Lifelong learning as a response to the challenges of Industry 5.0 within the context of Horizon 2030

Pablo Rial-Gonzalez
EUNCET Business School. Spain.
pablo.rial.gonzalez@gmail.com

M. Carmen Sarceda-Gorgoso
Olaya Santamaría Queiruga
Universidade de Santiago de Compostela. Spain.
carmen.sarceda@usc.es
olaya.queiruga.santamaria@usc.es

Received: 15/1/2024
Accepted: 4/5/2024
Published: 28/5/2024

Abstract

Lifelong learning is a key element to face the challenges of the fourth industrial revolution, or Industry 4.0, which involved digital transformation and the automation of production processes. In this context, the current fifth industrial revolution, or Industry 5.0, based on artificial intelligence (AI), requires a renewed focus on lifelong learning. The horizon of 2030 is an estimated date for achieving some of the objectives of this revolution: to improve competitiveness, innovation and social inclusion. This paper aims to deepen the understanding of lifelong learning and its strategic role in meeting the challenges of this new context of transition from Industry 4.0 to 5.0. To this end, a systematic literature review is carried out with a bibliometric analysis in Scopus and WOS on lifelong learning, Industry 5.0 and transformations in relation to work and education. The results show that continuing education is key to acquiring the necessary knowledge and skills, not only from an economic perspective, but above all as a means of promoting openness, tolerance, democracy and social inclusion. However, it is necessary to reflect on what the roadmap should be for adapting training processes to these emerging needs.

Keywords: agenda 2030; professional skills; education 5.0; industry 5.0; artificial intelligence; lifelong learning

Resum. *El* lifelong learning *com a resposta als reptes de la revolució 5.0 dins del marc de l'horitzó 2030*

El *lifelong learning* és un element clau per afrontar els desafiaments de la revolució 4.0 que ha implicat la transformació digital i l'automatització dels processos productius. Partint d'aquest antecedent, l'actual revolució 5.0, basada en la intel·ligència artificial (IA), requereix tornar a centrar la mirada en l'aprenentatge al llarg de la vida. L'horitzó 2030 és una data estimada per aconseguir alguns dels objectius d'aquesta revolució: millora de la competitivitat, innovació i inclusió social. Aquest treball planteja com a objectiu aprofundir en el *lifelong learning* i el seu paper estratègic per afrontar els desafiaments d'aquest nou context de transició d'indústria 4.0 a revolució 5.0. Per fer-ho, es realitza

una revisió sistemàtica de literatura amb una anàlisi bibliomètrica en Scopus i WOS sobre el binomi treball-formació, la revolució 5.0 i les transformacions en relació amb el treball i l'aprenentatge. Els resultats obtinguts permeten concloure que l'educació permanent és clau per adquirir els coneixements i les aptituds necessaris, no sols des d'una perspectiva econòmica, sinó especialment com a mitjà per promoure l'obertura, la tolerància, la democràcia i la inclusió social. No obstant això, requereix reflexionar sobre quin ha de ser el full de ruta per adaptar els processos formatius a aquestes necessitats emergents.

Paraules clau: agenda 2030; competències professionals; educació 5.0; indústria 5.0; intel·ligència artificial; *lifelong learning*

Resumen. *El* lifelong learning *como respuesta a los desafíos de la revolución 5.0 en el marco del horizonte 2030*

El *lifelong learning* es un elemento clave para afrontar los desafíos de la revolución 4.0 que ha implicado la transformación digital y la automatización de los procesos productivos. Partiendo de este antecedente, la actual revolución 5.0, basada en la inteligencia artificial (IA), requiere volver a centrar la mirada en el aprendizaje a lo largo de la vida. El horizonte 2030 es una fecha estimada para alcanzar algunos de los objetivos de esta revolución: mejora de la competitividad, innovación e inclusión social. Este trabajo plantea como objetivo profundizar en el *lifelong learning* y su papel estratégico para afrontar los desafíos de este nuevo contexto de transición de industria 4.0 a revolución 5.0. Para ello, se realiza una revisión sistemática de literatura con un análisis bibliométrico en Scopus y WOS acerca del binomio trabajo-formación, la revolución 5.0 y las transformaciones con relación al trabajo y el aprendizaje. Los resultados obtenidos permiten concluir que la educación permanente es clave para adquirir los conocimientos y las aptitudes necesarios, no solo desde una perspectiva económica, sino especialmente como medio para promover la apertura, la tolerancia, la democracia y la inclusión social. Sin embargo, requiere reflexionar sobre cuál debe ser la hoja de ruta para adaptar los procesos formativos a estas necesidades emergentes.

