy, S. (2022). Digital curricular transformation and fourth Industrial Revolution 4.0 (4IR): Deepening divides or building bridges. *E-Journal of Humanities, Arts and Social Sciences*, 308-326. https://doi.org/10.38159/ehass.2022sp31124

Atmojo, I. R. W., Ardiansyah, R., & Saputri, D. F. (2022, July 1). Empowering Science-Based Entrepreneurship (SciPreneur) Skills through CEL-BaDiS Up Learning Model

Barbour, M. K., LaBonte, R., Hodges, C. B., Moore, S., Lockee, B. B., Trust, T., Bond, M., Hill, P. & Kelly, K. (2020). Understanding pandemic pedagogy: Differences between emergency remote, remote, and online teaching. *State of the Nation: K-12 e-Learning in Canada*.

Bennett, E. E., McWhorter, R. R. (2021). Virtual HRD's Role in Crisis and the Post Covid-19 Professional Lifeworld: Accelerating Skills for Digital Transformation. *Advances in Developing Human Resources*, 23(1), 5–25

Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O., & Kerres, M. (2020). "Mapping re- search in student engagement and educational technology in higher education: a systematic evidence map," *International Journal of Educational Technology in Higher Education*, 17(1). Springer, https://doi.org/10.1186/s41239-019-0176-8

Bucea-Manea-Ţoniş, R., Kuleto, V., Gudei, S. C. D., Lianu, C., Lianu, C., Ilić, M. P., & Păun, D. (2022). Artificial intelligence potential in higher education institutions enhanced learning environment in Romania and Serbia. *Sustainability*, 14, 5842. https://doi.org/10.3390/su14105842

Cahapay, M. B. (2020). Rethinking education in the new normal post-COVID-19 era: A curriculum studies perspective.

Cepel, M., Belas, J., Rozsa, Z., & Strnad, Z. (2019). Selected eco- nomic factors of the quality of business environment. *Journal of International Studies*, 12(2), 228–240. https://doi.org/10.14254/2071-8330.2019/12-2/14

Chaka, C. (2022). Is education 4.0 a sufficient innovative, and disruptive educational trend to promote sustainable open education for higher education institutions? A review of literature trends. *Frontiersin Education*, *7*. https://doi.org/10.3389/feduc.2022.824976

Choudhury, S. (2020). Will the Pandemic Bring Industrial Revolution 4.0 Closer to Home? In P. Kumar, A. Agrawal, and P. Budhwar (Ed.) Human & Technological Resource Management (HTRM): New Insights into Revolution 4.0 (pp. 157-166). Emerald Publishing Limited, Bingley.

Daley, S., & Cordell, G. A. (2021, March 1). Natural Products, the Fourth Industrial Revolution, and the Quintuple Helix. https://scite.ai/reports/10.1177/1934578x211003029

Economist Intelligence Unit. (2019). Fostering exploration and excellence in 21st century schools. The Economist Intelligence Unit Limited.

Fataar, A. (2020, January 1). The emergence of an education policy disposit if in South Africa: An analysis of educational discourses associated with the fourth industrial revolution. https://scite.ai/reports/10.17159/2520-9868/i80a01

Frank, P., & Stanszus, L. (2019, May 2). Transforming Consumer Behavior: Introducing Self-Inquiry-Based

and Self-Experience-Based Learning for Building Personal Competencies for Sustainable Consumption. https://scite.ai/reports/10.3390/su11092550

González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of Education 4.0 in 21st century skills frameworks: systematic review. *Sustainability*, *14*(3), 1493.

Gurumurthy, A., Bailur, S., Friederici, N., Heeks, R., & Morgan, S. L. (2019). Gender, digital tech, and the global South: Women's inclusion in technology programmes in Africa, Asia, and Latin America. Gender and Development.

