EDUCATION 4.0 AND SKILLS FOR TWIN TRANSITION – AN EXPLORATORY STUDY

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Abstract. *The concern for economic, social, and environmental challenges and sustainability education requires higher education systems to improve their alignment with the economic environment to ensure that graduates have the mix of skills needed to make the most of the digital society.*
Technological advancements are changing the way education systems can unlock the potential of technology for teaching and learning as a response to Industry 4.0, greatly incorporating the use of digital technologies, opening up higher education and knowledge to more students, improving access across different socio-economic groups, and provide high-quality learning material aligned with labor market needs.
The paper aims to ascertain the current views on the role of higher education in the context of digital transformation i.e. Education 4.0 and related implications on the current challenges with regard to the complex skills development of graduates.
The study emphasized the Romanian country in the pursuit of adjusting education to the future of work and deciphering several key performance indicators in coherence with the challenges faced by the higher education sector. Given the longstanding structural vulnerabilities, improving Romania's performance indicators is critical for sustainable growth potential and job creation. The pursuit of green and digital transition is expected to enable valuable interventions to develop digital skills at all levels to ensure that higher education graduates can participate in society and take advantage of the digital transition.
Finally, the study emphasizes specific interventions and actions needed to overcome major structural vulnerabilities of Romania's higher education system such as substantial interventions to facilitate digitalization, investments in digital equipment, training of teaching and academic staff, and other measures to improve teachers' and students' digital skills.

Keywords: *continuous improvement; digital and green skills; Education 4.0; sustainability education; quality education.*

Introduction

In the race for disruptive innovation and technological advancement, the transition toward more sustainable systems tackling climate and environmental-related challenges is paramount to protect, conserve and enhance the European Union's natural capital, and protect the health and well-being of citizens. In particular, this transition has to put people first, ensuring the supply of critical raw materials necessary for clean technologies, digital, space, and business applications, reducing and reusing materials before recycling, and embedding significant efforts on a new path of sustainable and inclusive growth.

The European Skills Agenda emphasized the parallel green and digital transitions that are transforming how people live, work, and interact and the significance of a change in people's skill sets to fully capitalize on the digital transformation, which is a key enabler for achieving the Green Deal objectives (European Commission, 2020). According to research, between 2005 and 2016, 40 percent of new employment was generated in sectors with high levels of digital activity, and in some job categories, over 90% of positions demand particular types of digital abilities. In addition, OECD (2019a) stressed that the deployment of digital technologies across all economic sectors, including non-tech sectors, will require a more digitally skilled workforce at all skill levels and ages.

Higher education systems must better connect themselves with the economic climate in order to provide graduates with the variety of skills demanded by the labor market, particularly those required for the twin transitions to green and digital economies. The concern for economic, social, and environmental challenges and sustainability education to deliver skills, knowledge, and values is addressed by a specific action covering a set of strategic interventions to support the acquisition of skills for the green transition and sustainable future. This action puts skills at the heart of the European policy agenda and calls on the Member States and all stakeholders to develop skills to accompany the green and digital transitions in jobs and beyond (European Commission, 2020).

In this context, the paper aims to ascertain the current views on the role of higher education in the context of digital transformation i.e. Education 4.0, and related implications on the current challenges with regard to the complex skills development of graduates. To this end, the paper commences with an updated literature review on the framework of Education 4.0 and the major challenges framed by the shift to the green economy and digital-rich workplaces. Furthermore, the study put emphasis on the Romanian country and its state of play in the attempt to adjust education to the future of work as well as deciphering several key performance indicators from the huge array of available data and measurements, in coherence with the challenges faced by the higher education sector.

Although all educational levels are extremely important for developing human capital, the study is focused only on higher education since it plays a critical role in enhancing the acquisition of workforce skills needed to thrive in the digital workplace and a greener economic era. Also, the study aims to emphasize specific interventions and actions needed to overcome major structural vulnerabilities of Romania's higher education system.

Literature review

The emergence of Industry 4.0 and the associated digital transformation, including mobile communication, social media, cloud, big data analytics, smart devices, connected things, and sensors, radically change how people live, work, and communicate. These resulted in significant structural changes in the world economy, automation, and digitalization, changing the nature of work and leading to further urgency to ensure those quality investments in people and their skills are made.