Palabras clave: agenda 2030; competencias profesionales; educación 5.0; industria 5.0; inteligencia artificial; *lifelong learning*

Summary

1. Introduction

The relationship between work and education has always been complex and changing. In pre-industrial societies, work was based on the transmission of knowledge and skills from one generation to the next, through the family, the guild or the community. Training was informal, practical and adapted to the needs and demands of each context. The industrial revolution radically changed the nature of work. New occupations and sectors were created, machines and technologies were introduced, and productivity and specialisa-

tion increased. In post-industrial societies and in the context of the Fourth and Fifth Industrial Revolutions (Industry 4.0 and Industry 5.0), work has experienced new vicissitudes: globalisation and the interconnection of markets, greater flexibility and mobility of labour, diversification and complexity of tasks, and constant innovation and renewal of knowledge and skills. As Schwab (2016) argues, the Fourth Industrial Revolution presents itself as a Copernican shift of incalculable voracity, leaving little room for error in understanding its implications, and in which artificial intelligence (AI), also a defining feature of the Fifth Revolution, is having a significant impact on both learning and work. In this regard, the World Economic Forum (2023a) explores how jobs and skills will evolve over the next five years, and predicts that AI and digitalisation will create 97 million new jobs by 2025. It is therefore crucial to complement and develop skills, including digital skills, to meet the needs of the new labour market and prevent technological unemployment.

In the context of transformations that are taking place at breakneck speed, education is challenged to provide an adequate response to these demands, facing the challenges of updating training and integrating new technologies; in short, Industry 5.0 requires Education 5.0 (AlMalki & Durugbo, 2023; Moraes et al., 2023). The link between the two dimensions will be reflected in a series of international and European recommendations and proposals aimed at adapting society to the new industry (European Parliament, 2023; World Economic Forum, 2023b).

In this context, this paper examines the crucial role of lifelong learning as a key strategy for addressing new challenges, highlighting its importance in achieving the sustainable development goals (SDGs) set out in the 2030 Agenda for Sustainable Development (United Nations, 2015), in which lifelong learning is seen as the key to acquiring necessary knowledge and skills, not only from an economic perspective, but also as a means to promote openness, tolerance and democracy in society. Thus, in the words of Himmetoglu et al. (2020, p. 12), "open access, individualised education, mental transformation, integration of digital technologies in education, seamless learning environments, lifelong learning, exploratory education and multidisciplinary education are the main components that define Education 4.0." From this starting point, this paper explores how lifelong learning is becoming the key to enabling today's generations, both in terms of education and in terms of the labour market, to develop the socio-occupational skills needed to thrive in this dynamic environment. Lifelong learning is seen as a strategic response to the emerging challenges in the context of the Industrial Revolution 4.0, with a time horizon of 2030 (CEDEFOP, 2020; European Parliament, 2023; United Nations, 2023). The reflection focuses on the imperative need to adapt and transform professional profiles in order to maintain employability in an environment characterised by profound structural changes.

2. Research method

A literature review was conducted between September 2023 and February 2024, focusing on the relationship between lifelong learning and the achievement of the sustainable development goals over the last decade.

The databases selected were Scopus and Web of Science (WOS) as document repositories, due to their comprehensive coverage of peer-reviewed research papers in education (Hallinger & Wang, 2020; Mongeon & Paul-Hus, 2016). The initial search used the following set of keywords through the following equation: '(TITLE-ABS-KEY (lifelong learning) AND TITLE-ABS-KEY (education or learning) AND TITLE-ABS-KEY (sustainable AND development))'. This search in Scopus and WOS returned a list of 349 records in both repositories. The time range of the search was set from 2018 to 2024. The search was refined by selecting articles in the research areas of "Education", "Educational Research" and "Social Sciences". Inclusion criteria included high-impact studies linking lifelong learning and sustainable development goals with cross-sectional, pre-experimental or quasi-experimental methodological designs, and with sufficient statistical power to analyse this relationship.

3. Results

After an initial assessment of the titles and abstracts, a systematic reading of the full studies was carried out, eliminating those that did not meet the established criteria. This selection process resulted in the exclusion of 302 articles. To ensure the quality and timeliness of the data, a logical comparison and comprehensive synthesis of the information collected was carried out.

Taking into account the contextualisation of the research areas and the inclusion criteria, a total of 349 scientific articles were published in the period analysed, of which 47 were selected to form the body of the article.

3.1. New challenges for learning and work: Industrial Revolution 5.0

Technology has influenced our way of life, requiring science, research and training to adapt in order to generate knowledge and skills applicable to work and socio-occupational environments (Schwab, 2016; World Economic Forum, 2023b).

