Bologna Process Researchers' Conference
Future of Higher Education

Education 4.0: Navigating the digital wave of connected learning

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Abstract

Education 4.0 represents a revolutionary paradigm in education, supported by the rapid technological advances of the fourth industrial revolution. This marks a significant evolution in the educational landscape, promoting connected and personalized learning that responds to the challenges and opportunities of the digital age. The article analyses the state of digitalization in universities in South-East Europe, highlighting how Education 4.0 and connected learning are reshaping higher education by integrating advanced technologies such as artificial intelligence, virtual reality and the Internet of Things.

Through the use of online platforms and virtual classrooms, educational resources become more accessible, supporting flexible and student-centered education. Good practices in distance teaching and learning involve personalizing learning to meet student needs, implementing continuous assessment and real-time feedback, and encouraging digital collaboration and communication. These approaches not only develop digital skills, but also prepare students for the interconnected nature of the digital world.

At the same time, the transition to Education 4.0 and connected learning raises significant ethical implications, including student data protection, cyber security and equity in education. It is essential that teachers and educational administrators are aware of the potential risks and develop appropriate strategies to address them.

The article highlights the critical role of university digitalization in promoting flexible, technology-enabled, student-centered educational experiences that improve accessibility, support lifelong learning, and prepare students for the demands of the digital age. By adopting distributed classrooms and interactive teaching methodologies, higher education can effectively respond to contemporary challenges, helping to shape the future of education in an era characterized by digitalization and global interconnectivity.

1. Introduction

In the era of Education 4.0, the learning landscape is undergoing a profound transformation fuelled by the rapid integration of digital technologies. This shift in the educational paradigm is not merely focused on the integration of technology into the learning process but entails a fundamental re-evaluation of the structure, delivery, and experience of education in a society increasingly moulded by the progressions of Industry 4.0. Within this emerging paradigm, change is characterized by the widespread influence of advanced technologies such as artificial intelligence (AI), virtual reality (VR), and the Internet of Things (IoT), each playing an instrumental role in redefining educational practices

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and pedagogies. As such, Education 4.0 encapsulates a transformative framework where technology-based pedagogies converge to reimagine learning, empowering learners with unprecedented opportunities for engagement and exploration (Quresh, et al., 2021).

Education 4.0 focuses on the cultivation of skills such as critical thinking and the capacity for continuous learning and adaptation among learners. With respect to digital literacy, it is imperative that learners transcend mere digital fluency, instead developing sophisticated critical thinking and analytical abilities to effectively navigate societal transformations. This pedagogical shift departs from traditional rote[5] learning and passive information absorption, advocating for a more interactive, student-centered learning experience that encourages exploration, experimentation, and application of knowledge in real-world contexts (Nugent A., 2019). Connected Learning environments[6] described as a socio-technical approach where digital networks promote a participatory culture, allowing learners to pursue their interests in a supportive community of peers and mentors (Ito, et al., 2013). This amalgamation of technology and learning principles generates an educational ecosystem that transcends traditional boundaries, making educational resources more accessible and the learning journey more flexible (Kumpulainen & Sefton-Green, 2014).

However, this revolutionary shift towards Education 4.0 and Connected Learning does not come without its ethical conundrums. The exponential rise in digital connectivity and data-driven educational practices gives rise to multifaceted ethical dilemmas (Swartz, 2021).

Amid this intersection of technological innovation and ethical imperatives, this paper explores the intricacies of Education 4.0 and Connected Learning. Through examining fundamental principles and ethical considerations, this research aims to elucidate the transformative potential of these paradigms while advocating for a conscientious approach that balances technological advancements with ethical responsibilities. By synthesizing insights from seminal works and contemporary research, we seek to delineate the critical facets of Education 4.0 and Connected Learning, shedding light on their implications for responsible educational practices in the digital era.

2. Method

Our research methodology was designed to explore three fundamental queries within the scope of Education 4.0: (1) How do emerging technologies impact the learning process in the context of Education 4.0? (2) Which pedagogical strategies may be employed to personalise online learning? (3) What ethical considerations arise in the context of Education 4.0, and how could they be effectively addressed?

As such, we commenced with a systematic literature review, aiming to conduct an in-depth analysis of existing academic literature pertaining to Education 4.0, as detailed in Sections 3 and 4. Our primary focus was to explore research on the integration of emerging technologies in education, the development of strategies for personalising online learning experiences, and the examination of ethical considerations within this realm. The review focused mainly on peer-reviewed journals, conference proceedings, and significant policy documents - particularly those published in recent years and broadly addressing *higher education*, *technology integration*, and *educational ethics*. Furthermore, the review process entailed a comprehensive thematic analysis, which aimed to discern

[5] Rote learning is a method of learning based on repetition (memorization).

6 Consider the various initiatives at the international level, such as: https://commission.europa.eu/projects/school-40-next-generation-classrooms-0_en

prevailing trends, challenges, and best practices in shifting towards Education 4.0 across diverse educational settings.

Following the literature review, the research progressed with an empirical study to better understand the perceptions and practices associated with Education 4.0 among digitalization leaders in seven member universities of the European University Alliance (Section 4). This phase of the study involved surveying participants, especially digitalization experts, academic staff, and administrative staff from seven universities in Romania and Turkey. Respondents to the survey were heads of digitalization departments, project team coordinators or members of the teams that developed the university's digitalization strategy, deans of computer science faculties, or vice-rector responsible for digitalization. The questions asked can be found in annex 1 of the article. Data collection was done through Microsoft Forms, and Python code was created for data analysis.

A thorough analysis of the digitalisation strategies at the seven universities - where five distinct strategies were identified - was conducted using a bibliometric method. This method combines semantic and network analysis, facilitating the operation of both complex parametric and non-parametric models, integrating structural and loose semantic algorithms alongside mathematical and statistical algorithms which were employed for the dynamic visualisation of data. In order to perform the semantic analysis, we used the open-source semantic software Tropes (ACETIC, 2002).

The foundational theory underpinning the software merges two established theoretical frameworks: propositional discourse analysis, (Ghiglione, Kerenbosch, & Landré, 1995), and predicative propositional analysis (Kintsch & Dijk, 1978). This analytical approach arises from the necessity to discern both the cognitive and syntactic units essential for processing primary information and for effectively segmenting discourse. The sentence is identified as the minimal unit satisfying these dual criteria. In terms of content analysis, this theory hinges on the premise that sentences reveal interconnected 'microworlds' of varying degrees of complexity and completion. Within these microworlds, various actors (actants and those acted upon) are illuminated through predicates, reflecting the influences of argumentative strategies and the inherent constraints of the linguistic system. The thematic richness of a topic is gauged by the number of associated 'microworlds' or references, anchored by key objects termed as 'nodal references'. These nodal references constitute the structural pillars of the semantic universe being explored. Additionally, a logical model for discourse construction is applied, enabling the delineation of cause-effect relationships and facilitating the identification of pivotal nodes that generate references, which play a crucial role in both shaping and analysing discourse (Caragea & Curaj, 2013).

The bibliometric analysis utilises the outputs from Tropes, which primarily include matrices of references focusing on central topics, predominantly composed of user-defined keywords, and establish directional cause-consequence relations based on the placement of references within a sentence and their co-occurrences. Further analysis is conducted using network analysis tools, for which the open-source software Gephi was employed. The core methodology involves merging the capabilities of two software tools. The network analysis software interprets the matrices of references and their relationships, or the semantic ontology produced by Tropes, as nodes and edges in a network. This integration significantly enhances Big Data visualization through statistical algorithms suited for semantic analysis. For instance, the multi-level modularity class aggregation, a method for decomposing networks and identifying communities, helps in discerning modular subnetworks of references, which represent discursive episodes (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008). These are essentially groups of keywords that frequently appear together in sentences or are connected through the same connectors or keywords (Curaj & Holeab, 2018).