As acknowledged by the World Economic Forum (2020) in the *Future of Jobs Survey*, the companies' likelihood to adopt cloud computing, big data, and e-commerce remain high priorities, in line with the trend established in previous years. In particular, 55% of companies pinpointed their intention to transform the composition of their value chain, introduce further automation, reduce the current workforce (43%) or expand their workforce as a result of deeper technological integration (34%), and expand their use of contractors for task-specialized work (41%). Also, the survey emphasized companies' vulnerabilities in their attempt to capitalize on the growth potential of new technology adoption due to the persistence of workforce skills shortages. For tasks involving information and data processing and retrieval, administrative work, and some aspects of traditional manual labor, digitalization of the work process is anticipated, whereas humans are anticipated to retain their advantage for managing, advising, decision-making, reasoning, communicating, and interacting activities.

Furthermore, according to the revised OECD Employment Outlook 2019, up to 15 percentage of current jobs could disappear due to automation in the next 15 to 20 years, and another 32 percentage could experience significant changes as a result of the automation of some tasks that used to be performed by workers. Digital technologies will replace the workforce for those tasks that can be automated (e.g. routine tasks) and the workers will use technology (e.g. ICT tools) to perform tasks more efficiently which both have implications for the mix of skills people need (OECD, 2019b).

Digital skills and the ability to operate digital technology are yet considered the major transversal competencies needed across various jobs. As acknowledged by recent studies, digital skills are permeating societies and labor markets not only in high-tech occupations but across virtually all jobs and sectors. Thriving in the digital workplace requires both digital skills and strong cognitive and socio-emotional skills in growing occupations linked to new technologies (OECD, 2019c).

Albeit is quite impossible to predict which technologies will be developed in the long-term and their impact on the citizens' lives, some trends are clear and require reshaping the developments of workforce skills and capabilities through education, learning, and work.

These technological advancements are changing the way education systems can unlock the potential of technology for teaching and learning as a response to Industry 4.0, greatly incorporating the use of digital technologies, opening up higher education and knowledge to more students, improving access across different socio-economic groups, and provide high-quality learning material aligned with labor market needs. The conceptualization of these implications within education sectors refers to Education 4.0 which is responsible for preparing a new generation of graduates to use appropriate

physical and digital resources to provide innovative solutions to current and future societal challenges. Current studies devoted their attention to analyzing the challenges faced by the so-called Education 4.0 that are expected to smoothly incorporate new technologies that enhance learning opportunities and help develop skills for the 21st century.

In this view, Kipper et al. (2021) structured the set of competencies necessary for Industry 4.0 in terms of skills such as initiative, communication, innovation, adaptability, flexibility, and self-management, as well as pro-activity, creativity, problem-solving, interdisciplinary, teamwork, collaborative work, knowledge of contemporary fields like information and communication technology, algorithms, automation, software development and security, data analysis, general systems theory, and sustainable development theory. In particular, they highlighted the need for cooperation among companies and universities to reform curriculums, create real learning environments, and develop interdisciplinary competencies to solve problems and challenges posed by the fourth industrial revolution.

Looking at the components of Education 4.0, Miranda et al. (2021) compiled relevant concepts throughout the transition from Education 1.0 to the current educational paradigm and proposed four core components that shape the concept of Education 4.0. such as competencies, including transversal (soft) and disciplinary (hard) ones, learning methods that consider the use of technologies and pedagogical procedures that are increasingly used in higher education, information and communication technologies (ICT) that incorporate working principles of technologies and techniques to provide technology-based solutions for educational and management purposes, and infrastructure for learning and teaching practices that accommodate students' learning needs and support current educational challenges.

According to Yusuf and Jamjoom (2022), curricula emphasizing hard skills at the expense of soft skills are unsustainable. Job readiness skills like interpersonal and communication skills, teamwork, leadership, digital fluency, and creativity have emerged as essential components of achieving sustainable employability. The study also made the case that all interested parties should participate in creating projects and programs that strengthen cross-sector employability skills, with the opinion of industry leaders being particularly valuable as they frequently have first-hand knowledge.

The concern for a new era of digitalization and Education 4.0 was tackled by current studies which figured out three pillars in terms of flexible learning according to the needs and interests of each student, learning at an individual pace and at the speed of each student regardless of age and grade. In order to help students develop their abilities and skills with real projects by involving them in situations that are relevant to and related to their environment, the scholars introduced the challenge-based learning experience and courses. These courses encourage students to develop sustainable solutions in terms of the environment, society, and the economy. The outcomes can be seen in the cutting-edge instructional tactics and learning methodologies used to integrate the university curricula with the new competencies demanded by this globalized environment (Gutiérrez-Martínez et al., 2021).