The Industrial Revolutions serve as pivotal milestones in understanding the evolution of education systems. The first industrial revolution introduced fundamental economic changes in the agricultural and industrial sectors; the second consolidated mechanisation, gave rise to transcendental inventions such as the internal combustion engine, the automobile and the electric light, transformed society and already generated some environmental concerns (Hobsbawm, 2016); the third revolution accelerated cultural and social changes and laid the foundations for the Industrial Revolution 4.0. This new phase, characterised by rapid change, disrupts established norms and manifests itself

in a variety of areas, from personal relationships to technological advances that were unpredictable until recently (Himmetoglu et al., 2020; Schwab, 2020).

The Industrial Revolution 4.0, a term coined by Schwab (2016), represents a 180-degree shift. This fourth industrial revolution differs from its predecessors in that it has emerged from the fusion of technologies and an increasing harmonisation and integration of different scientific disciplines (Bonfield et al., 2020; European Parliament, 2023; OECD, 2021). Industry 4.0 is based on intelligent robotic systems linked to the Internet of Things, or networked computer systems, robots and AI interacting with the physical, digital and biological world, redefining the organisation of production in industry and other production systems.

At the end of 2015, people started talking about the "fifth industrial revolution". In December of that year, Rada published an article in which he defined Industry 5.0 as the union, in the form of work, of "machines, advanced technologies and robots working hand in hand with natural persons in an efficient way to carry out production and social life activities" (Pérez-Domínguez, 2024, p. 46). What is new about Industry 5.0 compared to its predecessor is that, in addition to digitisation, data analytics and AI, it includes human-machine collaboration, cognitive computing and 'cobots' (collaborative robotic systems). Revolution 5.0 brings with it fundamental changes in the way we live, work and relate to each other, and even in what it means to be human (Moraes et al., 2023; Schwab, 2020). This paradigm shift therefore requires changes not only in the way learning and work are conceived, but also in the actions of trainers and training scenarios. Its impact extends from the production base to social interactions, requiring agile adaptation to harness its benefits and mitigate potential challenges in society and the workplace.

3.1.1. Artificial Intelligence (AI) and its impact on the workplace

UNESCO (2019) warns of significant challenges related to the fourth industrial revolution and the impact of AI on employment. The pervasiveness of AI in the modern working environment has systemic implications, as it is estimated that 30 per cent of work activities could be automated by 2030, affecting up to 375 million workers worldwide (Frey & Osborne, 2017). While middle-income jobs are the most vulnerable, high-skilled jobs requiring unique creative and analytical skills are expanding.

Against this backdrop, workers are being forced to develop new skill sets or to retrain to adapt to the new occupations made possible by AI. Education ministries responsible for training must anticipate these changes to equip the current workforce and prepare new generations with essential technical and soft skills for the transition to an AI-dominated world (European Commission, 2023; Gmyrek et al., 2023).

Globally, several countries have begun to develop strategic plans to address the impact of AI on the future of work. In the United States, for example, the National Strategic Plan for Artificial Intelligence Research and Development promotes long-term investment and research in various theoretical and practi-

cal approaches to AI (Nabil, 2022), while in other countries, such as China, Japan or the European Union, efforts are focused on promoting spaces for reflection and debate, as well as policies and strategies to regulate, promote and harness AI in a safe, ethical and sustainable manner (Saidakhrarovich & Sokhibjonovich, 2022).

3.1.2. Artificial Intelligence (AI) and its impact on learning

In education, AI has grown exponentially over the last decade, particularly in the wake of the COVID-19 school closures. Although its use has increased, evidence on how AI can improve learning outcomes and contribute to the understanding of the learning process remains limited (European Commission, 2023; Ezzaim et al., 2022; U.S. Department of Education, 2023). Several categories of AI applications in education have been proposed, including system-oriented, student-oriented and teacher-oriented (UNESCO, 2023). In addition, four emerging and potential categories have been proposed: education management and delivery; learning and assessment; teacher empowerment and teaching improvement; and lifelong learning (European Commission, 2023).

There are many resources that illustrate the diversity of AI applications in education, from efficient education management to personalised learning support and automated assessment. By way of an example, and following the contributions of Garcia-Brustenga et al. (2018) and Gonulal (2019), among others, we can highlight "Educational Chatbots" (online software that uses cloud services and AI techniques to have simulated conversations with users, provide information or perform simple tasks), "OU Analyse" (an AI application designed by the UK's Open University that predicts student outcomes and identifies those at risk of failure), or "Swift" (based on a set of methods developed to help education management systems use the data generated in an e-learning module, allowing them to collect data from student interactions to create personalised learning plans based on preferences and performance).

