Transforming Education in the Digital Age: Exploring the Dimensions of Education 4.0

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***Abstract*—The education sector, a cornerstone for social and economic development, has seen minimal transformation despite technological advancements. The shift towards digital evolution in adult education and lifelong learning is imperative for societal progress. Utilizing digital tools enhances learning experiences and employment prospects, crucial for attracting skilled workers in a flexible work environment. Modern digital technologies contribute to global competitiveness, fostering social cohesion and improving the quality of teaching. The 21st-century education revolution emphasizes internet-based pedagogy, bridging formal and experiential learning through technology. Lifelong learning, essential for skills enhancement, gains significance with emerging technologies, thus reducing barriers to access while promoting inclusiveness. Digital platforms, e-learning, and innovative methods revolutionize adult education beyond dispute, transcending traditional classrooms into engaging learning environments. The global "right to quality and inclusive education" is therefore facilitated by digital technology, offering flexibility, accessibility, and adaptability. Expanding beyond conventional classrooms nurtures inclusive and effective adult education, thereby propelling overall progress. The education landscape evolves, emphasizing on remote learning, interdisciplinary collaboration, and the acquisition of digital skills to meet the demands of a dynamic future job market.**

***Index Terms*—Education Transformation, Lifelong Learning, Digital Education, Global Competitiveness, Remote Work Skills**

I. Introduction

Education is a critical sector for society and the economy; however, its fundamental methods have remained unchanged for years, revolving around transmitting sterile knowledge through traditional classrooms and textbooks, with limited adaptation to numerous technological innovations. Embracing digital transformation in adult education and lifelong learning presents a societal challenge today, utilizing digital means to provide more substantial education. Employing appropriate digital and visual tools in lifelong learning and continuous employee training enhances their employment prospects and professional development. For businesses, the ability to work from anywhere, at any time, becomes a crucial factor in attracting skilled workers [62].

Furthermore, the application of modern digital technologies in education contributes to social cohesion and strengthens the competitiveness of businesses and economies on both European and global scales. From the early 19th century to the present day, driven by the Fourth Industrial Revolution, the education system has experienced significant transformations. The quality of teaching and learning has recently improved considerably with the support of integrated technology systems [19].

In the 21st century, society witnessed a profound transformation in education, shifting from traditional pedagogy based on physical classrooms to emerging internet-based pedagogy. Technology has permeated every aspect of knowledge acquisition and made it accessible globally, bridging the gap between formal and experiential education. The advent of Industry 4.0 has led to the rise of innovative technologies and reduced physical labor [52]. Individuals must acquire digital and virtual education to succeed in the future job market. In the changing landscape of education at schools, universities, or workplaces, digital skills have become increasingly vital.

As a result an educational revolution has occurred, encompassing universal education, globalization, knowledge societies, and information technology. These structural changes are particularly evident in lifelong learning and adult education. Lifelong learning is a well-established field where adults engage in systematic, ongoing learning activities to enhance their knowledge, skills, attitudes, values, and employability [32]. Today, lifelong learning has gained more significance with the emergence of new technologies that change how information is accessed, collected, collaborated upon, and communicated. Digital technology can overcome the disparity between traditional and experiential education.

By reducing barriers to access, such as distance, cost, and availability, digital learning becomes a key lever for the global "right to quality and inclusive education, training, and lifelong learning," as defined by the European Pillar of Social Rights. Digital technology strongly influences all aspects of learning, providing access to the realm of knowledge from any location and, at any moment, suiting the needs of learners.

In this context, online platforms, e-learning programs, and emerging digital methods (for instance, virtual and augmented reality and gamification) continuously gain traction in adult education, gradually replacing traditional classrooms. The modern education system, simultaneously taking advantage of a broad spectrum of learners worldwide, has eliminated the spatial constraint of physical classrooms, encouraging participation from remote locations. Concurrently, global inter-

disciplinary and business teams are constantly seeking remote work options irrespective of location and working hours, along with a need to acquire new skills [26].

II. Digital Transformation of Learning - Education 4.0

Education is a critical sector for society and the economy. Yet, its essential methods have remained unchanged for years, mainly revolving around transmitting dormant or with no utility knowledge through classrooms and textbooks and little in tune with numerous technological innovations [35]. Implementing digital transformation in adult education and lifelong learning is currently a societal challenge to use digital media to make adequate provision of education [11]. When appropriate digital and supervisory tools are used in the lifelong learning process of employees, their employment prospects and ability to develop professionally are enhanced. In the case of companies, the ability to work from anywhere and at any time also becomes an essential factor in attracting skilled workers [25]. Moreover, the application of modern digital technologies in adult education improves social cohesion and enhances the competitiveness of companies and economies on a European and global scale.