By tackling a narrow approach to engineering education, other studies were focused on addressing the challenges induced by solving social problems with the help of the

integration of physical and virtual spaces i.e. so-called Industry 5.0. The researchers identified the convergence phenomenon—in which the distinctions between disciplines are blurring—and the digital transformation—which is the cross-fertilization of a wide variety of ideas. They highlighted the paradigm shifts in basic skill sets and proposed four strategies that could assist higher education institutions in redesigning their curricula in the areas of sustainability, resilience, hands-on data fluency and management courses, lifelong learning and trans-disciplinary education, and interaction between humans and machines (Gürdür Broo et al., 2022).

The concern for challenges and opportunities brought by the new paradigm of Education 4.0 was also tackled. Scholars put forward that the universities that laid the foundation for future talents or trends in society must adapt and modernize existing programs, facilities, and infrastructure. In this view, Mian et al. (2020) figured out major requirements for universities to prepare for Industry 4.0 in terms of proper financial planning, specialized staff, expanded industrial collaborations, new infrastructure, updated curricula, robust security measures, as well as awareness-raising and educational initiatives or marketing tactics. Despite certain advantages brought by digital technology such as higher productivity, greater flexibility, sustainability development, and accelerated enterprise growth, the results stressed major prerequisites that have to be fulfilled to adopt digital technology in academic practices such as training the existing staff, acquiring new talent, overcoming employees fear and concerns through proper counseling and job security, guidelines with the aid of experts in the field, allocate sufficient funds, and set down procedures to minimize security threats.

The current scientific literature also embodies the quest to implement communication technology in educational practices. Wang et al. (2021) found that the effective adoption of digital technology in education will likely depend on the teachers' pedagogical capability and determination to improve students' learning activities. In particular, when it comes to considering the effort, time spent, and resources used to prepare adequate materials, teachers tend to be hesitant about using new technology even with the many teaching and learning advantages of new technology brought by artificial intelligence (AI), virtual reality (VR), augmented reality (AR), and the Internet of Things (IoT). Worthy to mention, the scholars highlighted the critical role of teachers in successfully implementing new technology into the education environment.

The roles of teachers in the new model of Education 4.0 was also acknowledged by scholars who figured out the necessity to enrich the value-cognitive content of education by expanding the social and humanistic component to developing social, emotional, communicative, and practical intelligence skills of teachers. To this end, the improvement of the professional skills of teachers themselves, the integration of innovative processes in education around the idea and principles of sustainability education, and standardization and organizational design of the institutional framework of education for sustainable development should be considered as important improvement areas (Galtseva et al., 2020).

Several conceptual ideas were highlighted in other analyses of the Education 4.0 model, focusing on the model's contextually challenging and moderately organized character in terms of transversal and subjective direction, integration, and forward-looking features. According to this perspective, Karpan et al. (2020) highlighted the function of Education

4.0 in systematically forming people's fundamental characteristics for participating in the field of education for sustainable development – critical thinking, environmental worldview, subjective-value approach to the environment, and eco-cultural values. They stated that in order to resolve the contradiction between accelerated economic expansion and the need to preserve resources and ecosystems, digitization should be used in conjunction with an emphasis on morality and responsibility.

Although plenty of studies in the scientific literature have been dedicated to deciphering the changing paradigm of Education 4.0, further inquiries into the national educational context need to receive particular attention to better understand structural vulnerabilities and ensure that education will be aligned with labor market needs.

Methodology

In order to fulfill the aim, the study draws on data from official reports and documents from European Commission to evaluate the gap between national states of play compared to other EU member states. Although a huge array of data and performance indicators may support the analysis of quality education, a particular set of indicators were selected to be analyzed in coherence with EU 2030 education targets and the thematic focus of the study – skills for twin transition.

In this view, *table 1* showcases the framework with performance indicators used for highlighting the state of play with regard to the capabilities of the national higher education system to prepare the students for future work.