3.2. International and European recommendations and proposals for adapting society to Industry 5.0

As discussed above, there is a significant shift in the contemporary work environment, in which traditional functions in different job roles retain historical elements of training and work. However, these are combined with new cross-cutting approaches promoted by leading international organisations. Among these, the International Labour Organisation and the United Nations have played a crucial role.

The need to harmonise national standards at international level led to the creation of the International Federation of the National Standardizing Association (ISA), which would lay the foundations for the creation of the International Organization for Standardization (ISO) in 1946. Its standards, issued in the form of recommendations, covered all sectors of production and train-

ing, and defined tangible and intangible aspects such as quality. Disruption was avoided by providing a structured framework for technological progress.

In this context, higher education institutions that incorporate cutting-edge technologies are notable for ensuring continuous, systematised and high-quality access to education. The concept of Education 4.0, according to González-Pérez and Ramírez-Montoya (2022), differs from traditional education by integrating technologies such as AI, robotics and cloud computing. This approach, supported by teaching-learning frameworks, aims to develop twenty-first century skills. Bonfield et al. (2020) define this as the alignment of educational services and curricula to prepare the Industry 4.0 workforce. The focus is on developing STEM skills for equitable and inclusive progress. The STEM Education Framework initiative, supported by the New York Academy of Science & Global STEM Alliance (2020), proposes learning strategies that focus on key twenty-first century skills.

Education 5.0 continues to work along the lines established in Education 4.0, but incorporates into the use of technology the need to develop and enhance socio-emotional or soft skills, with the aim of preparing people to be able to autonomously seek and find solutions that improve life in society in a complex, uncertain and highly technological scenario (Arevalo et al., 2023). Education 5.0 emphasises adaptive learning, using AI to analyse individual student performance, progress and preferences, and personalising content, pace and assessments to create a unique and optimised learning journey (Rane et al., 2023). This personalisation not only improves student motivation and engagement, but also maximises learning effectiveness. By tailoring instruction to individual strengths, weaknesses and learning styles, Education 5.0 enhances the development of skills and knowledge that prepare students to meet the challenges of today's and tomorrow's world.

This new paradigm becomes a fundamental ally of lifelong learning. However, we must not lose sight of the educational inequalities that have emerged in recent times, which require a radical transformation of education itself, and of teaching and learning methods (Clark et al., 2023). To reduce these inequalities, it is necessary to teach and develop skills such as the ability to learn continuously, to adapt to new situations and to develop new skills. Lifelong learning, driven by Education 5.0, should also promote the use of teaching methods that focus on the development of socio-emotional skills (essential for success in the future of work), such as creativity, problem solving, critical thinking, effective communication, teamwork and adaptability (Schultheiss & Backes-Gellner, 2023). The aim is for individuals to become autonomous and resilient learners, able to navigate an increasingly complex and uncertain world of work (Kolade & Owoseni, 2022). In this way, Education 5.0 is emerging as a fundamental tool for preparing people for the challenges and opportunities of the 21st century.

A clear sign of the awareness of the importance of teaching and learning by skills is the fact that the current proposals focus on this issue. Put simply, skills standards are presented as a tool for creating an integrated system, organ-

ised by qualifications and aimed at students and workers, both employed and unemployed, so that they can plan training paths according to their expectations and needs (European Commission, 2020). In the case of Spain, this also makes it possible to break the model that divides vocational training into two sub-systems, and instead create a single, more accessible system. This new integrated system of skills standards, divided into five levels, allows for the integration of learning and its recognition, regardless of the context in which it was acquired.

CEDEFOP has also played a crucial role in addressing the skills gap in green and digital transitions. It has highlighted the key role of vocational education and training (VET) in the European Union's post-pandemic recovery. By collecting and analysing information on skills, CEDEFOP (2021) has provided strategic guidance for investment in skills at national level. Its approach includes identifying labour demand, assessing current and future needs, addressing gaps, adapting education and training policies and providing tailor-made guidance. On the other hand, and in the context of the green transition, an increase in employment in sectors that embrace this transformation is expected, highlighting the importance of skills at different levels. The creation of the Green Skills Observatory offers new perspectives to combine information from different sources to understand skills needs in a green context (CEDEFOP, 2022).

In this new context, micro-credentials, seen as flexible tools for skills upgrading and vocational re-skilling, are high on the EU agenda. However, the lack of common standards and the diversity of formats have led to uncertainty and trust issues around micro-credentials, despite their undeniable potential to make learning visible and valued.