3. From Education 1.0 to Education 4.0

The transition from Education 1.0 to Education 4.0 marks a significant transformation in the way education is perceived and delivered, mirroring wider shifts within society, advancements in technology, and the evolving concept of knowledge.

The origins of **Education 1.0** can be traced back to the late 18th century when teachers adopted a traditional, teacher-led methodology. This early model prioritized rote memorization, positioning teachers as central figures in the dissemination of knowledge. It aimed to instil basic skills such as literacy and numeracy, prioritizing strict discipline and memorization of information. In this configuration, classrooms were highly structured environments where a clear hierarchy prevailed, and there were minimal opportunities for students to actively engage in their learning journey (Miranda et al., 2021).

As society moved into the 20th century, **Education 2.0** began to take shape. This phase marked a shift towards a more inquiry-based approach, where the teacher's role transitioned from a sole disseminator of knowledge to a guide or facilitator (Tirziu&Vrabie, 2015). Some authors link this to ancient philosophical means of study (Donskikh, 2019). Collaborative learning started to gain importance, with an emphasis on critical thinking and problem-solving skills. The onset of technology in classrooms, such as the use of radio, films, and eventually television, began to influence educational methods (Miranda et al., 2021).

Education 2.0 was characterised by a significant shift towards the integration of emerging technologies, such as artificial intelligence, virtual reality, and collaborative online platforms, into educational environments. The research in this era delved deeply into how these technologies impacted teaching methodologies, student engagement, and the overall learning landscape. Simultaneously, the development of the first Massive Open Online Courses (MOOCs) marked a pivotal moment. Various studies were conducted to examine the efficacy of online learning platforms in offering accessible and flexible education to a diverse range of learners, with researchers investigating the challenges and opportunities associated with these massive online courses, particularly in terms of completion rates and the quality of learning outcomes. Additionally, personalised learning was a key focus, emphasising experiences tailored to individual student needs. The implementation and effectiveness of adaptive learning technologies were explored, aiming to improve student outcomes. In the realm of collaborative learning, the role of social media and other collaborative tools in promoting interaction and knowledge sharing among students received considerable attention, with scholars analysing the impact of social networking platforms, online forums, and other technologies on student collaboration, communication, and community building. Concurrently, the use of data analytics in education was a significant development, being utilised to track student performance, identify learning patterns, and facilitate timely interventions. This period also saw an emphasis on teacher professional development, focusing on preparing educators to effectively integrate technology into their teaching practices, thereby enhancing instructional methods.

Further on, with the advent of the Internet and digital technology, **Education 3.0** emerged. This stage is characterized by an even greater emphasis on student-centered learning and the use of technology to facilitate personalized learning experiences (Allison&Kendrick, 2015). The role of the teacher evolved further into that of a mentor or coach, supporting students as they navigated an increasingly diverse and rich landscape of information. Collaborative and experiential learning became more pronounced, leveraging the connectedness provided by the Internet (Watson et al., 2015).

Education 3.0 focuses on learner-centric approaches, placing the learner at the heart of the educational process. Pedagogies that empower learners to take an active role in their education are being developed and explored, thereby fostering autonomy and self-directed learning. Additionally, holistic development is a central theme, with educators considering not only cognitive aspects but also social, emotional, and ethical dimensions of learning. Curricular designs and teaching methods are being tailored to nurture well-rounded individuals capable of critical thinking and problem-solving. Concurrently, Education 3.0 places a strong emphasis on experiential learning, where students actively engage in real-world experiences to apply theoretical knowledge. This approach includes integrating internships, projects, and hands-on experiences to enhance learning outcomes and better prepare students for the demands of the modern world. In the realm of collaborative and interdisciplinary learning, Education 3.0 encourages environments where students work together on projects and engage in interdisciplinary studies, aiming to foster creativity, innovation, and a deeper understanding of complex issues. Additionally, while going beyond mere technological integration, Education 3.0 recognises the importance of digital literacy skills for learners to meaningfully navigate and contribute to the information age, with ethical considerations of technology use being addressed. The paradigm also incorporates a global perspective, emphasising educational practices that promote cultural competence and global awareness among learners. Finally, there was a shift in focus towards innovative assessment methods that align with the principles of Education 3.0, moving beyond traditional exams to evaluate holistic learning outcomes, with studies exploring authentic assessment practices that capture the depth and breadth of student understanding.

The recent and ongoing shift towards **Education 4.0** describes the frontier of educational evolution in close alignment with the needs and dynamics of the 21st century. It is heavily influenced by the ever-more rapid advancements in technology, such as artificial intelligence, the Internet of Things (IoT), and virtual/ augmented reality. In this educational model, education not only is, but will continue to evolve as highly personalised and adaptive, with a distinct emphasis on lifelong learning. The learner's progress can already be monitored and tracked thanks to advanced data processing algorithms, and the education methodology can be personalised accordingly (Ciolacu et al, 2017). The focus can be better placed on developing competencies such as creativity, critical thinking, problem-solving, futures literacy, digital literacy, and collaboration (Sharma, 2019). The learning environment is more flexible, transcending traditional classroom boundaries and extending into virtual and augmented realities (Miranda et al., 2021).

Education 4.0 aligns closely with the fourth industrial revolution, frequently focusing on integrating Industry 4.0 technologies into educational settings. This includes the utilisation of advanced technologies such as machine learning to enhance various aspects of teaching, learning, and educational administration. Alongside, Education 4.0 promotes personalised learning experiences through adaptive technologies, involving AI algorithms to tailor educational content to individual student needs and learning styles. Moreover, the role of data analytics is emphasised in informing decision-making processes in education. Educators are equipped with tools to leverage big data for assessing student performance, identifying learning trends, and optimising educational strategies. In terms of immersive learning experiences, Education 4.0 incorporates virtual and augmented reality tools, with research exploring their impact on student engagement, comprehension of complex concepts, and skill development. The alignment with Industry 4.0 also means that Education 4.0 is geared towards equipping students with skills required for the future workforce, such as critical thinking, problem-solving, futures literacy, digital literacy, and adaptability. Furthermore, the transformation necessitates that educators adapt to new technologies and pedagogies, with a significant body of literature focusing on their professional development needs. This includes effective training methods and strategies for integrating technology into teaching practices. Additionally, a key element of Education 4.0 is global collaboration and connectivity, utilising technology to facilitate

international partnerships, collaborative projects, and cultural exchange. Finally, current scholarly discussions address the ethical concerns associated with the use of advanced technologies in education, particularly issues related to privacy, data security, and algorithmic bias.

To summarise, the evolution of educational systems has been marked by the shift from traditional teaching methods, known as Education 1.0, to innovative and technologically advanced approaches, called Education 4.0. This transition reflects profound changes in the way knowledge is transmitted, assimilated, and applied in the context of an increasingly digitalized world. Table 1 provides a comparison of the different stages of this evolution, highlighting the key components that define each educational era.

Table 1 "Presentation of the transition from Education 1.0 to Education 4.0" (Source table: Miranda, et al., 2021).