In Germany, better skills highly impact earnings and employment probability more than in most European countries, reflecting the need for more vital specialization and enhanced skills [48]. Therefore, possessing formal skills to a greater extent than the average population implies an increase in hourly wages of around 23%. Statistical methods of studying job performance suggest that increased skills have a causal relationship with high efficiency [46]. The impact of better ICT skills on relative earnings is of similar magnitude [31].

However, implementing and utilizing educational technology presents significant challenges, including concerns about excessive screen time, instructors' effectiveness in using technology, and issues regarding fairness in its application. These challenges have been further highlighted by the COVID-19 pandemic, emphasizing the growing importance of online educational content. Educators are now tasked with creating and evaluating online learning materials, encouraging students to analyze topics from diverse perspectives critically. While some students thrive in online learning environments, others face obstacles due to inadequate support, especially those who struggled in traditional face-to-face settings and relied on now-unavailable services. Furthermore, instructors may encounter difficulties adapting to online education, particularly in areas where it is not widely practiced [45].

III. Traditional Education Methods

Traditional learning, as practiced for decades, involves using conventional tools of blackboards, chalk, books, and pens. It is mainly done through reading texts, asking questions, watching lectures, discussions, and videos, oral or written examinations, and solving problems and hypotheses. Confined within the walls of the classrooms, students obtain face-to-face instruction from qualified teachers who are present and receive direct assistance in case of difficulty or doubts about the subjects taught. The advantages offered by traditional classroom learning are:

- Proper guidance: The presence of the teacher is considered beneficial as doubts that arise amid lectures have the potential to be resolved immediately. Face-to-face training also offers more interactions between trainees - and instructors, enhancing the trainees' learning potential.
- Socialisation: Participatory learning and socializing between trainees are vital as they offer social integration and solidarity between different groups while increasing knowledge sharing and teamwork. Learners feel they do not face educational challenges alone and may even build more self-confidence.
- Ability to work in groups: Traditional training allows for group work and interaction with other apprentices. As a result, learners can learn from each other and share their doubts and concerns. These social links help to find new ideas and stimulate creativity and synergy.
- Stable learning plan: Learners who lack self-discipline appreciate a study plan that offers stability and is easy to follow. Traditional education requires the learner to attend classes and study regularly [65].

However, traditional teaching methods also have several fundamental disadvantages, mainly related to the rigidity of an outdated and inflexible education system. Reformers advocate moving away from classical, teacher-centered teaching, in which students are passive recipients of knowledge, and moving towards more student-centered teaching, based on meaningful understanding, which focuses on exploration and experimentation, reinforcing the skills gained through Information and Communication Technologies and new digital systems [77]. Traditional classroom learning, therefore, has amongst others the following disadvantages:

- Schedule rigidity: There needs to be more flexibility in creating a personal schedule, combining learning with personal or professional life, sometimes adapted to the learner's commitments.
- Travel requires financial costs: Moreover, if the place where the face-to-face courses are held is at a distance, time is another factor to be considered. In-class training programs require a time commitment and regular physical presence, making students consider both time and transportation costs.
- Loss of personalization: In a large group of students, it is difficult for a teacher to follow an individualized study plan that fits each person's needs. The heterogeneity of the class and the different levels of perception thus make the teaching task more difficult.
- Limited and more expensive teaching materials: Traditional education is more limited, as it usually includes a single textbook. Other supervisory media, such as photos, videos, educational forums, and practice workshops, are inaccessible around the clock. This lack can limit learning and hinder a good study plan.

- Lack of engagement: Traditional learning becomes monotonous and boring based solely on repetition, rote learning, and memorization of concepts and facts, which learners are less interested in and tend to forget after exams.
- Need more feedback: The traditional classroom does not encourage critical thinking skills or the ability to apply information acquired through experience and reasoning actively. Instead, it emphasizes the role of teachers as knowledge distributors and students as repositories. This style of education does not create more profound levels of understanding and feedback in students, which are needed for more complex concepts and lifelong learning.

Traditional methods should, therefore, evolve by adopting modern digital technologies. The integration of emerging technologies in adult education and training is necessary, not only because of the entry of new people into the workplace but also because of the need for continuous, ongoing training of older people in modern technologies. New technologies and digital media are the tools for creating the necessary learning environment where training can be carried out most effectively.