In conclusion, the adaptation of society to Industry 5.0 implies the integration of international standards and advances in Education 4.0, with a global approach that seeks not only to meet the current demands of the labour market, but also to anticipate and prepare for the challenges of the future, in which education, and more specifically vocational education and training, has a strategic role to play.

3.3. Agenda 2030: Challenges for the Spanish vocational education and training system

The lifelong learning or lifelong education strategy is positioned as a key pillar for achieving the Sustainable Development Goals (SDGs) set out in the 2030 Agenda for Sustainable Development (United Nations, 2015). Looking specifically at SDG 4, which aims to ensure inclusive, equitable and quality education and lifelong learning opportunities for all, the focus on lifelong learning reflects a commitment to high quality primary and secondary education, equitable access to higher education, the development of essential skills for employment, and the promotion of literacy and basic skills (UNESCO, 2016).

At the same time, SDG 8 aims to promote sustainable, inclusive and productive economic growth, as well as full employment and decent work for all, with the lifelong learning strategy as a key support. Diversification, innovation and the strengthening of small and medium-sized enterprises are supported by the continuous upgrading of skills and the promotion of entrepreneurship that characterise lifelong learning. It also helps to address specific challenges such as reducing the number of unemployed and unskilled young people, protecting workers' rights, and creating safe working environments. However, the reality shows that, although there is progress, it is moderate, as shown by Eurostat (2023), despite the efforts of the various countries to make progress in meeting the SDGs.

In the Spanish context, it is necessary to highlight the current Organic Law 3/2022 of 31 March on the Organisation and Integration of Vocational Training, as this was created to attempt to respond to all these new challenges. The vocational training strategy addressed by the law aims to reduce the gap between labour supply and demand, to respond to the human capital needs of companies and to match professional skills with the training on offer. It aims to minimise labour shortages by giving vocational training a status comparable to that of university education, both undergraduate and post-graduate, thus facilitating access to employment and labour mobility.

The strategy also promotes public-private cooperation, identifies the training needs of the productive fabric and involves enterprises in the training of workers. It recognises professional skills acquired through experience, work practice or non-formal learning, thus promoting labour market integration and lifelong learning. It also seeks to develop vocational training processes within the framework of quality management systems in order to guarantee excellence and innovation in this field.

Organic Law 3/2022 aims to improve the quality and employability of students at levels C and D, which correspond to levels 3 and 4 of the European Qualifications Framework. It stipulates that all training courses relating to the National Catalogue of Standards for Vocational Skills will have a dual component, with part of the training being carried out in a company or equivalent institution.

In summary, the objective of Organic Law 3/2022 is to create and organise a single, integrated vocational training system that responds flexibly to the demand for lifelong vocational qualifications and to productive and sectoral needs. The vocational orientation of the system aims at personal and professional development, improvement in the relationship with the labour market, and the proactive provision of information regarding the accreditation of professional skills and lifelong qualification, within the framework of the commitments made in Agenda 2030.

3.4. Lifelong learning as a key strategy to face the new challenges

Within the current situation, the concept of continuous or lifelong learning can be seen as a response to the dynamic challenges of our work environment (European Commission, 2020). This paradigm finds its roots in the key meeting held in Rome in 1994 by The European Initiative on Lifelong Learning.

The need to standardise the vocabulary and the different practical approaches prompted the creation of the definition that was adopted at that meeting, understanding lifelong learning as the development of the human potential of individuals, requiring a constant support process that stimulates and trains individuals to acquire the knowledge, values, skills and understanding they will need, and to be able to apply them in the different contexts that are necessary. This definition clearly positions lifelong learning as a strategy aimed at initiating and maintaining individuals' skillsets, allowing them to maintain their role in work and to safeguard their employability.

This initiative resulted in a working document (European Commission, 2000). It highlights that lifelong learning encompasses learning at all ages and modalities, recognising its importance for personal and professional development, and for social cohesion and economic competitiveness, and opening up a European-wide debate to implement a global strategy aimed at applying lifelong learning at individual and institutional levels, as well as in all areas of public and private life.

Similarly, organisations such as UNESCO (2019, 2020), the European Commission (2020), or CEDEFOP (2021, 2022) affirm that creating a global culture of lifelong learning will be key to addressing the challenges facing humanity, from the climate crisis to technological and demographic change, thus advocating for its consideration as a new human right.

Today, this type of learning has become imperative for all individuals, regardless of gender, age or social position, becoming a key factor for job retention and the sustainability of human resources in companies (European Commission, 2022). It is thus a crucial tool for addressing the challenges posed by the fifth industrial revolution, globalisation, demographic changes, and the impact of information technologies. The Global Commission on the Future of Work and the International Labour Organization (ILO, 2020) highlight the importance of a collective global response to harness the benefits and address the risks.