	Education 1.0	**Education 2.0**	**Education 3.0**	**Education 4.0**
Period	Late 18th-Century	Early 20th-Century	Late 20th-Century	Present
Philosophy	Essentialism, behaviourism, and instructivism	Andragogical, constructivist	Heutagogical, connectivist	Heutagogical, peeragogical and cybergogical
Educator role	Sage	Guide, information source	Orchestrator, curator and collaborator	Mentor, coach, collaborator, reference
Student role	Largely passive	Emerging active "owning of the knowledge"	Active "Knowledge ownership", initial independence	Active, high independence, trajectory designer
Approach	Teacher-centered	Peer assessment encouraged, high teacher importance	Co-constructed, first student-centred	Mostly student-centered
Learning outcome	Grades, graduation degree	License to professional practicing	Prepared for practice and scenario analysis	Training of key competencies both soft and hard
Enablers	Mechanical printing, graphite pencil, ballpoint pen, typewriter	First computers, electronic devices, and calculators	Computers and widespread use of the Internet	ICTs tools and platforms powered by IoT
Information source	Standard texts	Adopted texts and open-source material (physical)	Texts, case studies, second-hand experience	Based on online sources
Facilities	Universities/classrooms	Blended laboratories and classrooms	Blended and flexible physical shared spaces	Cyber and physical spaces both shared and individual
Industrial technology	Mechanical systems, steam-powered	Mass production, industrialization, and electricity	Internet access, automatization, and control	Connectivity, digitalization, and virtualization

This progression from Education 1.0 to 4.0 reflects a broader societal shift from industrial to knowledge and digital economies. The role of the educator has transitioned from a source of knowledge to a facilitator of learning experiences, where students are encouraged to be active, self-directed learners. The integration of technology has been pivotal, not just as a tool for teaching and learning but also as a means of preparing students for the demands of a rapidly changing, technologically advanced world.

3.1.3.1. Connected learning

Before the COVID-19 pandemic, various voices were advertising the need for a change in academia, primarily due to factors like decreasing natality and political support for vocational education. In the context of educational transformations precipitated by the COVID-19 pandemic and technological developments, the concept of "connected learning" is becoming increasingly relevant (Kumpulainen&Sefton-Green, 2014). The pandemic accelerated a societal shift towards in-home activities, increasing the reliance on alternative information sources like YouTube, Ted Talks, podcasts, and MOOCs. The emerging metaverse concept, enhanced by impressive communication speeds (5G/6G), suggests potential for virtual 3D educational environments or the **virtual university**. The infancy of machine learning, and now AI and Generative AI, with their significant potential and disruptive capabilities, poses both opportunities and threats to traditional job markets. The past decade saw a noticeable student disengagement from conventional university models, evident in changing lecture attendance patterns and study habits.

The historical backdrop of European universities circa 1800, where conventional lectures faced criticism amid a burgeoning knowledge landscape, draws parallels with contemporary challenges. The swift proliferation of information sources and advancements in machine learning technologies raises inquiries about the epistemic authority inherent in traditional educational models. In response, universities may contemplate reassessing their distinctive value propositions in an era dominated by machine learning and information technology. The emphasis could pivot towards offering personalized, transformative educational experiences that incorporate human interaction, memorable moments, and meticulously designed curricula. Despite technological strides, the significance of inspirational lectures and individual wisdom in education remains irreplaceable. However, this stance does not signify an endorsement of pre-pandemic educational norms. Automation and data science are reshaping professional landscapes, compelling a thorough reconsideration of educational approaches. Universities should set themselves apart from tech giants by concentrating on human literacies that confer a competitive edge over machines, all the while judiciously incorporating technology as a complement to human intellect (Parker, 2021).

3.2. Challenges and opportunities

The analysis of the current education system concerning three criteria – preparation for the labour market, the ability to compete with intelligent machines for jobs, and the creation of long-term economic value – reveals the following aspects: firstly, a percentage of 34% of students believe that their schools are not adequately preparing them for success in the labour market (WE Forum, 2020). This underlines the need to improve the transition from education to employability. Second, it is estimated that 60% of future jobs have not yet been developed, and 40% of preschool (kindergarten) children in current schools will need to work independently to earn an income (Foundry, 2021). It is therefore essential to prepare students for jobs that do not yet exist and to encourage them to

become entrepreneurs. How we learn, what we need to learn, and the role of the teacher are constantly changing.

Studies reveal that universities lack a comprehensive understanding of critical thinking. Typically, educational curricula emphasize teaching subject matter in isolation, assuming that students will naturally engage actively in the learning process. For instance, while history, biology, and math are taught individually, there is insufficient emphasis on cultivating critical thinking within these disciplines. Although students are expected to analyse information, there is a notable absence of clear methodologies for teaching the essential components of analysis (Paul, 2004).

Despite the desire for students to apply intellectual standards in their thinking, there exists ambiguity regarding the specific standards to be employed and how to articulate them. The intellectual traits required for various academic disciplines are not clearly defined, contributing to a lack of clarity on the relationship between critical thinking and other crucial skills such as creativity, problem-solving, decision-making, and effective communication (Paul, 2004).

Furthermore, the significance of thinking in comprehending subject matter is not well understood, and students often remain oblivious to the ineffectiveness of didactic teaching methods. Consequently, the reasons behind students struggling to grasp fundamental concepts within a subject are not fully comprehended. There is a distinct absence of classroom strategies aimed at facilitating students' mastery of content and fostering proficiency in the learning process (Paul, 2004).

Most teachers face these problems, but without being sufficiently aware of them. This situation emphasizes the need for a **comprehensive reform in education**, which includes a reconsideration of teaching methods, course content, and the role of teachers in the formation of students' critical and creative skills. It is vital to emphasize the development of critical thinking, creativity, and adaptability among students to prepare them for a rapidly changing world and jobs that do not yet exist.

3.3. Innovating Higher Education: Decoding the elements of Education 4.0

The rapid evolution of technology and the widespread impact of globalization are exerting profound pressures on institutions of higher education, necessitating the provision of education that is both accessible and inclusive throughout an individual's life. Since March 2020, the unforeseen upheaval in higher education has presented opportunities for fostering creativity and promoting essential transformations. Projections indicate that by 2025, 60% of the working-age population in the United States will require some form of post-secondary qualification for employment, a significant increase from the current 52% (Gazi & Baker, 2021).

The closure of campuses due to the pandemic highlighted the lack of systematic online instructional delivery, exposing the unpreparedness of these institutions to provide meaningful, large-scale online learning (Lederman, 2020). Despite substantial investments in educational technology, higher education has not yet made significant progress in developing the capacity for widespread online education. Digital learning allows universities to reach extensive learner populations beyond traditional classrooms, yet the effectiveness of such large-scale education remains a subject of debate (Joksimović, et al., 2018). This scepticism is particularly evident in the context of Massive Open Online Courses (MOOCs). However, this scepticism has gradually given way to innovative approaches, leading to the development of early, affordable models for comprehensive online programs. The technologies and devices that initially popularised MOOCs now form the essential infrastructure enabling many universities to offer remote learning to their students (Pelletier, 2019).

In the next segment, we aim to explore and delineate the contours of pedagogy in the post-pandemic era. Given the significant pandemic-induced transformations in the educational landscape, it is imperative to take an analytical perspective on teaching paradigms.

To examine the application of critical thinking, it is pertinent to consider two specific instances where its implementation proves notably challenging within an online context. First, consider the domain of mathematics. Traditionally, we envision a teacher employing the classic chalk-on-the-board method to impart mathematical knowledge. However, mathematical proficiency is inherently tied to critical thinking, necessitating students to independently formulate solutions in their minds, actively engaging with the intermediary steps of problem-solving. Brainika! is an educational platform designed for children, with a focus to foster an intuitive understanding of math. The platform employs ingenious methods, incorporating spaced repetition, recall, deliberate practice, feedback, and positive reinforcement. Such strategies stand out as some of the most effective ways to cultivate mathematical intuition through the procedural system (Oakley, 2021).