IV. Positioning the New Educational Identity within the Landscape of Lifelong Learning

From the early 19th century to the present day, due to the fourth industrial revolution, the education system has experienced a significant revolution [18], while in the 20th century, the quality of teaching and learning was thoroughly criticised. However, nowadays, teaching standards have improved significantly with the support of new integrated technology systems [59]. The 21st century is witnessing a substantial transformation of education from the traditional 'classroom' pedagogy to the emerging 'web-based' pedagogy. In the last decades, ICT has penetrated every sector of the industry [23], [78]. In this case, integrating technology in education certainly accelerates the progress of Industry 4.0.

Ingenuity and reduced physical labor are the cornerstones of Industry 4.0 [75]. People must have the proper digital and virtual training to succeed in the future workplace. At school, university, or at work - the ever-changing digital landscape makes IT skills increasingly essential and effective [84]. As a result, an educational revolution has occurred with universal education, globalization, the knowledge society, and IT [6], [51]. These structural changes are particularly evident in lifelong learning and adult education. Adult education is a highly developed branch of education where adults go through a systematic, ongoing learning activity to improve "their knowledge, attitudes, values, and skills" [21].

Today, lifelong learning has become more critical with new technologies changing how information is received and collected, how people work together, and how they communicate. Technology has the potential to bridge the gap between formal and experiential education [85]. As adult education remains well below the EU's defined target, digital learning, and any EU action to promote its development, can help to overcome the economic, organizational, and methodological barriers that prevent equal opportunities for Lifelong Learning (LLP), particularly in higher education while continuing Vocational Education and Training (VET), from unfolding.

Moreover, at all ages, digital learning is the critical method for acquiring digital skills, which 43% of Europeans still lack today but which will be necessary for 90% of future jobs. By reducing barriers to access to equal learning opportunities, such as distance, cost, and absence of supply, digital learning potentially becomes the key driver for the global 'right to quality and inclusive education, training and lifelong learning' as defined by the European Pillar of Social Rights [10].

Digital technology has a strong influence on all aspects of learning, making the world of knowledge accessible at any place and at any time to suit the requirements of educatees [71]. Thus, through the internet and digital technology, online platforms, e-learning programs, and other emerging digital methods (e.g., augmented books, virtual and augmented reality, gamification, etc.) are increasingly gaining ground in adult education and swiftly replacing traditional classrooms. Benefiting from a wide range of learners worldwide simultaneously, the modern education system has alleviated the space constraints of the physical classroom, encouraging participation from any remote location. At the same time, global interdisciplinary and entrepreneurial teams increasingly demand more and more remote work, regardless of time and place, as well as new skills [80].

These new digital skills are now labelled as "desirable skills" by employers, leading to a growing need for continuing education. This affects not only the organization (employees) but also the teaching staff themselves. Therefore, digital media are increasingly important "to promote learning" [49]. Typically, this kind of technology-based teaching and learning experience provides expanded self-learning opportunities at the individual learner's pace, as well as better quality of these more accessible and expanded opportunities. The terms "digital learning" [2], [37] and "ICT learning" [3], [44], [64], [79] have occupied an essential place in lifelong learning and adult education.

Digital technologies are expanding learning opportunities, allowing people, especially in adulthood, to learn on demand, based on what they need most and want, personalizing their learning process, which is more motivating and, therefore, likely to be more effective. Another advantage concerns the better monitoring of each learner's performance through the data collected from the digital platforms used and the educational process; this can lead to personalised modules and learning programmes to respond to the individual characteristics of the learners, thus making the learning process more adaptable and highly effective for each individual [10]. Consequently, acquiring new digital ICT methods is particularly effective in accelerating learning.

V. Developing Digital Skills

Although it has been argued that digital technologies are likely to have the same impact on the learning process as the invention of the printing press in Gutenberg's time, additional

social and economic factors make this new transformation far more important [91]. As mentioned in previous chapters, digital skills are associated with various benefits that impact the human factor and the broader economy. Such benefits include improved employment prospects, economic prowess, access to support services, health and well-being perks, along with the ability to participate in social engagement and career development. So, digital skills are necessary for individuals lest they find themselves in dire social, occupational, and economic conditions.

The increasing use of environments mediated by this technology provides flexible, ubiquitous, and on-demand access to educational material. For example, employees have the opportunity to develop knowledge and skills through modern Learning Management Systems (LMS) [27], [88], webinars [29], [39] or even through digital videos (simulators) based on different usage scenarios [27], [56]. The new digital skills education identity still includes additional elements such as Remote Proctoring, Chatbots, Video Conferencing, Adaptive Learning, Inquiry-Based Learning, Smart Classrooms, and the extensive use of augmented and virtual reality.