It is also necessary to remember that lifelong learning goes beyond economic considerations, promoting goals of openness, tolerance and democracy. Investment in lifelong learning is essential for eliminating barriers to entering the labour market, for reducing inequality and for preventing social exclusion (ILO, 2020). In the European framework, the European Employment Strategy and the strategic objectives formulated by the Council and the Commission highlight the importance of education and training to improve the qualification level of citizens (European Commission, 2020). In a world characterised by the knowledge society, the free movement of workers and labour mobility, lifelong learning is a basic component of the European social model.

In conclusion, lifelong learning is an essential strategy to face contemporary challenges, with continuous education the key to social progress, employment sustainability and individual and collective development (European Parliament, 2023), especially considering, as the ILO (2023) warns, the issues arising from the COVID-19 crisis, the conflict in Ukraine, the acceleration of climate change, and various unprecedented humanitarian crises. However, the effective implementation of lifelong learning depends not only on governments and international organisations but also on the active participation of companies and citizens, recognising their fundamental role in building a more equitable and dynamic society.

4. Conclusions and discussion

Against a horizon of 2030, the pressing need to adapt and transform professional profiles represents a strategic response to the emerging challenges of the fifth industrial revolution, or Industry 5.0. In the field of vocational training, lifelong learning has been explored as an essential tool to safeguard employability in an environment characterised by profound structural changes and their resulting challenges, in order to contribute to appropriate employment, equality and inclusion for all individuals.

Ever since the first industrial revolution, the guiding principles that have shaped the relationship between work and education have been analysed, evidencing methodological and conceptual changes in training over time. Currently, the fifth industrial revolution, or Industry 5.0, represents an unprecedented change, redefining production and productive systems through computerisation, digitisation, the development of artificial intelligence, and collaborative work between humans and machines, advanced technologies and robots. This will bring about significant changes in the way we understand learning and work, affecting not only production but also social interactions.

The impact of AI on employment is undeniable, with estimates suggesting that up to 30% of work activities could be automated by 2030. This phenomenon will affect workers at various levels, driving the need to develop new sets of skills to adapt to the new occupations enabled by AI. Driven by the connectivity provided by the Internet, AI has emerged as the main springboard for this revolution, marking a new paradigm in education and employment (OECD, 2021), and a fundamental component in both learning and work, with applications ranging from educational management to automated assessment. AI is increasingly a key element in addressing new challenges, essential for job retention and the sustainability of human resources based on a combination of formal, non-formal and informal education, and providing a comprehensive framework for understanding the various processes of acquiring educational skills throughout life.

In this context, international and European recommendations and proposals can be seen as indispensable guidelines for society's adaptation to Industry

5.0. International standardisation, Education 5.0 and the crucial role of CEDEFOP in managing skills in ecological and digital transitions are key aspects in the context of the 2030 agenda.

Lifelong learning can therefore be seen as an essential strategy to equip current generations with essential socio-labour skills; and as a fundamental pillar for achieving sustainable development goals, especially SDGs 4 and 8. In the Spanish context, Organic Law 3/2022 in Spain seeks to align vocational training with the demands of the labour market, promoting public-private collaboration and recognising professional skills acquired through experience. This necessarily requires a combination of international standards, innovative approaches in education, skill management strategies, and a firm commitment to lifelong learning. Such a comprehensive approach not only addresses current demands of the labour market but also anticipates and prepares society for future challenges.

In conclusion, among the most important findings of this work is an understanding of the importance of lifelong education as a key strategy in responding to the new skills required for this new industrial revolution, not only from an economic perspective but also as a means for sustainable development, and to promote openness, tolerance, democracy and inclusion in society.

At the same time, despite the significance of these findings, it is necessary to acknowledge the limitations of this research, which has confined itself to conducting an exploratory and descriptive study. Expanding and strengthening this research through the incorporation, analysis and evaluation of specific studies on the adaptation of the educational field and its capacity to respond to these new socio-labour demands should therefore be seen as essential. Similarly, consideration should be given to what form the roadmap for adapting training processes to these emerging needs should take.

Bibliographical references

AlMalki, H.A. & Durugbo, C.M. (2023). Evaluating critical institutional factors of Industry 4.0 for education reform. *Technological Forecasting and Social Change*, 188. <https://doi.org/10.1016/j.techfore.2023.122327>

Arevalo, M.A., Luna, H.E., Ching, J.X. & Zambrano, A.M. (2023). Educación 5.0: más que un cambio de tecnología, un paso adelante en la educación. *Revista Conrado*, *19*(94), 384-392. <https://conrado.ucf.edu.cu/index.php/conrado/article/view/3364>

Bonfield, S., Davies, M. & Smith, P. (2020). *Education 4.0: A skills framework for the 4th Industrial Revolution*. Pearson.

