

ACCESSIBILITY, CONNECTIVITY AND COMMUNITY FOR THE DIGITIZATION OF ROMANIAN PRE- UNIVERSITY EDUCATION

Denisa Mihaela ȘULĂ

ORCID: <https://orcid.org/0009-0008-9097-8788>

University of Craiova, Craiova, Romania

E-mail: denisamihaelas@yahoo.com

DOI:

Abstract

The article explores the critical factors of accessibility, connectivity, and community in the digitization of Romanian pre-university education. Human capital is considered the cornerstone of educational transformation, and its development must align with sustainability principles to ensure long-term growth. This requires a systematic enhancement of pedagogical practices, the integration of technology, and the expansion of teacher competencies, particularly in digital skills. The professional development of educators plays a key role in meeting evolving educational demands. The paper emphasizes the importance of digital infrastructure, including the availability of broadband and technological tools, as essential elements for a sustainable educational ecosystem. Additionally, the article argues for a decentralized decision-making approach to provide schools with greater autonomy in addressing local needs. Despite the challenges, Romania's education system has the potential to evolve through the adoption of innovations, the reinforcement of digital capabilities, and the integration of existing best practices.

Keywords: Human capital, sustainable education, teacher competencies, digital transformation, professional development.

1. An Introduction on Innovative Solutions and the Digital Education Ecosystem

The education system must evolve, adapting to the profile of its beneficiaries to fulfill its mission of preparing them for the interconnected and complex world in which they live, with all its changes. From an internal perspective, this involves stimulating innovation and creativity among teachers.

Alongside these priorities, the education system must be supported. Support refers to raising awareness of its importance for society and the economy. This approach requires collaborations with the external environment of the education sector, as well as collaborations within the system.

Internal collaboration means educational partnerships through which human resources can develop professionally, while learners acquire the competencies needed for the job market. Any form of collaboration is based on the innovation potential realized by the teachers. Innovation in education refers to identifying,

prioritizing, and planning actions based on the specific activities of teachers and those they work with in the educational process.

The innovative potential of the education sector can be assessed, with a useful tool being the HEInnovate platform (HEInnovate, 2025), a self-assessment tool from the European Union offered to educational institutions that wish to explore their innovative potential.

The support offered consists of the possibility for any educational institution to identify its current situation and potential areas for action.

These areas of action may include leadership and governance, organizational capacity, entrepreneurial teaching and learning, preparing and supporting entrepreneurs, digital transformation capacity, knowledge exchange and collaboration, institutional internationalization, and impact measurement.

If a school institution supports its development objectives through innovative activities, then key resources, such as funding, investments, human resources, expertise, and knowledge, are very important.

Entrepreneurial teaching and learning involve exploring innovative teaching methods and finding ways to stimulate an entrepreneurial mindset.

Entrepreneurship is merely a context; the entire educational process must aim at shaping the "open minds of learners", which involves exposing them to educational experiences that help them acquire the skills and competencies needed to develop an innovative mindset. Schools benefit from infrastructure and digital technologies to varying degrees.

Therefore, it is necessary for them to fully take advantage of the opportunities for digital transformation and consider digital technologies (integration, optimization, and transformation of digital technologies to support the educational process) as a key factor. Knowledge exchange is an important catalyst for organizational innovation and teaching progress.

2. Digital Education Ecosystem

It is a continuous process of stimulation, direct application, and exploitation of knowledge for the immediate benefit of teachers and learners and, in the long term, for the social and economic benefit of society.

The education sector is conducive to creating the knowledge triangle (education-research-innovation) through collaboration, sustainable competitiveness, and a proactive approach to the changes it faces.

OECD and Eurostat (2019) present the structure of innovation as a result of the innovation process.

The structure of innovation, according to OECD and Eurostat (OECD and Eurostat, 2019), consists of "knowledge, the novelty offered, its implementation and efficient use, and value creation". Knowledge involves "applying existing and newly acquired information and knowledge," obtained "through cognitive effort and, therefore, is difficult to transfer because it requires learning on the part of the recipient" (OECD and Eurostat, 2019).