In the world of computer programming, James Bowen, a Java, DevOps, online teacher, and author, has taken the fundamental concepts of procedural and declarative learning and applied them specifically to improving one's coding ability. He introduced to developers the idea, which he further applied to the learning of Kotlin. Today, James is trying to help coders unpack the ability to recognize an opportunity consciously but execute the skill automatically. (Bowen, 2021)

The current landscape is undergoing rapid transformation, driven by automation and the advent of the digital age. This transformative shift, indicative of the commencement of the fourth industrial revolution, demands an appreciation and cultivation of skills pertinent to the changing dynamics of work, technology, and intricate processes. Amidst this transformation, a crucial aspect involves revisiting foundational skills essential for success in both current and future work environments. As recognized by McKinsey, a diverse set of skills is imperative for the future workplace, with an emphasis on active learning as a key factor in their development (refer to Figure 4). Consequently, there is a need to recalibrate traditional education systems to better prepare individuals for forthcoming challenges (Dondi et al., 2021).

The 21st century requires a diverse range of skills, with education playing a key role in providing them. Recent research identifies 56 essential future work skills into four subgroups: cognitive, interpersonal, self-management, and digital skills. These areas collectively comprise the varied but indispensable skills required for future training. In the cognitive domain, skills such as critical thinking, effective planning, communication, and mental flexibility are highlighted. These competencies are increasingly crucial as they facilitate adaptation to the rapidly evolving global landscape by improving critical communication and decision-making skills.

Figure 1 Skills Necessary for the Future of Work (Source image: Dondi, et al., 2021).

Interpersonal skills, which encompass areas such as relationship building and teamwork effectiveness, are indispensable in any future work context. Effective interaction within and between teams is vital to achieving collective goals. Self-leadership skills, including self-awareness, self-management, entrepreneurship, and goal achievement, are critical to future success. Cultivating leadership and self-awareness enables individuals to build stronger relationships and increase the effectiveness of projects in which they will be involved.

Digital skills, which include digital fluency, ethical digital citizenship, use of software, and understanding of digital systems, are central to the ethos of technology talent training programs. In the evolving digital landscape, having strong digital skills is imperative for success in future work environments.

Active learning as an educational approach should be prioritized for its ability to promote responsibility and adaptability in learning processes. This method transcends traditional course grades, allowing students to experiment, fail, and understand concepts through practical application. The work of the future will require fundamental skills that allow individuals to add value beyond what can be automated, operate in digital settings, and continuously adapt to new work methods and occupations (Dondi, Killer, Panier, & Schubert, 2021). Therefore, active learning is not just a pedagogical choice, but a necessity, empowering students to actively engage with concepts and apply them to real-world scenarios. Active learning is a method of learning that enables students to be more

responsible and flexible with their learning. Not only does it allow students to try and fail different approaches, but it enables them to understand concepts by doing rather than by hearing. Taking notes on a lecture will never compare to actively learning the concept and putting it to the test in the real world.

As a fundamental pedagogical approach that aligns well with the principles of Education 4.0, Active Learning emphasizes learner engagement, collaboration, and the integration of technology. Active learning encourages students to actively engage with the learning process, moving beyond passive reception of information. In Education 4.0, where learner engagement is a priority, active learning strategies promote participation and interaction in the educational experience. Education 4.0 emphasizes collaborative learning, recognizing the importance of teamwork and interpersonal skills. Active learning methods, such as group discussions, projects, and problem-solving activities, foster collaboration among students, preparing them for the collaborative demands of the fourth industrial revolution.

Active learning often incorporates technology tools and platforms to enhance the learning experience. In Education 4.0, where technology integration is a key aspect, active learning methods can leverage digital resources, simulations, and online collaboration platforms to create dynamic and interactive learning environments. Education 4.0 underscores the development of critical thinking and problem-solving skills. Active learning activities, such as case studies, debates, and hands-on projects, provide opportunities for students to apply theoretical knowledge to real-world situations, fostering the analytical skills needed in the modern workforce.

Active learning allows for a more personalized and learner-centered approach. Students can explore topics at their own pace, and educators can tailor activities to meet individual learning needs. This aligns with the personalized learning goals of Education 4.0. Education 4.0 promotes continuous assessment and feedback. Active learning methods facilitate ongoing evaluation of student understanding and progress, enabling educators to provide timely feedback and adapt instructional strategies accordingly. Active learning aligns seamlessly with the principles of Education 4.0, contributing to learner engagement, collaboration, technology integration, and the development of essential skills needed in the rapidly evolving landscape of the fourth industrial revolution.

For cognitive skills, a lot of responsibility is placed on the students to think critically, communicate effectively, and self-manage. With the self-paced and remote nature of online programs, students have the flexibility to complete projects and learn without sacrificing other important commitments in their lives. They can develop ways of learning that work for them individually. The projects should be engaging to them and should require out-of-the-box thinking. This helps students in the long run for future employment and careers. Students should be asked to explain their thinking and reasoning to an external source, which helps them better understand how they solve the problem. Through coding collaboration and live coding sessions, students should be given opportunities to translate their knowledge, ask questions, and work on communication techniques of public speaking. Structured problem-solving should be involved with each quest a learner completes.

The skills described above are only learned through hands-on practice. Knowledge transmission does not even come close to being enough for students to learn what is required. Learning skills such as mental flexibility will demand being put in positions where flexibility is pushed, and learners are outside their comfort zone. That doesn't happen in a lecture where they're not engaged in the emotional or mental part of learning these skills. People do not like being outside of their comfort zone and will think they have learned more via lectures but the science of skill development holds experiential learning is far more effective whether learners like it or not. It is hard to accept change

and establish new ways, but the sooner a student can, the sooner she can learn new skills and be **prepared for the future of work.**

4. Perceptions and attitudes towards education 4.0: Analysis of responses

4.1. The strategic approach to digital transformation in universities

After understanding the risks and concerns related to Education 4.0 and the adoption of current technologies, we aimed to investigate what is the status quo in 7 universities in two European Higher Education Area member countries (Romania and Turkey).

Considering the difficulties identified in universities' conception of teaching and deep and critical understanding of the disciplines, it is remarkable that five of the seven institutions responding to our study have already adopted digital transformation strategies (see Figure 1). It is noteworthy that among those who stated that their institutions have a digital transformation strategy, all indicated that these strategies are designed to be applied over the long term, thus underscoring the universities' deep and sustained commitment to continuous adaptation and innovation. This fact underlines a gradual transition towards the integration of digital technologies in the educational framework, which can facilitate a more effective and engaging approach to the learning process. Despite this progress, there are still universities that need to formalize a digital transformation strategy, reflecting an untapped opportunity to improve students' ability to learn in a more interactive and applied way. The transition to digital is essential to support the wide-ranging reform of education and to cultivate students' critical and creative skills, preparing them for the future challenges of the labour market.

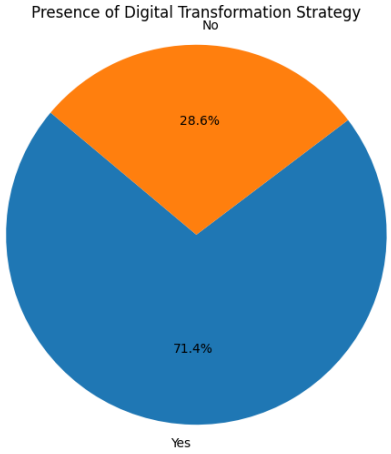

Figure 2 The existence of a digital transformation strategy within the responding universities (Source image: Authors`own contribution).

Predominantly in digital transformation strategies, Artificial Intelligence (AI) has been embraced, making up 35.7% of strategies, signifying a desire to integrate AI for personalized pedagogical experiences and administrative efficiency. Next comes Augmented Reality/Virtual Reality (AR/VR) reflecting the commitment to promote experiential learning environments through immersive technologies.

According to our findings (see Figure 3), both the Internet of Things (IoT) and distributed classrooms hold an equal stake. The data suggest a concerted effort to establish interconnected, smart campus infrastructures and promote accessible, non-traditional learning spaces. Some universities have added that among the priority points of their digital transformation strategy are adaptive learning and digital

agriculture, which indicates the nascent but strategic efforts to adapt educational trajectories and incorporate digital methodologies in agricultural studies, congruent with the goals of sustainable development.