Grenčíková, A., Kordoš, M., & Navickas, V. (2021). The impact of industry 4.0 on education contents. *Business: Theory and Practice*, *22*(1), 29-38. https://doi.org/10.3846/btp.2021.13166

Haidir, H., Muhammad A., and Miftah F. (2021). "An Innovation of Islamic Religious Education in The Era of The Industrial Revolution 4.0 in Elementary School." Nazhruna: *Jurnal Pendidikan Islam*4 (3), 720–34. https://doi.org/10.31538/nzh.v4i3.1688

Innovationexcellence.com. (2016). The Education Revolution of the Fourth Industrial Revolution. Retrieved from https://www.innovationexcellence.com/blog/2016/04/19/the- education-revolution- of-the-fourth- industrial-revolution/

Jam, N. A. M., Puteh, S., & Puteh, S. (2022, January 1). Exploring the Teaching and Learning Indicators towards Education 4.0 in MTUN, Malaysia. https://scite.ai/reports/10.18178/ijiet.2022.12.2.1602

Ji, S., Pan, S., Cambria, E., Marttinen, P., & Philip, S. Y. (2021). A survey on knowledge graphs: Representation, acquisition, and applications. *IEEE transactions on neural networks and learning systems*, *33*(2), 494-514.

Jung, J. (2020). "The fourth industrial revolution, knowledge production and higher education in South Korea," J. *High. Educ. Policy Manag*., 42(2), 134–156, https://doi.org/10.1080/1360080x.2019.1660047

Lame, G. (2019, July). Systematic literature reviews: An introduction. In *Proceedings of the design society: international conference on engineering design* (Vol. 1, No. 1, pp. 1633-1642). Cambridge University Press.

Lee, J. H., & Lee, J. W. (2018). South Korea's Smart Education Policy. *Education Policy Analysis Archives.*

Lee, S. E., Choi, N., & Kiaer, J. (2023). The social perceptions of young children's use of smart devices in South Korea: Evidence from big data methodologies. *Contemporary Educational Technology*, *15*(3), ep424.

Lozano, R., F., Del Cerro Velázquez, F., & Morales Méndez, G. (2023). Key competences for sustainability: technical project supported by Ecodesign of educational spaces to achieve SDGs.*Sustainability*, *15*(5), 3959.

McCowan, T. (2018). The Fourth Industrial Revolution and Education: An Overview. *Prospects*, 48(2), 185-198.

Mijwil, M. M., Ali, G., & Sadıkoğlu, E. (2023). The Evolving Role of Artificial Intelligence in the Future of Distance Learning: Exploring the Next Frontier. *Mesopotamian Journal of Computer Science*, *2023*, 98-105.

Morris, T. H. (2020). Experiential learning–a systematic review and revision of

Kolb's model. *Interactive learning environments*, *28*(8), 1064-1077.

Mudzar, N. M., & Chew, K. W. (2022). Change in labour force Skillset for the fourth Industrial Revolution: A literature review. *International Journal of Technology*, *13*(5), 969 https://doi.org/10.14716/ijtech.v13i5.5875

Natarajan, U., Lim, K.Y.T., & Laxman, K. (2021). A national vision for information and communication technologies in education: reflections on Singapore's ICT technologies Masterplans. *International Journal of Educational Management*, 35(5), 943-954

Nwosu, L. I., Bereng, M. C., Segotso, T., & Enebe, N. B. (2023). Fourth Industrial Revolution tools to enhance the growth and development of teaching and learning in higher education institutions: A systematic literature review in South Africa. *Research in Social Sciences and Technology*, *8*(1), 51-62. https://doi.org/10.46303/10.46303/ressat.2023.4

Gagnon, P., Carlstedt-Duke, J. and Zary, N. (2019). "Key Aspects to the Design, Development, Deployment and Evaluation of a Fully Digitized Undergraduate Programme," 2019, 5821–30, https://doi.org/10.21125/edulearn.2019.1408. 5 World Economic Forum, "Schools of the Future

Pitchforth, J., Fahy, K., Ford, T., Gerhardus, A., & Van den Broucke, S. (2017). Assessing the methodological quality of qualitative research in systematic reviews: Criteria, process and reporting. *BMC Medical Research Methodology*, 17(1), 1-9.