Digital education encompasses a broader, more cost-effective, and enhanced learning experience. The integration of technology in adult education is also changing the culture of the classroom as well as the responsibilities of educators. Some teachers and learners find the exchange of roles between them exciting, while others find it unsettling and confusing. Learners have access to a greater variety and depth of information. They are independent of the teacher, who no longer needs to specify exactly what all the activities within the classroom are but may well become a remote supervisor/monitor or even facilitator that questions, encourages, helps, and stimulates interest. Students thus take more control and responsibility for their learning; they become autonomous learners. However, so far, only a few programs in a few countries are actively implementing this adult education model [41]. Despite the advantages of technology learning environments, Human Resources trainers would gain more insight if they understood how learners derive value when engaging in digital learning, what they experience, and how they perceive online learning.

In addition, more knowledge is needed about the skills that educational staff need to possess in order to navigate, orchestrate, and work skilfully in educational contexts dominated by digital technology [53], [69], [82]. Therefore, in addition to producing studies on learners' experiences and perceptions, researchers need to look deeper into the digital competencies, skills, and attitudes of educators towards digital media and infrastructure [13], [40], [81].

A further element concerns the versatility of adults to the embracement of ICT and their fluid adaptation to new digital systems. As younger generations, who are actually born in technology and are digital natives, are more familiar with such innovations, constant training and ongoing adult education, who are the digital immigrants now, is required for their smooth transition and success in ever-shifting working settings. Thus, the ability to continuously upgrade and acquire new skills is indeed a challenge for adults, which is required in response to adjust priorities in the workplace, revising outdated work functions, and applying new technologies. As ICT is often at the heart of such changes, the technologically illiterate find their options and opportunities limited. Moreover, workers who can use today's technologies are the ones who are best equipped to learn tomorrow's technologies [41].

In a study conducted in Asia, Europe, and North America to investigate how learners and trainers live and work with digital technologies in adult education and human resource development [40], the following data were found:

1) In the first study, a mixed-methods approach was used to analyse the emotional reactions of learners who participated in webinars. Using quantitative and qualitative data from interviews, the authors find that learners were satisfied and reacted positively towards the direct, synchronous communication with facilitators and peer learners in their webinars. In addition, the findings suggest that learners preferred webinars with less than 90 minutes on weekdays after work rather than on weekends and webinars that allowed for virtual consultation with their facilitator. Overall, the study demonstrates the effectiveness of webinar-based training [40].
2) In the second study, the authors used a quantitative research approach, and their results suggest that the most commonly used method to support learning includes LMS, cloud file sharing, and online search engines. Although the research was set in higher education contexts, the results are equally valuable and need to be applied to vocational training and general human resource development because, firstly, they indicate the importance of human interaction in learning environments and, secondly, they demonstrate that digital technologies should work in a complementary way, complementing rather than replacing traditional face-to-face training methods with blended learning scenarios [27].
3) In the third study, the results of two experiments examining the impact of learning prompts on older adults aged 55 to 70 years. An experimental approach revealed that older learners exhibit poorer performance in online learning when prompts are provided compared to when they are not. This outcome remained consistent regardless of the prompt; whether them being processing (establishing connections between new educational content and prior knowledge or experiences) or metacognitive prompts (self-assessment of learning progress). The differences between younger and older adult educators regarding attitudes and skills were insignificant. Overall, the study is highly informative in looking at different aspects such as age, educational background, employment, and participation in digital media-related training programs [56].
4) The fourth study examines adult educators' attitudes and competencies. Using quantitative online survey data, their analyses show that teachers with higher educational

and technological levels were more positively inclined toward digital media. In addition, teachers who worked in adult education centers were less critical of them. The differences between younger and older adult educators regarding attitudes and skills were insignificant. Overall, the study is highly informative in looking at different aspects such as age, educational background, employment, and participation in digital media-related training programs [81].

5) In the fifth study, relationships between teaching competence instruments, teaching self-efficacy instruments, attitudes towards the use of digital media, and actual use of digital media in education were investigated. Using quantitative data from an online survey of adult educators, findings showed that self-reported digital media teaching competence was unrelated to self-efficacy and digital media use in education. Moreover, self-efficacy was positively associated with digital media use in education. Adult educators, who participated in a digital media course, reported higher teaching ability and self-efficacy, more frequent use of media, and less negative attitudes towards digital technologies compared to adult educators who did not participate in this course [13].