Clark, S., Gallagher, E., Boyle, N., Barrett, M., Hughes, C., O'Malley, N., Ebuenyi, I., Marshall, K. & O'Sullivan, K. (2023). The International Education Index: A global approach to education policy analysis, performance and sustainable development. *British Educational Research Journal Open Access*, *49*(2), 266-287.

CEDEFOP (2020). *Empowering adults through upskilling and reskilling pathways. Volume 2*. Publications Office of the European Union. <https://doi.org/10.2801/61322>

— (2021). *Osnabrück declaration on vocational education and training as an enabler of recovery and just transitions to digital and green economies.* <https://www.cedefop.europa.eu/files/osnabrueck_declaration_eu2020.pdf>
— (2022). *Observatorio de Capacidades Verdes*. Publications Office of the European Union.
European Commission (2000). *A Memorandum on Lifelong Learning.* <https://www.uil.unesco.org/sites/default/files/medias/fichiers/2023/05/european-communities-a-memorandum-on-lifelong-learning.pdf>
— (2020). *European Skills Agenda for Sustainable Competitiveness, Social Inclusion and Resilience.* <https://ec.europa.eu/social/BlobServlet?docId=22832&langId=en>
— (2022). *Questions and Answers on the new Human Resources Strategy and Greening the Commission.* <https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_2167>
— (2023). *Artificial intelligence in education.* Publications Office of the European Union.
European Parliament (2023). *REPORT on fostering and adapting vocational training as a tool for employees' success and a building block for the EU economy in the new industry 4.0.* <https://www.europarl.europa.eu/doceo/document/A-9-2023-0232_EN.html>
Eurostat (2023). *Sustainable development in the European Union Monitoring report on progress towards the SDGs in an EU context 2023 edition. Publications Office of the European Union*. <https://ec.europa.eu/eurostat/en/web/products-flagship-publications/w/ks-04-23-184>
Ezzaim, A., Kharroubi, F., Dahbi, A., Aqqal, A. & Haidine, A. (2022). Artificial intelligence in education - State of the art. *International Journal of Computer Engineering and Data Science (IJCEDS)*, *2*(2). <https://www.ijceds.com/ijceds/article/view/37>
Frey, C.B. & Osborne, M.A. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change*, 114, 254-280. <https://doi.org/10.1016/j.techfore.2016.08.019>
Garcia-Brustenga, G., Fuertes-Alpiste, M. & Molas Castells, N. (2018). *Briefing paper: los chatbots en educación*. UOC. <https://doi.org/10.7238/elc.chatbots.2018>
Gmyrek, P., Berg, J. & Bescond, D. (2023). *Generative AI and jobs: A global analysis of potential effects on job quantity and quality*. International Labour Organization. <https://doi.org/10.54394/FHEM8239>
Gonulal, T. (2019). The Use of Instagram as a Mobile-Assisted Language Learning Tool. *Contemporary Educational Technology*, *10*(3), 309-323. <https://doi.org/10.30935/cet.590108>
González-Pérez, L.I. & Ramírez-Montoya, M.S. (2022). Components of Education 4.0 in 21st Century Skills Frameworks: Systematic Review. *Sustainability*, 14, 1493. <https://doi.org/10.3390/su14031493>
Hallinger, P. & Wang, R. (2020). The evolution of simulation-based learning across the disciplines, 1965–2018: A science map of the literature. *Simulation & Gaming*, *51*(1), 9-32.
Himmetoglu, B., Aydug, D. & Bayrak, C. (2020). Education 4.0: Defining the teacher, the student, and the school manager aspects of the revolution. *Turkish Online Journal of Distance Education*, *21*(Special Issue-IODL), 12-28. <https://doi.org/10.17718/tojde.770896>

Hobsbawm, E. (2016). *La era del capital*. Crítica.

ILO (2020). *El futuro del trabajo en el mundo de la industria 4.0.* <https://webapps.ilo.org/wcmsp5/groups/public/---americas/---ro-lima/---ilo-buenos_aires/documents/publication/wcms_749337.pdf>

— (2023). *World Employment and Social Outlook Trends 2023*. <https://doi.org/10.54394/SNCP1637>

Kolade, O. & Owoseni, A. (2022). Employment 5.0: The work of the future and the future of work. *Technology in Society*, 71. <https://doi.org/10.1016/j.techsoc.2022.102086>

Ley Orgánica 3/2022, de 31 de marzo, de Ordenación e Integración de la Formación Profesional (BOE núm. 78, de 01/04/2022).