Poszytek, P. (2021). The landscape of scientific discussions on the competencies 4.0 concept in the context of the 4th Industrial Revolution—A bibliometric review. *Sustainability*, *13*(12), 6709. https://doi.org/10.3390/su13126709

Qureshi, M. I., Khan, N., Raza, H., Imran, A., & Ismail, F. (2021). Digital technologies in education 4.0. Does it enhance the effectiveness of learning? A systematic literature review. *International Journal of Interactive Mobile Technologies (JIM)*, *15*(04), 31.https://doi.org/10.3991/ijim.v15i04.20291

Rahmatullah, A. S., Mulyasa, E., Syahrani, S., Pongpalilu, F., & Putri, R. E. (2022). Linguistics and Culture Review, 6(S3), 89-107. https://doi.org/10.21744/lingcure.v6nS3.2064

Ritzhaupt, A. D., Cheng, L., Luo, W., & Hohlfeld, T. N. (2020). The digital divide in formal educational settings: The past, present, and future relevance. *Handbook of Research in Educational Communications and Technology: Learning Design*, 483-504.

Ronchi, M., & Ronchi, A. (2019). "e-Learning: How Teaching and Training Methods Changed in the Last 20 Years," in e-Services, *Springer International Publishing*, pp. 69–113. https://doi.org/10.1007/978-3-030-01842-9_2

Sahlberg, P., & Hargreaves, A. (2016). Finnish lessons 2.0: What can the world learn from educational change in Finland? Teachers College Press.Top of Form

Schwab, K. (2017). *The Fourth Industrial Revolution*. Currency.

Shenkoya, T., & Kim, E. (2023). Sustainability in Higher Education: Digital Transformation of the Fourth Industrial Revolution and Its Impact on Open Knowledge. *Sustainability* https://doi.org/10.3390/su15032473

Tan, C. (2020). The impact of COVID-19 on student motivation, community of inquiry and learning performance. *Asian Education and Development Studies*, *10*(2), 308-321.

Tiemann, R., & Annaggar, A. (2020). A framework for the theory-driven design of digital learning environments (FDDLEs) using the example of problem-solving in chemistry education. Interactive Learning Environments, 1–14

Tokareva, G. V., Skiperskaya, E. V., Lezhebokov, A. A., Baicherova, A. R., & Zolotareva, T. A. (2020, July). Achieving the Polyprofessionality of the Future Personnel Through the Development of Entrepreneurial Competencies. In *International Scientific Conference on Philosophy of Education, Law and Science in the Era of Globalization (PELSEG 2020)* (pp. 221-224). Atlantis Press.

Tran, K., & Nguyen, T. (2021). Preliminary research on the social attitudes toward AI's involvement in Christian education in Vietnam: Promoting AI technology for religious education. *Religions*, *12*(3), 208.

Trilling, B., & Fadel, C. (2009). 21st century skills: Learning for life in our times. John Wiley & Sons.

UNESCO. (2019). Futures of Education: Learning to Become. UNESCO.

UNESCO. (2020). Education in a Post-COVID World: Nine Ideas for Public Action. United Nations Educational, Scientific and Cultural Organization.

Weber, E. (2016). Industrie 4.0: Wirkungen auf den Arbeitsmarkt und politischeHerausforderungen. *ZeitschriftfürWirtschaftspolitik*, *65*(1), 066-074. https://doi.org/10.1515/zfwp-2016-0002

West, M., Kraut, R., & Ei Chew, H. (2019). I'd blush if I could: closing gender divides in digital skills through education.

Wong, S. L., & Shen, L. (2018). A critical review of research on technology-supported teaching and learning models in higher education. Educational Technology & Society, 21(4), 183-197.

World Economic Forum. (2018). The Future of Jobs Report 2018. World Economic Forum

World Economic Forum, J. (2020). The future of jobs report 2020. *Retrieved from Geneva*.

Zgraggen, M. (2021). Blended learning model in a vocational educational training hospitality setting: from teachers' perspectives. *International Journal of Training Research*, 1–27

Ziden, A. A., Ziden, A. A. A., & Ifedayo, A. E. (2022). Effectiveness of augmented reality (AR) on students' achievement and motivation in learning science. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(4), em2097.