Table 1. Framework with performance indicators – structural aspects (source: Eurostat 2019, E&T database)

Indicator [unit of measure], [Eurostat main data code]	**Country performance**			**EU-27**
	Romania	**Strongest performer**	**Weakest performer**	
Public expenditure on education [% of GDP] [educ_uoe_fine06]	0.81	2.31 Denmark	0.44 Luxembourg	1.19
Public expenditure on education per students [euro] [educ_uoe_fine09]	3,533.3	42,428.8 Luxembourg	1,780.0 Greece	9,880.4
Ratio of students to teachers and academic staff [ratio] [educ_uoe_perp04]	19.4	4.9 Luxembourg	22.5 Cyprus	15.3
Tertiary educational attainment [%] [edat_lfse_03]	24.9	60.6 Luxembourg	24.9 Romania	40.9
Employment rate by educational attainment level [%] [lfsa_ergaed]	88.8	89.5 Lithuania	74.5 Greece	83.8

Percentage of the ICT sector in GDP [% of GDP] [isoc_bde15ag]	3.74	7.66 Malta	2.27 Greece	4.89
Employed ICT specialists by educational attainment level [%] [isoc_sks_itspe]	76.3	85.1 Lithuania	39.6 Italy	63.7
Employed ICT specialists – total employment [%] [isoc_sks_itspt]	2.4	7.6 Finland	2.1 Greece	4.3

To investigate the state of play, several indicators were used in the pursuit to depict the structural challenges of the higher education system such as public expenditure per student, public expenditure as a percentage of Gross Domestic Products (GDP), the ratio of students to teachers and academic staff, tertiary educational attainment, and employment rate by educational attainment level.

Furthermore, the level of development concerning the ICT sector is evaluated in connection with major indicators such as the employed ICT specialists by educational attainment level, employed ICT specialists from total employment, and the share of the ICT sector as a percentage of Gross Domestic Products (GDP).

The values of indicators were extracted from the statistical database Eurostat, the statistical office of the European Union. Considering the scope of the study, the displayed data are relevant for tertiary education level i.e. ISCED 5-8 which covers three educational layers of the Bologna process: Bachelor studies, Master studies, and PhD studies (OECD, 2015).

The analysis goes further with several contextual indicators linked to green and digital transition. As digital skills at all levels is a condition to ensure that all people can participate in society and take advantage of the digital transition, several indicators measuring the degree of digital skills were taken into account such as the degree of individuals' digital skills, degree of computer usage and cloud services, the frequency of internet access, the usage of ICT devices and software applications for working purpose.

In this regard, *Table 2* depicts the framework with performance indicators used for highlighting the state of play with regard to digital skills possessed by Romanian citizens. The values of indicators were extracted from the statistical database Eurostat including skills-related statistics.

Table 2. Framework with performance indicators – contextual aspects (source: Eurostat 2019, Skills database)

Indicator [unit of measure], [Eurostat main data code]	Country performance			EU-27
	Romania	Strongest performer	Weakest performer	
Individuals who have an above basic overall level of digital skills [%] [isoc_sk_dskl_i]	10	62 Iceland	10 Romania	31
Individuals - computer use [%] [isoc_ci_cfp_cu]	68	98 Iceland	65 Bulgaria	80
Individuals - use of cloud services (internet storage space to save documents and other files), [%] [isoc_cicci_use]	27	68 Iceland	24 Poland	31
Digital inclusion – individuals (frequency of internet access - once a week, including everyday), [%] [isoc_bdek_di]	76	99 Iceland	69 Bulgaria	85
Individuals – use of ICT devices at work [%] [isoc_iw_ap]	17	65 Norway	17 Romania	42
Individuals – use of occupational-specific software at work [%] [isoc_iw_ap]	7	50 Norway	7 Romania	24

Results and discussions

The analysis of structural indicators for higher education systems shows that Romania country is facing significant vulnerabilities coming from an underfinanced education system suggesting low educational outcomes and hampering the quality of education. The public investment in Romania is only 0.91% of the Gross Domestic Product compared to the EU-27 average of 1,19%. Albeit, the public expenditure on higher education varies significantly between EU countries, Romania's net value of public expenditure on higher education per student has encountered a slight increase from 2015 to 2019 but is still among the lower values in the EU (3533.3 euro/student in 2019 versus 2051.3 euro/student in 2015 but lugging behind the EU-27 average of 9880.4 euro/student in 2019). Romania's education budget was somewhat higher than the EU average as a percentage of all government spending (10.1 % vs. EU-27:10%), indicating a relatively low level of public spending (European Commission, 2021).

The concern for the quality of educational outcomes needs to be addressed by the adequate ratio of students to teachers and academic staff that enable the shift from

teacher-centered learning to a student-centered learning approach. These innovative teaching and learning pedagogies promote individual accountability for the learning process and require keeping the group size small in order to address distinct learning needs, interests, aspirations, and cultural backgrounds of individuals and groups of students. The data analysis shows that in 2019, Romania has a ratio of 19.4 students to teachers and academic staff significantly below the strongest performer with a 4.8 (Luxembourg) ratio but close to the EU-27 average of 15.3 students to teachers and academic staff.