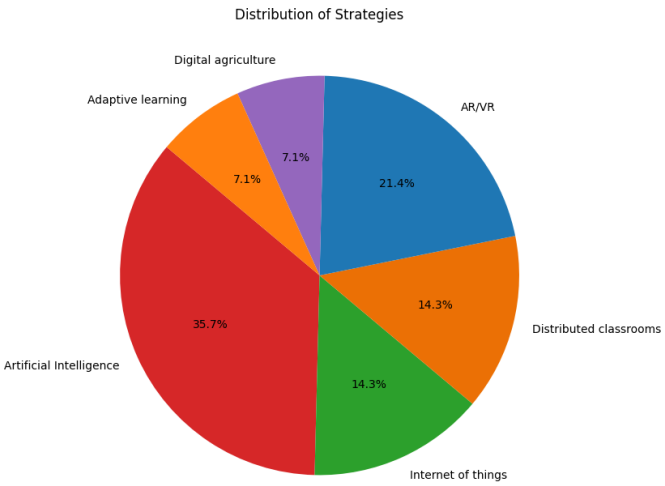

Figure 3 The main points considered for establishing of the digital transformation strategy of the responding universities (Source image: Authors` own contribution).

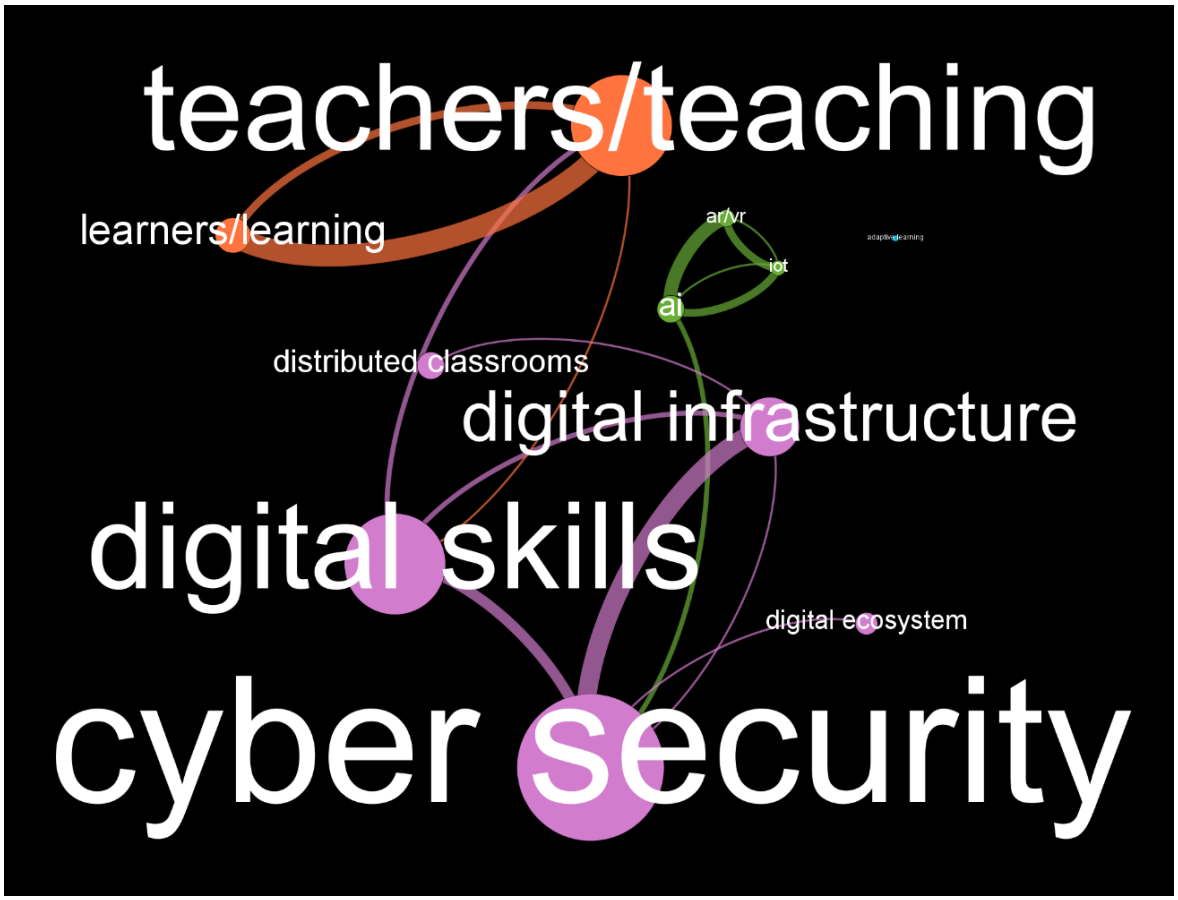

Figure 4 The semantic network of the textual corpus of five identified digitalisation strategies

Figure 4 shows the semantic network of the five digitalisation strategies and its distinct modular classes (marked with three different colours) i.e. thematic subnetworks of references with strong connections among them. It reveals: (a) a major focus on cyber security when discussing investments in digital infrastructure, (b) a significant focus on digital skills - otherwise significantly disconnected from the digital technologies, especially AI, IoT and AR/VR, (c) a rather fragmented strategic discourse, especially on the (green) digital technologies (which, for example, have no connections with teaching or with learning), and (d) a rather marginal focus on distributed classrooms - which only minimally connects to digital infrastructure, and moreover on adaptive learning - the 4th (light blue) modular class as not being discussed in connection to any other reference included in the semantic analysis (in the semantic network).

4.2. Ethical implications of Education 4.0

As previously discussed, Education 4.0 represents a profound transformation in learning methodologies (Ito et al., 2013). While this shift comes with significant advancements in education, it also brings forth critical ethical concerns that demand thoughtful attention and resolution (Swartz 2021).

One major ethical challenge revolves around collecting and handling student data (Swartz 2021). The extensive information generated through online learning platforms, student interactions, and assessments poses substantial privacy risks (Ito, et al., 2013; Quresh, et al., 2021). To diminish the risks, educators must establish robust data protection protocols within the institutions they represent, ensuring ethical collection, usage, and protection of student data (Swartz, 2021).

Another ethical issue of concern is the potential for biases and discrimination embedded in algorithms utilized in Education 4.0 (Ito et al., 2013; Qureshi et al., 2021). Machine learning algorithms might perpetuate existing societal biases, leading to unfair outcomes for specific student groups (Swartz, 2021). For instance, automated grading systems or personalized learning tools might disadvantage certain student demographics. To resolve this, educators and institutions need to closely examine the fairness embedded within the AI models used (Ito et al., 2013; Qureshi et al., 2021; Swartz, 2021).

Following the analysis of the data collected from the digitalization experts who responded to our survey there is a varied awareness of ethics in the use of AI and not all universities recognize the importance of ethics in the use of AI, not all have an adequate level of awareness or training to implement ethical practices efficiently.

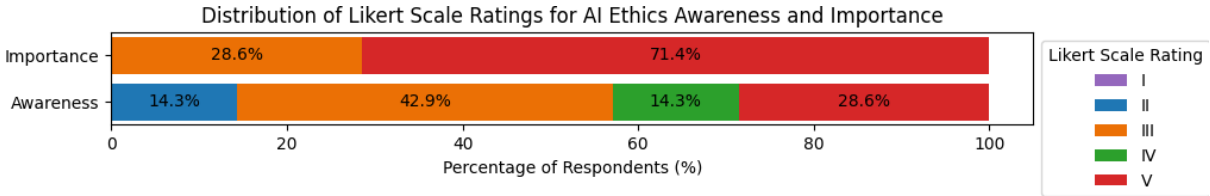

Figure 5 Respondents' perception of the importance and awareness of the ethical use of AI (Source image: Authors`own contribution).