These five studies reflect a range of issues regarding the development of digital skills of instructors and learners, for example, the level of instructor competence [13], [81] and how these issues are perceived and affect learners emotionally [27], [40].

Simultaneously, when examining the development of digital skills, educational models like blended learning (BL) and hybrid learning (HL) have attracted considerable interest due to their inventive methods of combining traditional in-person teaching with online learning elements. BL combines traditional face-to-face methods with online components, offering flexibility and adaptability to diverse topics and contexts [38], [43]. It incorporates technology to promote active learning, critical thinking, and collaboration. Some proponents recommend that the suggested online activity time be at least 30% of class time [83]. However, this may vary depending on the institutional context and does not necessarily have a straightforward correlation with student learning outcomes. Effective BL implementation requires careful planning and consideration of accessibility and digital literacy. A study of blended learning found that while high-achieving students thrived, academically challenged peers struggled with the online component and achieved lower grades [70].

On the other hand, HL stands apart from conventional instructional methods by deliberately integrating technology to substitute traditional class time, aiming to foster an environment conducive to student learning. Within the HL framework, a segment of in-person class sessions is supplanted by technology-mediated instruction or activities conducted outside the classroom, such as viewing lecture videos or engaging in collaborative online assignments [83]. The specific proportion of time allocated to traditional versus technology-enhanced instruction varies based on the course workload and institutional regulations, typically between 20% and 79% of conventional class time [5]. This substitution not only addresses limitations in physical classroom space but also enables increased flexibility in lesson planning to cater to the diverse needs and preferences of students and faculty. Studies of hybrid learning show its efficacy in introductory courses, lab settings, and various post-secondary levels, including community colleges [50].

VI. Inquiry-based Learning

The concept of "knowing" has shifted from the ability to memorise and repeat information to the ability to find and properly utilise it. Discovery-inquiry learning is primarily a pedagogical method based on exploring questions, scenarios, or problems [58]. Therefore, inquiry-based learning engages learners by connecting with reality through exploration, questioning, and observation. It is an approach that encourages students to engage in complex problem-solving and experiential learning. Instructors actively encourage learners to share their thoughts, design and conduct experiments, formulate hypotheses, question, discover, and redefine new ideas and perceptions. Inquiry and discovery-based learning refers to a transformation of the traditional classroom. Students are encouraged to participate in group projects to learn from their peers while participating in various forms of guided learning provided by an instructor. Inquiry-based learning enhances understanding; rather than memorising facts and taking notes, students are encouraged to discuss ideas with each other. This practically means that students adopt a scientific approach, making their discoveries and generating knowledge through the activation and restructuring of new knowledge schemas [66]. Through inquiry and scientific data collection, research activities provide a valuable context for learners to acquire, clarify, and apply an understanding of science concepts [30]. With this learning model, both learners and their instructors share joint responsibility for learning outcomes.

The inquiry-based learning model was initially proposed by scholars and researchers at the University of Illinois at Urbana-Champaign [60]. The key features of inquiry-based instruction include:

1) the project's focus on authentic problems and issues related to students and the real world,
2) defining questions for students to study as well as guidelines for the educational process,
3) gaining knowledge of what is happening (and how is it happening?) through fieldwork, planning, construction, interviews, experiments, and other explorations that lead students to new ideas;
4) gaining a deep understanding of the topic under consideration after reflection [17].

The following are the main advantages of inquiry learning:

- It enhances the content of the curriculum
- Promotes deeper understanding of the content
- It makes learning rewarding
- Builds the concept of initiative and goal attainment

- Encourages the creation of a sense of ownership of the learning process and the learning process
- Can lengthen the retention period of new knowledge
- Increases problem-solving flexibility and creativity
- Increases students' motivation to learn [61]

With modern technological advances such as computer simulations, more effective inquiry-based learning can be implemented. Using simulations to model a phenomenon or process, students can conduct experiments by changing variables and then observe the effects of these changes. In this way, learners (re)discover the properties of the underlying model [22].