Šova *et al.* (2019) state that "the novelty of an innovation is related to its potential uses, determined by the characteristics of a product or process compared to others, as well as the prior experiences of the provider and the intended users of the innovation."

The requirement for implementation is a key characteristic of innovation, which distinguishes it from inventions, prototypes, or new ideas (Şova *et al.*, 2019). The true value of an innovation is often uncertain and cannot be fully assessed until some time has passed since its implementation.

From the perspective of innovation theories, particularly in education, Rogers (1962) explains that innovation is a process where new ideas are progressively communicated and adopted within a group. This process unfolds gradually as members of the group begin to embrace and implement the new ideas.

In practical terms, Kline and Rosenberg (1986) describe innovation in education as a learning process that benefits from multiple contributions. It involves ongoing problem-solving and requires approaches that are both multidisciplinary and interdisciplinary. This is essential because the education system is continually changing and must be able to adapt to new needs and challenges.

Pedagogical innovation can influence various aspects of the education system, including teaching methods, curriculum structures, and learning environments. According to Şova *et al.* (2019), innovation is closely linked to improved educational outcomes. In particular, introducing innovative practices has been shown to enhance academic performance by fostering more effective and engaging learning experiences.

Innovation is also crucial for motivating students to engage in their learning. This is especially important in light of the fact that traditional teaching methods often fail to capture students' interest. By incorporating innovative approaches, educational experiences become more appealing and satisfying for students, leading to greater engagement and improved results.

In addition to benefiting students, innovations help bridge existing gaps, such as the digital divide, by ensuring equal access to new technologies and educational resources. Innovations also contribute to reducing inequalities in education by making learning opportunities more accessible to diverse student groups.

Moreover, innovations in education play a significant role in promoting the professional development of educators. For teachers, innovation is both a result and a catalyst for ongoing growth, encouraging them to adopt new teaching strategies and engage with fresh ideas in the classroom.

While innovations have the potential to reduce costs in education, the lack of sufficient funding can slow down or even hinder the innovation process. This reality underscores the importance of financial stability and predictability for supporting and sustaining innovation in the education sector.

Rogers (1962) also identifies different types of individuals who contribute to the process of innovation adoption. Innovators are open to new ideas and quick to implement them, while early adopters are focused on their own achievements and do not advocate for every innovation. The early majority adopts innovations once they have been tested and proven, while the late majority is more skeptical and only embraces new ideas under pressure. Laggards, on the other hand, resist change and tend to rely on traditional methods and past experiences.

Covey (2001) analyzes the human aspect of innovation, emphasizing that innovation depends on people's ability to generate new knowledge and ideas. It also depends on their capacity to apply these ideas effectively both in the workplace and within society. To support innovation, it is necessary to systematically utilize creative methods and create an environment that stimulates

creativity, while also encouraging employees to actively participate in the innovation process.

The involvement of educators in the innovation process is critical, as it is considered one of the most complex and demanding tasks, requiring a significant level of commitment from teachers (Covey, 2001). Innovation holds educators accountable, as it becomes an ongoing goal they must strive to meet daily.

Innovation in the education system is part of a structured vision for its development, which includes digital education and the digital transformation of the field. There are lessons learned from the COVID-19 pandemic that inform the transformation and sustainable development of education. These lessons guide future directions for the sector's evolution in a durable and sustainable manner.

The advancement of digital education and the transformation of the educational system can be achieved by adopting smart technologies and adapting them to online teaching and learning with new, more efficient solutions. However, this is a broad approach to digital transformation, and more in-depth efforts are needed. These include the establishment of educational platforms, digital learning environments, teaching methods, infrastructure, digital teaching competencies, and curricula designed to foster and develop (interdisciplinary and transversal) digital skills, along with educational policies and administrative capacities.

This approach contributes to the creation of a digital learning ecosystem (DLE), which is grounded in enhanced digital competencies. This vision for the digital transformation of educational systems aligns with the European Commission's strategy, as outlined in the Digital Education Action Plan – Resetting Education and Training for the Digital Era 2021-2027 (European Commission, 2020).