After analysing the survey data, we found that 43% of universities have implemented training programs for the ethical use of AI for both students and faculty. In these cases, the training sessions

are held annually and supported by the universities' employees. Despite widespread recognition of the importance of ethics in the use of AI, evidenced by the significant weights assigned by respondents in the Likert ratings of awareness and importance, there appears to be a gap between belief and action. The remaining 57% of universities have not implemented training initiatives dedicated to ethics in AI, indicating a possible lack of resources, awareness, or strategic prioritization in this area. This absence of coherent policies and structured training programs on AI ethics suggests an urgent need for action and the development of a comprehensive framework to address these gaps.

The lack of equitable access to digital devices, reliable internet, or necessary technological skills between students could further impact the implementation of Education 4.0. A 2021 report by ANOSR, which surveyed 2765 students from Romanian universities, found that 25.8% of respondents had difficulties in accessing digital resources due to lack of technological competencies, 32.1% due to unreliable internet, and 28.7% due to not having access to a computer that met the performance requirements of the e-learning platforms used (ANOSR, 2020). Addressing this division, efforts from educators and institutions alike are required to provide equitable technology access, support digital literacy, and cultivate inclusive learning environments that meet diverse students' needs.

While technology plays a vital role in Education 4.0, educators' focus should be on prioritizing the human element in this process (Swartz, 2021). The improvement of education through technology is clear within Education 4.0, but it cannot replace the vital role of human guidance and interaction throughout the teaching al learning process. Overreliance on technology could devalue critical thinking and creativity (Ito et al., 2013; Qureshi et al., 2021; Swartz, 2021), eroding students' ability to develop innovative solutions for real-world problems. Educators need to ensure technology supplements rather than replaces these essential skills.

Educators hold a significant responsibility in navigating the ethical dimensions of Education 4.0 (Swartz, 2021). Proper training programs addressing technology integration ethics, data privacy, bias mitigation, and equitable education should be provided. Moreover, integrating ethical education into the curriculum empowers students to be responsible digital citizens.

The migration towards Education 4.0 requires an attentive examination of its ethical implications. It is of the utmost importance for all parties to maintain a responsible approach, maintain human connections, and nurture critical thinking within the student body. By aligning with ethical principles, educators can harness the potential of Education 4.0 while safeguarding the welfare of learners.

4.3. Beyond traditional walls: The distributed classroom

The distributed classroom, in our view, is a classroom experience distributed across time and space. The teacher does not have to be in the same place as the students, and the students do not have to be in the same place with each other. The teacher can teach synchronously to students physically in the same room, synchronously to students in remote locations, or asynchronously in general. The typical barrier of having to be in the same place at the same time disappears.

This might seem just like typical asynchronous online learning, where students watch lectures from home instead of coming to class and interacting via forums or chat rather than face-to-face. The key to the distributed classroom is that it is distributed across these spectrums rather than constrained into one. This means that a teacher can synchronously teach a class of co-located students, but that class can be live-streamed to another cohort of students in a different location, as well as live-streamed to a synchronous remote audience. Each of these groups can have their teaching assistants

to support their interactions and discussions, built based on the live lecture; These teaching assistants can then help facilitate live interaction between remote cohorts and the teacher, organizing questions to pass along while directly answering more low-level questions. Similarly, all cohorts would continue to interact with the instructor and the full teaching team through asynchronous mechanisms outside of class hours, or even through dedicated remote synchronous interactions such as a dedicated remote office hours session.

Then, once the lecture is ready for streaming, it can be easily recorded as well, allowing more fully asynchronous cohorts of learners to participate with both the course content and the training team. For example, a section might view course content with a 8 or 12-hour delay due to the time difference, or a section of adult remote learners who log into BlueJeans[7], Zoom[8] etc. together in the evening can view the morning content together. In both contexts, dedicated teaching support would be available to facilitate and structure these interactions, as well as to answer those questions that a person with knowledge at the level of a typical teaching assistant can answer. All these interactions are optional: it remains entirely possible for a student to interact with classmates and instructors through asynchronous mechanisms only as in our existing distance learning classes.

However, these optional synchronous interactions enhance the experience, reintroducing social learning that students would otherwise have to forgo to access the program in the first place without moving to another country or city. All these students can then interact with each other and with instructors on shared course forums like Piazza[9], submit their assignments to the same learning management system, and receive grades and human feedback from the same team of human teaching assistants. This is the distributed classroom: an attempt to distribute not just learning across time and space, but also the actual classroom experience—including synchronous interaction—even while removing the requirement to attend at a specific time and in a certain place.

To empirically assess the perceived value of the distributed classroom, responses to a survey of digitalization experts at the seven universities were analysed. The results provide insight into the reception and perceived effectiveness of this approach. It is noteworthy that more than half of the respondents (57.1%) indicated a medium level of understanding (rating III on the Likert scale), suggesting that although the concept is partially understood, there is significant ambiguity regarding the details or its applicability. This median distribution could signal a gap in effectively communicating the technical aspects or practical relevance of the distributed classroom concept. To ensure successful implementation and maximize the potential for associated benefits, additional education and training measures are essential. Therefore, the stabilization of the concept among the target community will facilitate a better assimilation of knowledge and a more effective application in practice.

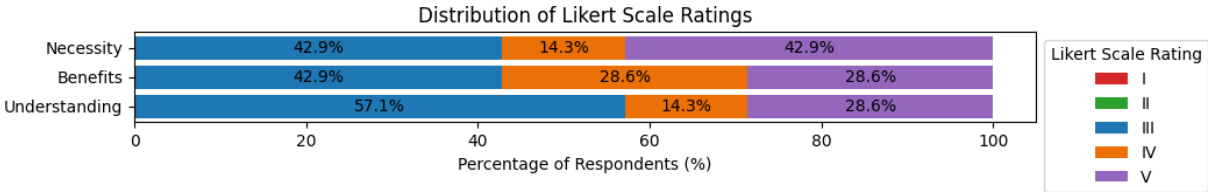

Figure 6. The results for the Likert scale (Source image: Authors`own contribution).

[7] https://www.bluejeans.com/
[8] https://zoom.us/
[9] https://piazza.com/

The data shows that a significant percentage of 42.9% of respondents assessed the need for this concept as "very high" (V) and another 14.3% as "high" (IV). This finding underscores a robust belief among the surveyed community on the critical importance of adopting distributed classrooms. In today's context, characterized by an accelerated embrace of digital solutions, these figures suggest a clear inclination of digitalization experts to support investments in distributed classrooms. This reflects the belief that by increasing the capacity to implement distributed classrooms, new horizons can be opened in the efficiency and innovation of educational processes. We can say that it is time for decision-makers and influencers in the field of digitalization to pay more attention to this trend and allocate appropriate resources for the development and integration of distributed classrooms. Investment in this area not only responds to an obvious demand from professionals but can also catalyse significant progress in adapting to an increasingly connected and technology-dependent world.

Several key benefits associated with distributed classrooms have been identified. Among them, "Facilitating Collaborative and Global Learning Experiences" is outstanding, as distributed classrooms eliminate geographic barriers, allowing students and professionals to participate in joint projects, exchange knowledge, and interact with colleagues around the world in an integrated virtual environment.

Additionally, another major benefit highlighted is "Increasing Flexibility in Learning Environments", where distributed classrooms give participants the freedom to access educational materials and engage in learning from anywhere, anytime. This not only supports a personalized learning style, but also aligns with the demands of contemporary life, which requires adaptability and constant accessibility to educational and training resources.