Mongeon, P. & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*, 106, 213-228. <https://doi.org/10.1007/s11192-015-1765-5>

Moraes, E.B., Kipper, L.M., Hackenhaar, A.C., Austria, L., Leivas, P., Moraes, J.A.R. & Witczak, M. (2023). Integration of Industry 4.0 technologies with Education 4.0: advantages for improvements in learning. *Interactive Technology and Smart Education*, *20*(2), 271-287. <https://doi.org/10.1108/ITSE-11-2021-0201>

Nabil, R. (2022). *Strategies to Improve the National Artificial Intelligence Research and Development Strategic Plan*. <https://www.cei.org/wp-content/uploads/2022/09/Ryan_Nabil_-_National_Artificial_Intelligence_Strategic_Plan.pdf>

New York Academy of Sciences & Global STEM Alliance (2020). *STEM Education Framework.* New York Academy of Sciences. <https://www.nyas.org/media/13051/gsa_stem_education_framework_dec2016.pdf>

OECD (2021). *OECD Skills Outlook 2021: Learning for Life*. OECD. <https://doi.org/10.1787/0ae365b4-en>

Pérez-Domínguez, L.A. (2024). Las principales tecnologías de la era de la industria 5.0. *Revista Ingenio*, *21*(1), 44-55. <https://revistas.ufps.edu.co/index.php/ingenio/article/view/4352>

Rane, N., Choudhary, S. & Rane, J. (November 2, 2023). Education 4.0 and 5.0: Integrating Artificial Intelligence (AI) for Personalized and Adaptive Learning. *SSRN*. <http://dx.doi.org/10.2139/ssrn.4638365>

Saidakhrarovich, G.S. & Sokhibjonovich, B.S. (2022). Strategies and future prospects of development of artificial intelligence: world experience. *WBML*, 9. <https://www.scholarexpress.net/index.php/wbml/article/view/841/754>

Schultheiss, T. & Backes-Gellner, U. (2023). Different degrees of skill obsolescence across hard and soft skills and the role of lifelong learning for labor market outcomes. *Industrial Relations: A Journal of Economy and Society*, *62*, 257-287. <https://doi.org/10.1111/irel.12325>

Schwab, K. (2016). *The Global Competitiveness Report 2016–2017*. World Economic Forum. <http://www3.weforum.org/docs/GCR2016-2017/05FullReport/TheGlobalCompetitivenessReport2016-2017_FINAL.pdf>

— (2020). La Cuarta Revolución Industrial. *Futuro Hoy*, *1*(1), 6-10. <https://doi.org/10.5281/zenodo.4299164>

U.S. Department of Education (2023). *Artificial Intelligence and Future of Teaching and Learning: Insights and Recommendations, Office of Educational Technology*. <https://tech.ed.gov/files/2023/05/ai-future-of-teaching-and-learning-report.pdf>

UNESCO (2016). Education 2030: Incheon Declaration and Framework for Action for the implementation of Sustainable Development Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. <https://uis.unesco.org/sites/default/files/documents/education-2030-incheon-framework-for-action-implementation-of-sdg4-2016-en_2.pdf>

— (2019). *BEIJING CONSENSUS on artificial intelligence and education*. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000368303>

— (2020). *Embracing a culture of lifelong learning: contribution to the Futures of Education initiative; report; a transdisciplinary expert consultation*. UNESCO Institute for Lifelong Learning. <https://unesdoc.unesco.org/ark:/48223/pf0000374112>

— (2023). *Guidance for generative AI in education and research*. UNESCO. <https://unesdoc.unesco.org/ark:/48223/pf0000386693>

United Nations (2015). *Resolution adopted by the General Assembly on 25 September 2015. Transforming our world: the 2030 Agenda for Sustainable Development*. A/RES/70/1. <https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf>

— (2023). *Times of crisis, times of change science for accelerating transformations to sustainable development.* <https://sdgs.un.org/sites/default/files/2023-09/FINAL%20GSDR%202023-Digital%20-110923_1.pdf>

World Economic Forum (2023a). *Cybersecurity Futures 2030 New Foundations*. <https://www3.weforum.org/docs/WEF_Cybersecurity_Futures_2030_New_Foundations_2023.pdf>

— (2023b). *Future of Jobs. Report 2023*. <https://www3.weforum.org/docs/WEF_Future_of_Jobs_2023.pdf>