The digital ecosystem is understood as a network of interconnected information technology resources that function as a unified whole. Nguyen and Tuamsuk (2022) in reviewing 35 publications from the 2021-2022 period related to the Digital Learning Ecosystem (DLE), identified three key research directions in the reviewed literature: components/models of DLE, roles within DLE, and factors that either foster or hinder the development of DLE.

The digital learning ecosystem has been explored from multiple perspectives. The nature of the terms has highlighted the characteristics and components of a learning ecosystem in various environments. Some studies identified a DLE with two main components: biotic (human) and abiotic (non-human). Other studies either expanded or narrowed the subcomponents of this ecosystem based on the characteristics of educational institutions or their external environments. For example, some definitions focused on digital platforms, teaching methods, technologies, educational resources, and learning tools. Others concentrated on systems, processes, changes, educational resources, and assessment methods.

Reyna (2011) designed a digital teaching and learning ecosystem based on an ecological approach, distinguishing between two components: a biotic component (teachers) and an abiotic component (technological devices, the internet, e-learning platforms, communication tools, collaboration tools, and content). Further studies, such as those by Gütl (2008), Kummanee *et al.* (2020), Markoska (2017), Põldoja (2016), and Sarnok *et al.* (2020), included additional elements such as users, educators, peers, families, tutors, system administrators, content creators, designers, experts, hardware, software, databases, networks,

media, pedagogical theories, open educational resources, learning environments, and assessment tools.

According to Quaicoe *et al.* (2016) physical devices, digital resources for teachers, ICT capabilities, training opportunities, and network creation are crucial tools in building an educational digital ecosystem. Similarly, Davidson *et al.* (2019) proposed a five-part conceptual framework, which includes personality, student approaches to learning, intrinsic motivation, perceptions of the course experience, and current and previous academic outcomes, introducing psychological and sociological elements into the understanding of the digital learning ecosystem.

Regarding roles within the digital educational ecosystem, they can be divided into two categories: biotic (teachers, students, e-learning system administrators) and abiotic (internet, infrastructure that provides and stores resources, technologies, interfaces, digital media, portals).

The learning management system must facilitate the sharing of learning resources, uploading functions, communication, collaboration, and dialogue. Additionally, electronic examination systems need to be developed to account for the characteristics, processes, and collaboration between groups, aiming to enhance the quality of electronic assessments within digital ecosystems.

A key characteristic of a digital educational ecosystem is the interaction between components that transforms information into knowledge. The interaction within the Digital Learning Ecosystem directs understanding and helps develop the knowledge of learners while improving communication skills.

Giannakos *et al.* (2011) highlight the relationship between teachers, learners, and resources as the foundation for five types of interactions: "teacher-student, student-student, student-resources, resources-resources, teacher-resources."

Laanpere *et al.* (2014) outline three principles governing the interactions among the elements of a digital educational ecosystem:

- The first principle emphasizes that "the flexibility of a digital learning ecosystem to export and/or import information and knowledge depends on the nature of the 'architecture' of the system's components (e.g., connectivity, grouping), the characteristics of the components, their diversity and distribution, and the interactions among them".
- The second principle focuses on "the response, change, and feedback of the system's components".
- The third principle relates to "the exchange of energy and matter within the network".

The constituent elements of the Digital Learning Ecosystem and those from its external environment have a significant influence on the development of a digital educational ecosystem. The interactions among the three analyzed areas have played a crucial role in improving the quality of education.

The viewpoint presented highlights key aspects that have been integrated into the strategies of the Romanian education system, such as the digital transformation of various elements of the education system, the digitization of specific educational processes through the use of technologies and digital data, and the digitization of the learning environment through digital tools and communication platforms.

The trend is toward digital transformation, which involves transforming activities, processes, and competencies in line with the opportunities offered by digital technologies.

The strategy for the digitalization of education in Romania, SMART-Edu (2021) a public consultation document included in the Romania Educated Project, presents the digital education ecosystem with the following components: "digital infrastructure and technological resources, connectivity, creation of open educational resources, cybersecurity, data protection, online safety and IT ethics, administrative capacity."

The structure proposed by SMART-Edu (2021) for creating the digital educational ecosystem includes processes and resources that support and ensure the functionality of such a framework. These elements are interconnected, with each one adhering to digital rights and principles.