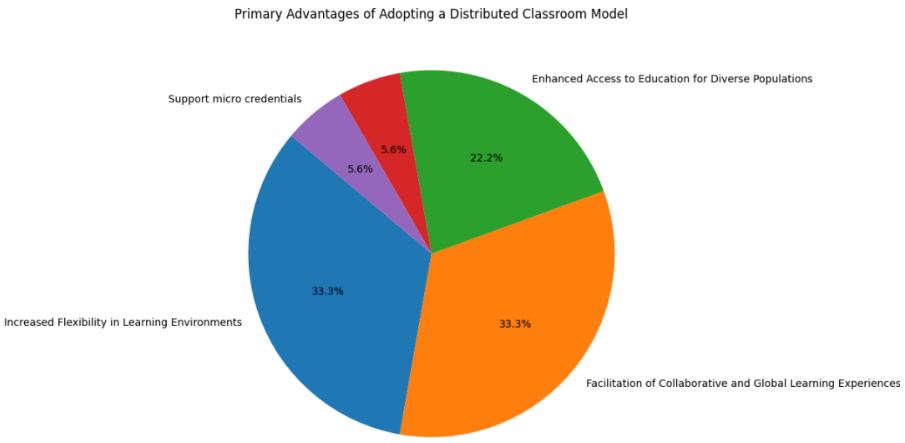

Figure 7. Advantages of Adopting a Distributed Classroom Model (Source image: Authors` own contribution

An emerging advantage identified is support for **micro-credentials**. This dimension of distributed classes represents an innovation in the recognition and certification of skills and knowledge acquired in a modular and specific way. Micro-credentials, by their nature, provide targeted and personalized learning opportunities that are validated through a flexible credential system that is adaptable to individual professional development needs. Distributed classrooms enable the accumulation and documentation of these micro-credentials in an efficient and scalable way, thus providing significant added value in the contemporary educational landscape.

Micro-credentials play a significant role in the context of Education 4.0, where there is an emphasis on personalized, technology-driven, and lifelong learning. Education 4.0 recognizes the need for continuous learning and skill development, and micro-credentials offer a flexible and modular approach to acquiring specific skills, allowing individuals to focus on relevant competencies as per their career goals.

Micro-credentials enable learners to create personalized learning pathways by selecting specific credentials aligned with their interests and career aspirations. This personalized approach is in line with the individualized learning goals of Education 4.0. And, as Education 4.0 acknowledges the importance of a diverse skill set beyond traditional academic qualifications, Micro-credentials provide a means to recognize and validate a wide range of skills and competencies, including those gained through experiential learning and real-world projects.

In the era of Education 4.0, where the pace of change is rapid, micro-credentials offer just-in-time learning opportunities. Individuals can acquire specific skills when needed, responding to the evolving demands of the job market and industry requirements. Not to mention that Micro-credentials can be tailored to address specific industry requirements, ensuring that learners acquire the relevant skills and knowledge demanded by the evolving job market.

Micro-credentials play a vital role in the paradigm of Education 4.0 by offering flexible, personalized, and technology-integrated learning opportunities that align with the evolving demands of the digital age and the fourth industrial revolution. Deploying the distributed classroom, along with the necessary infrastructure to manage micro-credentials, can serve to increase labour market mobility, rapidly recognize specific skills, and facilitate more adaptable and personalized career trajectories.

Our findings show an increasing need to adapt learning methods (Education 4.0) and supporting infrastructure (Distributed Classroom) to actively use active learning and inquiry-based learning through online distributed virtual labs.

Many high-education institutions (HEIs) can work together to create a learning environment where students learn at their own pace, experience the use of digital technologies, and actively work with data and applications through smart innovative labs. Scientists can present their data and use sensor readings that capture information in experiments and can analyse the data remotely in digital labs.

This is part of a culture of using technologies to develop Smart Labs as part of the Living Labs culture (Barbuti et al., 2019). The universities' newly created innovative labs (where the learning experience is centered on data) will support online training for smart specialization on IoT and Big Data technologies, and innovation through data co-creation.

With Smart Labs, technology integration and advanced tools have the potential to redefine the educational landscape (Bergvall-Kareborn et al, 2019). Smart labs leverage cutting-edge technologies such as augmented reality (AR), virtual reality (VR), Internet of Things (IoT), and artificial intelligence (AI) to create immersive and interactive learning experiences. And as Education 4.0 emphasizes experiential learning (see Section 3), smart labs provide a hands-on environment where students can engage in practical, real-world applications of theoretical concepts. This enhances their understanding and retention of information. Smart labs facilitate interdisciplinary exploration by integrating various subjects and technologies. This aligns well with the interdisciplinary nature of Education 4.0, preparing students for a holistic understanding of complex problems. With the help of data analytics and AI, smart labs can tailor learning experiences to individual student needs. This personalized approach

ensures that students can progress at their own pace and focus on areas where they need additional support.

Smart labs often include collaborative tools and platforms, enabling students to work together on projects, share ideas, and solve problems collectively. This collaborative aspect aligns with the collaborative learning emphasis in Education 4.0. And smart labs generate valuable data on student interactions and performance. Educators can use this data to gain insights into individual and collective learning patterns, enabling them to make informed decisions about instructional strategies. On the other side, Smart labs can provide instant feedback to students, allowing them to correct mistakes and refine their understanding immediately. This immediate feedback loop contributes to a more dynamic and responsive learning process.

Thus, Education 4.0 aims to prepare students for the demands of the future workforce. Smart labs expose students to emerging technologies and practical skills that are highly relevant in Industry 4.0, fostering a seamless transition from education to the professional realm. Through online connectivity and virtual collaboration tools, smart labs enable students to connect with peers, experts, and resources globally. This global perspective aligns with the interconnected nature of Education 4.0.

Smart labs serve as dynamic learning environments that align with the principles of Education 4.0 by embracing technological innovation, fostering experiential and collaborative learning, and preparing students for the challenges and opportunities of the fourth industrial revolution.

4.3.1. Possible barriers to the implementation of distributed classroom

The implementation of the concept of distributed classrooms between several universities, especially in an international context, presents several challenges and barriers that can prevent the effective integration of this innovative educational model. This involves the simultaneous participation of students and teachers from different fields. Universities, providing a diverse learning environment and access to a wide range of expertise. However, various obstacles may arise, including national legislation, technological infrastructure, human resource qualifications, as well as other aspects that may affect the implementation and effectiveness of this model.

a) *Different national legislation*: One of the most significant challenges in implementing "distributed classrooms" is the diversity of legislation. Each country has differences in its own set of laws and regulations governing the higher education system, including the accreditation of study programs or the protection of students' personal data.
b) *Lack of the technological infrastructure*: Effective implementation of "distributed classrooms" is highly dependent on the available technology infrastructure. This includes not only the technical ability to deliver real-time lessons and facilitate interactive interaction, but also course management systems, online collaboration platforms and assessment tools. Universities with limited resources may have difficulty securing the necessary technology to effectively participate in such programs.
c) *Insufficiently qualified human resources*: Teachers and administrative staff must have adequate technical and pedagogical skills to meet the specific challenges of "distributed classrooms". This includes becoming familiar with new technologies, adapting teaching methods to fit the online format, and developing cross-cultural communication skills. Without adequate training, academic staff may struggle to maintain student engagement and provide a quality learning experience.
d) *Financial and sustainability issues*: Developing and supporting a distributed classroom program involves significant costs, both in terms of technological infrastructure and in terms

of human and material resources. This can be a barrier for universities with limited budgets. Also, ensuring the long-term sustainability of these programs requires constant financial and administrative commitment.

In the context of the implementation of the distributed classroom concept between universities, the studies of the European University Alliance offer valuable insights to combat various barriers. First, it is essential to strengthen university autonomy, allowing institutions to make strategic decisions and quickly adapt to new educational conditions, such as the implementation of distributed classes. This requires a legislative framework that facilitates interdisciplinarity, flexible learning, and cooperation in education and research, respecting the diversity of university profiles (EUA, 2021).