In contemporary education, many educators and researchers have enthusiastically used location-based AR in teaching and learning [14], [20], [28]. As information acquisition through this technology is more intuitive, it can motivate learners to observe actively, formulate multiple hypotheses through observations, carefully evaluate the validity of observed phenomena and the correctness of proposed hypotheses, and formulate a final hypothesis after refuting multiple proposed hypotheses. Location-based AR is considered a valuable tool for education because it can increase the frequency of inquiry-based learning, enabling students to deepen their scientific thinking while studying. Students' increased immersion and frequent interactions with other classmates during the lesson lead to high-level thinking, deep understanding of the topic, and enhanced absorption of the course material [20], [87]. In addition, students using location-based AR have demonstrated increased initiative and focus in analyzing, finding, sharing, and discussing what they have discovered. Location-based AR using mobile devices has the characteristics of mobility, location awareness, interoperability, seamlessness, situational awareness, social awareness, adaptability, and diffusion, thus forming a holistic learning environment where learners receive knowledge at any time and place. Therefore, many scholars believe location-based AR has great potential for application in inquiry-discovery education [17], [92].

VII. Personalised and Experiential Learning Experience

Experiential learning originates from the studies of many theorists and philosophers of the last century, such as John Dewey, Jean Piaget, and Kurt Lewin. Within this model, concrete experience and reflective observation play essential roles in learning. The Soviet psychologist Lev Vygotsky (1978), who developed the social learning theory, argues that learning through experience is the central process of human development. One of the most influential theoretical educators of the 20th century, Dewey (1958), provided guiding principles for experiential learning theories. Lewin (1951), although focusing on organizational learning, later found that "learning is best realized in an environment of dialectical tension and conflict between direct, concrete experience and analytic objectivity." Another influential theorist was Piaget (1950), whose work focused on child development and how experience shapes intelligence. According to Piaget (1950), intelligence is not an innate characteristic of humans but rather "the result of interaction between man and his environment." The American educator David Kolb was the first to define experiential learning theory [55].

[54], [55] established and further developed an Experiential Learning Model (ELM) based on six propositions:

1) Learning should be understood as a process, not in terms of discrete outcomes. Feedback on the effectiveness of an individual's learning efforts acts as a catalyst for improving the learning process.
2) All learning is re-learning. Extracting the beliefs and ideas that a learner already has about a subject allows for it to be tested. The more sophisticated ideas and knowledge must be integrated with existing theories.
3) Learning helps to resolve conflicts between dialectically opposed ways of understanding the world. The learning process is one in which the learner "will move back and forth between opposing modes of reflection, action, emotion and thought" [55].
4) Learning is a "holistic method of adapting to the world, since it defines the integrated functioning of the whole person" [54], which includes thinking, feeling, perception and behaviour.
5) Learning is the distillation of collaborative exchanges, between the learner and their environment, a process of assimilating new experiences into existing concepts and projecting existing concepts into new experiences.
6) Learning is a social process of forming individual knowledge, created and recreated, through personal knowledge and interactions between individuals [90].

The main characteristic that distinguishes experiential learning lies in its cyclical dynamics: in this process there is the mobilisation of critical basic skills that, through observation and reflection, are transformed into new concrete experiences [7]. Thus, according to the experiential learning experience, learning involves four mental processes through which the learner interacts with a learning environment. On one side is the process of conceiving, experiencing, and understanding events based on this experience. On the other side is converting experience into knowledge and understanding. Based on these mental processes, the experiential learning experience is defined as a four-stage cycle consisting of concrete experience, reflective observation, abstract conceptualization, and active experimentation [90].

From a psychological point of view, an additional element that contributes to the concept of personalized and experiential learning is emotion, which can be classified into positive and negative emotions. Studies have formed different views on the types and architecture of emotion [34], [86]. Similarly, many psychologists have promoted the importance of emotional impact on individual learning and mental and physical feedback [73]. Positive emotion is considered to contribute to learning, while negative emotion may suppress learning [72]. Therefore, where traditional teaching can become dull and monotonous, new technologies transform learning into a thrilling hands-on experience.

Today, there is a big trend towards online learning via mobile devices in adult education. Emerging VR/AR technologies offer an ideal environment for personalised and experiential learning, making the most of the use of mobile devices to create a new education model. AR fosters a transition to a more active and engaging study method, in which students are no longer passive observers but actively involved in learning, fully immersed in the study process [36].

Augmented reality undoubtedly promotes greater student creativity, facilitates communication, and lends itself to a much more consistent and meaningful study experience [12]. Thanks to new technologies, education now has the potential to take place anytime and anywhere (on demand), not necessarily and only in the context of traditional classroom settings [63]. So, learning becomes "ubiquitous" [74] while it removes barriers between classroom and everyday life. This has resulted in the more frequent use of the term "learning experience" over the term plain "learning" [68].