The document *Digital Decade of Europe: Digital Objectives for 2030* (European Commission, 2021) outlines digital rights and principles, complementing existing rights found in other documents. It provides a reference framework for digital rights and offers guidelines for digital transformation, emphasizing the following points:

- People and their rights are at the center of digital transformation.
- Solidarity and inclusion must be supported.
- Online freedom of choice must be guaranteed.
- Public digital space participation is based on promotion.
- Enhancing safety, security, and empowerment of individuals.
- The sustainability of the digital future should be promoted.

The *Romania Educated Report* (2021) links the development of the digital education ecosystem with teacher training and addressing "digital divides." In this context, three key conditions are prioritized: "access to high-capacity internet networks, the presence of a functional computer lab with adequate hardware and software resources, and the availability of teachers with basic digital skills who can support the learning of students and peers" (Romania Educated Report, 2021).

Within this objective, *Romania Educated* proposes "the development of a national platform for educational resources, the provision of digital vouchers for purchasing appropriate portable educational devices for learning, and the offering of internet vouchers for students from socially vulnerable backgrounds" (Romania Educated Report, 2021).

Additional aspects include "developing the capacity of educational institutions to provide hybrid learning and teaching methods, and supporting parents/tutors in using online platforms" (Romania Educated Report, 2021). Cybersecurity, data protection, online safety, and IT ethics are also addressed.

SMART-Edu 2021 and the *Romania Educated Project* are crucial steps toward Romania building educational development strategies, policies, and competency frameworks aimed at improving the quality of the education system.

These elements play a crucial role in fostering the sustainable development of the educational system, helping to design learning management systems that align with the European digital vision for education.

Pinet et al. (2021) emphasize the importance of creating "sustainable and durable educational systems that leverage digital technologies as tools" for students.

The Romanian education system encompasses all the necessary components for constructing a digital educational ecosystem. The development of a digital learning ecosystem, equipped with appropriate policies, procedures, technologies, and the preparation of schools, teachers, students, and digital content, can be viewed as a vital tool for addressing crisis challenges and enhancing the sustainability of educational institutions.

3. Ensuring accessibility, fostering connectivity, and building a community for the digital evolution of education

The European Union has made supporting the green and digital transitions in education and training a key priority for creating a strategic framework to build a "European Education Area" (European Commission, 2021).

In this context, the Romanian education system must still work on improving its digital readiness, particularly in terms of accessibility and security (European Commission, 2023). The Digital Education Action Plan 2021-2027 (European Commission, 2020) emphasizes the importance of fostering a high-performance digital education ecosystem.

The national strategies of Romania, such as SMART-Edu (2021) and Romania Educated (2022), focus on enhancing accessibility by ensuring the provision of digital infrastructure and emerging technologies to guarantee inclusive and high-quality education.

Romania's vision for digital infrastructure in education (SMART-Edu National Strategy, 2021) links the technological architecture to the goal of offering equitable, relevant, and engaging digital education that doesn't marginalize children from disadvantaged backgrounds or those with disabilities.

The main goal is to create the necessary infrastructure and technological resources across all educational institutions to inspire motivation and engagement in learning (SMART-Edu National Strategy, 2021).

The strategies advocate for diversifying and ensuring accessibility to digital teaching tools, such as interactive digital textbooks, virtual labs, and lessons that meet accessibility standards (WCAG A, WCAG AA, WCAG AAA). Additionally, they promote providing ultraportable devices and peripherals, free access to software and applications, and access to educational resources for all students (2021).

The SMART-Edu strategy (2021) also outlines a plan to digitalize administrative procedures such as online admissions, managing students' daily activities, integrating distance learning systems, and issuing and recognizing diplomas in digital formats. To ensure accessibility, the strategy proposes virtualizing data centers in schools, offering services such as data, video, Wi-Fi, and secure connections, and implementing policies on access, security, digital identity, and data analysis (SMART-Edu National Strategy, 2021).

The strategy also outlines plans to introduce Artificial Intelligence systems for continuous monitoring of students' skills and progress, enabling real-time personalized adjustments to the teaching and learning process.