As far as educational attainment, only 24.9% of the Romanian population aged between 25 and 34 holds a tertiary education degree. Although the proportion has improved over time, it is significantly below the EU average of 40.9% and the EU-level target of 45% by 2030.

However, in 2019, more than two-fifths (40.3 %) of people in the EU-27 between the ages of 30-34 had completed a tertiary degree, meaning that the ET 2020 criterion had been met. This is significant because persons with higher levels of education generally tend to have a lower risk of being unemployed, have a larger variety of work choices, earn better incomes, and generally have higher levels of life satisfaction (Eurostat, 2020).

The ICT uptake is low in Romania since the share of the ICT sector in GDP is only 3.74% in 2019 versus 4.89% of GDP for EU-27. Interestingly, the employed ICT specialists count for 76.3%, above the EU-27 average of 63.7%, whereas the employed ICT specialists from total employment have a share of only 2.4% below the EU-27 average of 4.3%.

The analysis of contextual performance indicators reveals that the lack of basic digital skills and ICT specialists are key challenges for Romania. The country scores considerably below the EU average in all indicators, as only 10% of people aged between 16 and 74 have above the basic overall level of digital skills (31% in the EU as a whole), while 68% use computers within last 12 months (EU average: 80%). Only 27% of individuals use cloud services such as internet storage space to save documents and other files (EU average: 31%), 17% use ICT devices at work, and only 7% use occupational-specific software at work versus the EU average of 24%. These figures mark the lacking of digital skills and the shortage of ICT specialists. Finally, Romanian businesses do not fully use digital technologies such as electronic information sharing, social media, big data, and cloud services.

In sum, the workforce's skills remain insufficiently aligned with the needs of the labor market, skills shortages, and mismatches, and a weak education and training system negatively affects prospects. Likewise, the structural vulnerabilities of the higher education system and long-standing structural weaknesses of Romania's business sector hamper the twin green and digital transition and the reinforcement of economic and social resilience (European Commission, COM (2022) 624 final). Thus, Romania is still among the worst performers in the EU in meeting education and training. Further measures are needed to address serious and longstanding challenges in the country's education sector.

The findings call for significant interventions to support digitalization, investments in digital equipment, teaching, and academic personnel training, and other efforts to improve students' digital abilities in light of the challenges of Education 4.0. It is essential to make sure that the higher education system is adaptable enough to incorporate this new knowledge and realize the full potential of technology for teaching and learning in order to respond to shifting skill requirements for the green and digital transition.

Additionally, several suggestions are worth mentioning in increasing digital literacy:

- Digital skills are equally transversal, confirming the extensive penetration of tasks involving digital technologies across jobs in virtually all sectors. These call for redesigning the curricula to promote cross-fertilization among different areas and subjects. Higher education systems should support teachers in adapting to evolving curricula since excellent education is essential to developing transversal skills and capabilities.
- Universities should think about developing non-classroom learning settings in addition to more conventional ones. Interactive techniques are becoming increasingly technologically advanced, enabling the employment of cutting-edge equipment like virtual or augmented reality. Transversal skills can also be cultivated in an applied setting through study programs, internships, and placements.
- Finally, access to digital devices and connectivity, digital skills for students and teachers, and strong motivation are essential.

Conclusions

Higher education systems are facing increasing challenges posed by digital technology. The advent of Education 4.0 deals with the coherent usage of ICT technology in the teaching and learning environment and the development of the skills graduates need to make the most of the digital society.

Given the anticipated acceleration in the use of technology, there is an increased interest in adjusting higher education institutions to the future of employment. Governments confront significant hurdles in keeping their policies relevant and aimed at constantly changing demands. They must determine not only the abilities required today, but also new trends, industries, and areas where those skills will be most in-demand.

In this light, especially for the Romanian country, a coherent set of interventions and measures are critical to overcoming the long-standing structural weaknesses of the higher education system to make learning opportunities much more flexible and responsive to labor market needs through appropriate funding mechanisms, to improve equity in education and accelerating the twin green and digital transition.

The exploratory study attempts to fill in the knowledge gap in the framework of Education 4.0 and can be of value to the academic community by raising awareness and a better understanding of the challenges and threats faced by Romanian higher education in pursuing green and digital transition.

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