VR/AR technologies are exploited for high-value educational purposes, such as on-site field applications and 3D training simulations in industry, aviation, healthcare, and military facilities. Studies have repeatedly confirmed that learners are more easily motivated and retain their knowledge when actively engaged in a learning experience. Virtual and augmented reality can offer inexpensive, safe learning and skill acquisition from anywhere in the world by recreating realistic simulations that engage the mind and body. When people are immersed in this kind of simulated experience, it is highly engaging for them; their knowledge is retained and recalled more efficiently than simply reading a textbook or watching a video.

In addition, thanks to AR, it is possible to explore a variety of scenarios that otherwise could only be studied at a theoretical level. Abstract concepts can now be touched by hand and become considerably more accessible and exciting, offering unique experiential learning and skill acquisition experiences. Beyond this, however, if used in the right way, AR has the potential to evolve into an excellent educational implement, which not only allows to increase the cognitive activity of the individual but also acts as a relational tool to improve the user's communicative activity [7].

VIII. Educational Value, Benefits and Impact of Education 4.0

Through the continuous development, evolution, and application of technological innovations, which have been extensively analysed in the previous chapters, in the field of lifelong learning and training of adults in the workplace, it is easy to see that modern educational standards require introducing a new educational model. This new type of education, which is fully aligned with the need to acquire digital skills, finds strong parallels with Industry 4.0, as well as with the concepts of inclusiveness, equal opportunities for fair and quality education, vocational training, and development of employees, as stated in the Sustainable Development Goals (SDGs) in the 2020 report of the United Nations (UN) 2030 Agenda [89]. Hence, there is need to introduce a new term, in line with Industry 4.0, called Education 4.0, which emphasizes the need to focus on mentoring learners to face the challenges of the future head-on. Education 4.0 aims to improve digital technology skills at all levels and to enhance digital technologies in teaching and learning. Its approach works on three pillars:

1) Primary Digital Education at Student and Learner Level
2) Digitally Competent Teachers, Learners, and Employees
3) Introduction of Digital Supervisory Tools Combined with Face-to-Face Training to Optimize Outcomes[47].

The framework of Education 4.0 brings us one step closer to the developments by addressing the needs of society in an innovative and ever-changing era. This enhances the ability of learners and young workers to assimilate and apply new technologies, aiming to create a network of transnational public-private partnerships. What is more, it has a positive impact on healthy business competition and thus improves the global economy. The education sector is already overwhelmed by cognitive and cloud technologies, computers, the Internet of Things (IoT), cyber-physical systems (CPS), and various other parameters imposed by Industry 4.0. Therefore, a link already exists between Education 4.0 and Industry 4.0 [1]. Using digital technologies in the context of Education 4.0 promotes improving learning while exploring digital technologies and education holistically and in an integrated mode [67].

Creativity is an additional human characteristic necessary for Education 4.0, as it enhances the process of self-learning and self-improvement [15]. Supplementary to these, the new education model offers appropriate skills and strategies to meet the challenges of Industry 4.0, such as leadership, collaboration and teamwork, digital literacy, compelling and multidimensional communication and information, emotional intelligence, entrepreneurship, elements of global citizenship and intercultural understanding, problem-solving, critical thinking, creativity and innovation, self-learning and self-improvement mechanisms along with perceptual and evaluative skills [47], [57]. Therefore, Education 4.0 provides significantly more than mere education.

Education has gone through a multitude of changes until reaching its current stage. Although the start date of Education 4.0 is well defined in the literature - from Industry 4.0 (2011), there is a divergence in implementation times for the earlier stages, for the eras of education following the industrial revolutions. Thus, Education 1.0 begins in the late 18th and early 19th century, with the 1st Industrial Revolution. Then, the 2nd and 3rd Industrial Revolutions dictated the development of Education 2.0 and 3.0, respectively [4]. Education 1.0, 2.0, and 3.0 are considered a reflection of the evolution of the World Wide Web [16]. Ergo, Education 1.0 appeared around the 1980s, along with Web 1.0. Web 2.0, in the early 2000s, marks the beginning of Education 2.0, and Web 3.0, still under development, contributes to Education 3.0 [67].

Education 3.0 has allowed ICT to be integrated into educational processes, improving the format of education in recent years. Learning thus created a closer relationship with different sources of information as it was self-directed, and information-seeking was encouraged in a 100% digital way. This new

concept stimulated students' abilities by directing them to create new content from research, which significantly helped students and teachers change their mindset, with interaction becoming more dynamic, participatory, and creative [9]. So, this is how we arrive at the present and the adoption of the new education model of Education 4.0.