To strengthen accessibility further, SMART-Edu (2021) suggests creating a comprehensive map and database for connectivity and device access, allowing for better decision-making and efficient resource distribution.

The Romania Educated Project (2021) emphasizes the need to recalibrate teacher training programs to better equip educators with digital skills. Additionally, it

proposes access to high-capacity internet and the provision of necessary hardware and software for all schools.

These systemic changes are also accompanied by initiatives to create differentiated digital educational content, develop a national platform for educational resources, and provide digital vouchers for purchasing portable educational devices and internet access.

SMART-Edu and the Romania Educated Project share many common goals, though the latter presents them in a less detailed way, lacking a comprehensive operational plan with concrete steps.

Both documents have had a significant influence on the recent revision of the Education Law (Laws 198 and 199/2023). However, the situation remains challenging for Romanian education, especially when considering Romania's last-place ranking in the 2022 DESI (Digital Economy and Society Index) report, which evaluates the digital performance of EU countries. In terms of connectivity, Romania ranks 15th, which is below the EU average, with low scores in broadband uptake and coverage (DESI, 2022).

Furthermore, Romania's overall digitalization score is significantly lower than the EU average, reflecting a substantial gap that needs to be addressed.

The digital divide, marked by limited internet access, restricts educational opportunities and hinders learning, contributing to a growing digital inequality, as noted by SMART-Edu (2021). Ensuring connectivity requires not only better internet access but also the provision of educational equipment and the development of digital skills among educators.

The lack of reliable internet in rural areas, combined with energy poverty, exacerbates the digital divide and makes it harder for students in these regions to benefit from digital learning.

SMART-Edu (2021) addresses these challenges by proposing an integrated approach to connectivity, which includes providing secure and fast internet connections for schools to ensure uninterrupted learning experiences. It also suggests that students without internet access at home could benefit from free community-based internet access, which could help bridge the gap. Achieving effective connectivity requires coordinated efforts across multiple areas of the digital ecosystem, including electricity, educational devices, and digital curricula, to create a cohesive, supportive environment for students and teachers alike.

Additionally, SMART-Edu (2021) encourages the active involvement of stakeholders and proposes a program like "Adopt a Digital School," where mobile and data providers can help develop local networks to ensure better connectivity in underserved areas.

The approach being adopted is a public-private partnership aimed at addressing the connectivity gap while also fostering the creation of a digital community that guarantees access to electricity, signal, internet, and technology for the needs of schools.

In the context of the SMART-Edu Strategy (2021) a digital community is defined as a collaborative effort between public and private entities, including partnerships with fixed internet providers, mobile telecommunication companies to expand broadband infrastructure across the country, and electricity suppliers.

Accessibility, connectivity, and community are key components in the development of a digital education ecosystem. These elements represent both the functional and internal environmental aspects of the ecosystem. Their significance

lies in their technical nature, which ensures the functionality of digital transformation in education, thereby supporting the sustainable transformation of the educational system.

4. Conclusions

Human resources are universally acknowledged as the most valuable asset in education, and human capital is the central factor in driving the sustainable transformation of the educational system. This transformation requires a fundamental shift in how human capital in education is approached and nurtured.

From the perspective of sustainability, as outlined in the Brundtland Report, human capital in education should not only be preserved but actively developed. This means recognizing it as a dynamic resource that grows in value through continuous learning, adaptation, and improvement.

The sustainable development of education hinges on improving and evolving pedagogical practices, which must be considered in a long-term, systemic context. This involves not only enhancing current teaching practices but also ensuring their sustainability and relevance in the context of rapidly changing societal needs.

A sustainable educational system requires a strategic, forward-looking approach to the continuous development of teaching methodologies that align with the ongoing shifts in student populations and the hierarchical structure of education levels.

Moreover, the influence of human capital in education is not isolated but interconnected with various other social subsystems. It must be approached in a horizontal manner, meaning that teachers, students, and all involved stakeholders must collaborate in an integrated framework that emphasizes the professional growth of educators.