In addition to autonomy, university leadership must be strong and inclusive, able to shape the institutional profile, and articulate clear goals for the effective implementation of distributed classrooms. Transparency and the inclusion of stakeholders in the decision-making process are essential, and current and future leaders must be supported in developing leadership and transformational skills. In this sense, the professionalization of staff in all areas of university management is crucial and should be a key component of institutional development plans (EUA, 2021).

5. Discussions

Education 4.0 is a conceptual framework that represents the evolution of education in response to the challenges and opportunities presented by the fourth industrial revolution. It encapsulates a set of principles and practices that aim to reshape the educational landscape to better prepare individuals for the demands of the digital age. To understand where we are today with Education 4.0, we made an analysis digitalisation status in universities in South-East Europe. University digitalization is a crucial component of the broader Education 4.0 paradigm, which embraces the integration of advanced technologies to transform the landscape of higher education.

As expected, Universities are increasingly adopting online learning platforms[10] to deliver courses and programs. These platforms offer flexibility in accessing educational content, supporting the personalized and learner-centric approach advocated by Education 4.0. Digitalization enables the implementation of blended learning models, combining traditional classroom instruction with online components. This approach caters to diverse learning styles, fostering a more interactive and engaging educational experience.

Virtual classrooms and collaborative tools, on the other side, have the potential to facilitate real-time interactions among students and educators, transcending physical boundaries. This promotes collaborative learning, a key emphasis in Education 4.0, and prepares students for the interconnected nature of the fourth industrial revolution.

Universities are leveraging digital tools for assessments and feedback. This includes online exams, automated grading systems, and digital feedback mechanisms, contributing to the continuous assessment and feedback loop promoted by Education 4.0. Thus, digitalization allows universities to collect and analyse data on student performance and engagement. Data analytics can be used to

[10] According to our findings, Moodle (https://moodle.org/) seems to be the preferred learning platform put in place by most universities today.

personalize learning experiences, identify at-risk students, and tailor interventions, aligning with the data-driven decision-making aspect of Education 4.0.

Next, digitalization extends to laboratories, where technology-enhanced simulations and virtual experiments provide students with practical experiences. This addresses the challenge of offering hands-on learning opportunities, especially in fields where physical labs may be limited. By going online, digitalization facilitates global collaborations and virtual exchanges between universities worldwide. This fosters cross-cultural interactions and exposes students to diverse perspectives, supporting the global connectivity aspect of Education 4.0.

University digitalization is a key enabler of Education 4.0, promoting flexible, technology-driven, and learner-centric educational experiences. It enhances accessibility, supports continuous learning, and prepares students for the demands of the digital age and the fourth industrial revolution. Through our study we want to make a significant contribution in the context of Education 4.0, focusing on the development and improvement of educational processes in higher education. By highlighting future directions, the study highlights the importance of adapting to Education 4.0 approaches, which include the integration of advanced technologies, interactive teaching methodologies, and personalized pedagogies. This conclusion suggests that to effectively respond to contemporary challenges, higher education must evolve by adopting innovations such as distributed classrooms, strengthening university autonomy and leadership, and strategic investments in infrastructure and professional development. Thus, our study contributes to shaping the future of education in an era characterized by digitalization and global interconnectivity.

The concept of a distributed classroom, which involves decentralized and technology-mediated learning environments, is intricately linked with the principles of Education 4.0. In this context, the distributed classroom plays a significant role in fostering critical thinking skills. A distributed classroom leverages virtual collaboration tools, enabling students to engage in discussions, projects, and problem-solving activities beyond physical boundaries. This virtual collaboration enhances critical thinking as students navigate diverse perspectives, analyse information, and formulate well-reasoned arguments.

Education 4.0 emphasizes the ability to critically evaluate and navigate a vast amount of online information. In a distributed classroom, students are exposed to various online resources, requiring them to develop information literacy skills and discern the credibility and relevance of information. Asynchronous discussions, a common feature of distributed classrooms, has the potential to provide students with the opportunity for thoughtful reflection and in-depth analysis. This asynchronous format encourages critical thinking as students take the time to formulate well-reasoned responses and engage in meaningful discourse.

Distributed classrooms often incorporate problem-based learning approaches where students collaboratively tackle real-world challenges. This fosters critical thinking by requiring students to analyse complex problems, propose solutions, and evaluate the potential outcomes of their decisions.

In a distributed classroom, students can interact with peers and educators from diverse cultural backgrounds. Exposure to global perspectives encourages critical thinking by challenging assumptions, broadening perspectives, and fostering a more nuanced understanding of complex issues. The distributed nature of online learning allows for the implementation of continuous feedback loops. Immediate feedback on assignments, discussions, or assessments provides students with the opportunity to reflect on their thinking processes, identify areas for improvement, and refine their critical thinking skills.

Distributed classrooms often include project-based assessments that require students to apply critical thinking skills to solve authentic problems. These assessments go beyond traditional exams, emphasizing the application of knowledge in real-world contexts. The flexibility of distributed classrooms contributes to creating more inclusive learning environments. Students from various backgrounds and learning styles can actively participate, fostering a diversity of thought and perspectives that enrich critical discussions.

The distributed classroom in Education 4.0 serves as an environment conducive to the development of critical thinking skills through virtual collaboration, access to online resources, problem-based learning, and the integration of adaptive and interactive technologies. It prepares students for the complex challenges of the fourth industrial revolution by nurturing their ability to analyse, evaluate, and synthesize information in diverse and dynamic learning environments.

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Annex 1

Survey

General Data:

- Country
- Name of the University
- Name of the representative
- Position/Role
- Contact Information (Optional)

Strategy for digital transformation:

Does the university have a strategy for implementing digital transformation in the educational process and its related services and administrative processes?

YES/ NO

If YES, it is:

a) Annual

b) Multiannual

Attach a link to the document: .....

In the strategy, are there elements for the implementation of education 4.0 in your university?

YES/ NO

If YES, please present which would be found in the strategy:

a) Distributed classrooms
b) Artificial Intelligence
c) Internet of things
d) AR/ VR
e) Others:

Are there specific policies in your university related to the ethical use of AI?

YES/NO

Awareness and Perception	1	2	3	4	5	N/A
How do you rate the level of awareness and understanding of the ethical implications of artificial intelligence within your university?						
How important do you think the ethical use of AI is in education?						

Is there specific AI ethics training or courses for students or teachers?

YES/ NO

If YES: How often are these training sessions held?

a) once a quarter
b) two or more times per quarter
c) twice a year
d) once a year

The training sessions are supported by

a) Own employees
b) The process is outsourced

Understanding the Necessity of Distributed Classrooms:

	1	2	3	4	5	N/A
How well do you understand the concept of distributed classrooms?						
Do you believe distributed classrooms can benefit students and institutions?						
Do you believe there is a necessity for implementing distributed classrooms in today's educational landscape?						

Potential Benefits and Opportunities:

- In your opinion, what are the primary advantages of adopting a distributed classroom model?

  a) Facilitation of Collaborative and Global Learning Experiences
  b) Increased Flexibility in Learning Environments
  c) Enhanced Access to Education for Diverse Populations
  d) Other

- Can you provide examples or specific scenarios where distributed classrooms could be particularly beneficial?

Barriers and Challenges:

- Other than the ones mentioned above, what do you see as potential challenges or barriers to implementing distributed classrooms within universities?
- What kind of support and infrastructure do you think universities would require to successfully implement distributed classrooms?

Future Considerations:

	1	2	3	4	5	N/A
Do you believe that a hybrid approach (combining traditional and distributed classrooms) might be a more feasible option initially?						

- What steps do you think universities should take to gradually transition towards a distributed classroom model?

Additional Comments:

- Is there any additional information or insights you would like to share regarding distributed classrooms or their implementation?