The interface between Education 4.0 and Industry 4.0 leads to the conclusion that Education 4.0 is a gateway to Industry 4.0 knowledge [67]. Integrating the educational elements of Industry 4.0 is the beginning of a new educational model constructed to make the various learning factors more flexible, including pedagogical practices and the technology that supports learning. The integration includes connectivity and storage infrastructures, institutional guidelines, organizational processes, and practices to promote innovation and training of teachers in digital competencies so as to acquire the skills of digital-native learners [42]. The teacher's co-responsibility in constructing this new model requires noticeable effort to adapt to such dynamic, didactics, training and professionalism but also continuous acquisition of knowledge via using advanced technological tools inside and outside the classroom [9].

These initiatives and projects should be aligned with the needs and requirements of educational institutions to respond to current social contexts, taking into account the guidelines of technological megatrends that lead to innovative solutions [42].

The significant benefits that will result from the digital transformation in the context of Education 4.0 for the training of employees will concern:

1) Development of digital culture: Promoting a corporate culture where everyone can embrace new approaches, mindsets, and procedures is crucial to ensuring the success of digital transformation. Creating a work environment oriented toward a thorough and effective digital conversion requires openness, communication, teamwork, and expansion across the entire business.
2) Continuous learning perspective: To be competitive in the digital age, organizations need to cultivate a culture of knowledge sharing, ongoing learning, and collaboration. CEOs believe their company models and skill sets are insufficient to adjust. By providing access to platforms, tools, and curricula that enable individuals to continuously enhance their abilities in step with evolving trends and technological breakthroughs, continuous learning can help employees stand out from competitors.
3) Attracting talented employees: Today's employees choose to work for organizations that provide more than simply a job. Many candidates have learning and development opportunities as their top priorities when choosing a company to work for besides their professional growth.
4) Technology is becoming mainstream: A continual stream of new platforms and technologies are being developed to foster an agile workforce. To promote creativity across the country, the Canadian government has invested almost $1 billion in technology to establish five "innovation superclusters." These clusters will assist established businesses in embracing rising digital trends while enabling imaginative new start-ups to progress. The Canadian government promotes new alliances between corporations combining resources, infrastructure, and economic reach with cutting-edge cultures, goods, services, and innovations instead of concentrating solely on individual businesses or picking those it thinks are especially worthy [24].
5) Cultivating and discovering new skills: Training can provide learning and development executives with creative methods to find latent skills to improve the business's overall competencies. Employees can develop their current abilities and discover hidden talents by cultivating a culture of continuous learning and offering the platforms, resources, and support necessary to make this vision a reality.
6) Fostering innovation: Ongoing education and internal training can help employees feel more empowered, resulting in departmental and team collaborations that might not have happened otherwise. A business can significantly boost its digital marketing efforts by utilizing the insightful information that customer service representatives can provide to a marketing department on messaging, personas, and content development. Despite its massive size and complex corporate structure, Nestle for example has implemented a strategy where all of its employees work for intervals of 8 to 12 months in a different department to strengthen what is known as Digital Acceleration Teams (DATs) [33].
7) Economic development: When it comes to economic growth, the level of education of a nation's workforce is a fundamental driver for adopting and implementing existing technologies, pushing technological frontiers, and, therefore, for overall economic growth. Studies in many countries demonstrate that various student achievement measures are associated with higher economic growth rates and higher physical capital investment. Thus, numerous changes in the economy and technology, such as the increased participation of all stakeholders in the global economy (through digital technologies), mean that individuals and organizations are compelled to meet new demands in order to endure in an ever-evolving market. Individuals are expected to participate in creating and developing new values in the organization where they work and in the society where they belong, as well as to have positive attitudes towards ethnic, cultural, and religious diversity [76].

However, Education 4.0, driven by the principles of Industry 4.0, presents numerous challenges as it adopts innovative technology, artificial intelligence, and robotics to reshape the teaching and learning environment. Universities are tasked with aligning their curricula with the evolving requirements of a world dominated by cyber-physical systems in various industries. This shift necessitates significant changes in traditional

teaching methods so as to embrace technology-enabled mobile learning. With its turn, this will enable students to engage in self-directed education anywhere and anytime. Nevertheless, the implementation of Education 4.0 presents significant challenges. Financial limitations, the need for qualified faculty, upgraded infrastructure, collaborations with industries, curriculum adjustments, and comprehensive training workshops are essential requirements for successful integration. These vital resources could help effective adoption, limiting the transformative impact of Education 4.0. The dynamic nature of Education 4.0 further complicates matters, as it requires continuous pedagogical evolution to meet the evolving educational landscape and the needs of future generations [8].

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