Additionally, the role of technology cannot be overlooked. Teachers must be provided with the necessary tools and skills to utilize technology effectively, ensuring that the integration of digital resources is meaningful and beneficial to both educators and students alike.

In the context of sustainable educational transformation, it is essential to ensure that the realities of the education system align with the principles of sustainability. A fundamental understanding is that no school can function effectively without teachers, and the quality of a school is ultimately determined by the quality of its educators.

Therefore, the framework for teacher competencies must be continuously reassessed and expanded. The competencies required for teachers today must go beyond traditional knowledge to include not only expertise in their subject areas but also proficiency in pedagogical methods and the integration of technology into the learning process.

A highly skilled and competent teacher must be able to design their teaching approach based on a balance of specialized knowledge, pedagogical expertise, and technological fluency. The integration of digital competencies within teaching practices is particularly crucial in fostering an engaging, motivating, and supportive learning environment.

Teachers equipped with digital skills can make the learning process more accessible and adaptable to the needs of diverse student populations, ensuring that learning becomes an empowering experience for all students.

To achieve this, professional development and ongoing training of teachers must be prioritized. This is not just a one-time event, but rather an ongoing process that evolves alongside the changes in educational demands.

Teachers must be given continuous opportunities to develop their skills in response to emerging educational needs, and these opportunities should be designed to be systematic, structured, and comprehensive. By embedding a culture of lifelong learning among educators, the education system can ensure that it remains agile and responsive to the evolving needs of students and society as a whole.

Furthermore, the resources available within the education system must be leveraged and transformed to meet the demands of a rapidly changing world. The creation of a robust and dynamic digital educational ecosystem is crucial, and it is closely tied to the broader European vision for education. Such an ecosystem is essential for the sustainability of education as it allows for greater flexibility, inclusivity, and innovation within teaching and learning processes.

The concept of digitalization in education is not merely about incorporating technology into classrooms but about creating an environment where education is digitally enhanced, accessible, and inclusive for all.

The education system should be viewed as an investment for the future, rather than as a financial burden. The impact of teachers' work extends far beyond the present moment, shaping the future of students who will go on to become active citizens in society.

The knowledge and skills that students acquire today will lay the foundation for their contributions to society in the future. By investing in the professional development of teachers, the provision of high-quality resources, and the integration of technology, we can ensure that this investment yields long-term benefits for individuals and society as a whole.

The Romanian education system, despite the current challenges and criticisms, has been recognized for its intrinsic value and the achievements of its teachers. The country has shown that it is capable of producing high-quality educational outcomes, even under difficult circumstances.

Moving forward, the key lies in preserving and building upon what already works. This includes maintaining and expanding good practices, innovations introduced by teachers, integrating digital technologies into teaching, and adopting new curricular approaches. These elements must be at the forefront of efforts to create a sustainable educational system in Romania.

The decision-making architecture within the education system must also be restructured to facilitate greater autonomy for schools. A more decentralized approach to decision-making would allow for a more responsive and flexible system that can address the specific needs of individual schools and local communities.

School leadership should be collaborative, with decisions being made through consultation and engagement with teachers and other stakeholders. After all, the educators in the classrooms are the ones who best understand the unique challenges and opportunities within their own schools. They are the ones who are closest to the realities of the educational process and, therefore, should be actively involved in shaping the decisions that affect them and their students.

The integration of technology into the education system is crucial, but it is important to recognize that simply providing technological equipment is not

enough. The real transformation occurs when technology is embedded within the teaching process itself. Educational infrastructure, digital infrastructure, and connectivity are all essential components of a sustainable education system.

These foundational elements enable the creation of a more flexible, dynamic, and responsive education system, where teaching and learning can take place anytime and anywhere.

In conclusion, it is clear that Romania has the potential to create a sustainable and transformative education system. However, to achieve this, there must be a focus on identifying key priorities and structuring a model that fosters continuous improvement and adaptation.

The development of teacher competencies, the integration of digital tools, and the creation of a dynamic, inclusive learning environment are central to this vision.

Only through a concerted and coordinated effort across all levels of the educational system can Romania truly achieve a sustainable, future-ready education system that meets the needs of students, educators, and society as a whole.

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