

Building and Maintaining Learning Ecosystems in Alignment with the Digital and Green Transition

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Abstract

In an era of rapid technological advancements and the need for continuous learning, creating and maintaining effective learning ecosystems is essential for fostering adaptive, lifelong learning. This paper explores the theoretical foundations and practical strategies for building learning ecosystems that are sustainable, inclusive, and responsive to diverse learner needs. A learning ecosystem integrates various elements – such as digital tools, physical spaces, pedagogical approaches, and community involvement – to support formal, non-formal, and informal learning. Drawing on interdisciplinary research from education, technology, and systems theory, this paper presents a framework for designing learning ecosystems that promote learner autonomy, collaboration, and adaptability. It also examines key challenges, such as scalability and evolving learner expectations, and proposes strategies for maintaining these ecosystems over time.

Keywords: learning ecosystems, double transition, formal education, non-formal education, informal education.

1. Introduction

The Covid-19 pandemic significantly accelerated the digital and green transitions across nearly every dimension of contemporary life. This shift was particularly pronounced within Europe, where an array of policies actively encouraged and facilitated the adoption of sustainable practices across public institutions, private enterprises, and individual households alike. These policies underscored an urgent imperative for sustainability, fostering a collective move towards digital and ecological resilience as central pillars of post-pandemic recovery. Many of the concepts underpinning these initiatives were not entirely novel; indeed, ideas surrounding digitalization and sustainability had been progressively gaining traction on both political and social agendas well before the pandemic. However, the unprecedented constraints imposed by Covid-19, particularly the widespread necessity for social distancing and remote operation, catalyzed a swift reconfiguration of social and economic activities. For instance, the rapid pivot to online platforms within education underscored the potential of digital tools to not only maintain continuity but also introduce more efficient, flexible modes of learning. This transition to digital infrastructures, which had previously been approached incrementally, was expedited out of necessity, bringing a host of sustainable and environmentally considerate practices to the fore. As a result, what had initially been tentative steps towards digital and green transformation evolved into a comprehensive reimagining of traditional systems, each of which now incorporates an additional digital layer to varying degrees.

- Successful transitions require active collaboration among educators, learners, industry, and government.
- Educational institutions should adopt digital tools thoughtfully, ensuring they align with sustainability goals for long-term impact.
- Effective digital platforms must be inclusive, addressing disparities in digital literacy and access.
- Organizations should cultivate a culture of continuous learning and adaptability, fostering innovation and enhancing responsiveness to emerging challenges.

This increasing interconnectedness of systems, coupled with the rapid pace of transformations, has intensified the demand for more efficient and inclusive approaches to lifelong learning. This urgency is particularly evident across three distinct demographic groups: young people preparing for future employment, the current workforce seeking to maintain relevance and competitiveness, and, often less discussed, the elderly population whose adaptation to these changes is crucial for their autonomy and quality of life.

Firstly, there is a critical need to equip the younger generation with the skills, knowledge, and competencies essential for navigating the complexities of the modern world. Beyond basic literacy and numeracy, contemporary education must incorporate digital literacy, environmental awareness, and adaptability to prepare young people not only to succeed in the workplace but also to contribute meaningfully to an increasingly complex society.

For those of working age, the rapid evolution of technologies and job market requirements necessitates continuous professional development to ensure sustained employability. Workers are now expected to engage in ongoing skills acquisition, often in the form of digital and technical upskilling, to remain aligned with industry standards and competitive pressures.

Finally, and often under-emphasized in policy discussions, is the imperative to support older adults in adapting to technological and social changes that impact their daily lives. These demographic faces unique challenges as they navigate shifts in communication, healthcare, transportation, and essential services that increasingly rely on digital platforms. Ensuring the inclusion of older adults in the digital and green transitions is not only a matter of equity but also one of social cohesion and individual well-being.

Meeting those diverse educational needs necessitates the provision of robust resources and comprehensive approaches that empower individuals with the tools and competencies required for lifelong learning. To achieve this, it is essential to develop and implement adaptable learning frameworks that foster not only foundational skills but also the critical, digital, and environmental literacies increasingly indispensable in a rapidly evolving world which is the aim of the following paper.

2. Method

The methodology adopted for this research employs a mixed-methods approach designed to thoroughly examine contemporary developments, systematically map existing models, and identify exemplary practices in the field. By integrating both quantitative and qualitative techniques, this mixed-methods framework provides a comprehensive view of the current landscape and offers valuable insights into the applicability and effectiveness of emerging models.

To begin, a literature review was undertaken to build a theoretical foundation for the study, concentrating on selected scholarly articles, and recent publications. This review fulfilled

two key objectives: it offered a critical synthesis of predominant theories and frameworks related to learning ecosystems, and it enabled the identification of common themes, trends, and recurring challenges within existing research.

Building on the insights derived from the literature review, the research incorporated case study analyses of three trending digital platforms. These cases were selected based on their innovations, as well as their practical relevance within the current market. Each case study involved an examination of the product's design, implementation, and user impact. Data for these analyses were gathered through secondary sources, product documentation, user feedback, and, where possible, insights from industry reports. This method enabled a detailed exploration of best practices, as well as a nuanced understanding of the conditions and strategies contributing to the success or challenges of these digital products.

The triangulation of findings from the literature review and case studies facilitated a holistic perspective on the state of building and maintaining personal learning ecosystems. Moreover, this methodology allowed for the identification of specific "blind spots" in the field, which represent areas of significant potential for future research. These gaps, observed across both theoretical and practical domains, underscored the need for additional empirical studies to further refine and adapt models in response to evolving technological and environmental contexts.

3. Results

Integrating digital and green transitions into learning ecosystems presents a complex, multifaceted challenge that necessitates a comprehensive and holistic approach. The following insights delineate several critical features essential for their successful implementation and sustainability based on the literature review.

3.1 *Stakeholder inclusion and resilience in formal education and beyond*

Effective digital transformation in educational institutions, especially schools, relies on the inclusion of multiple stakeholders, robust resilience to potential disruptions, and the establishment of internal networks for sharing practices and knowledge. This development of sustainable educational reform is closely linked to building capacity through professional learning communities. They can foster continuous learning by enhancing motivation, skill development, and supportive organizational conditions. To ensure this, a strong support infrastructure is essential for professional learning communities, as it allows educators to engage in reflective practices, develop new skills, and implement effective instructional strategies (Stoll, Bolam, McMahon, Wallace & Thomas, 2006). Schools, as core engines to formal education, must strategically balance current technological needs with long-term developmental goals, incorporating technology in a way that is both adaptive and forward-looking (Jeladze & Pata, 2018). Here the idea of "mass collaborative" learning that moves beyond traditional, teacher-centric approaches toward self-directed models, where learners actively participate in creating and sharing knowledge has a core role. For these systems to succeed, organizational structures must support collaborative techniques and facilitate technology adoption. By empowering participants as co-creators, mass collaboration can enhance learning outcomes and strengthen community engagement within the ecosystem (Zamiri & Camarinha-Matos, 2019). This includes also focusing on design literacy and participatory co-design processes that are fundamental to the development of smart learning systems that prioritize human well-being and social innovation. By integrating digital technologies with co-design principles, learning ecosystems can align with the United Nations Sustainable Development Goals (SDGs), enabling learners and communities to address social and environmental challenges innovatively (Giovannella & Manca, 2019). To ensure the successfulness of the digital and more precisely e-learning dimension, it's required a nuanced

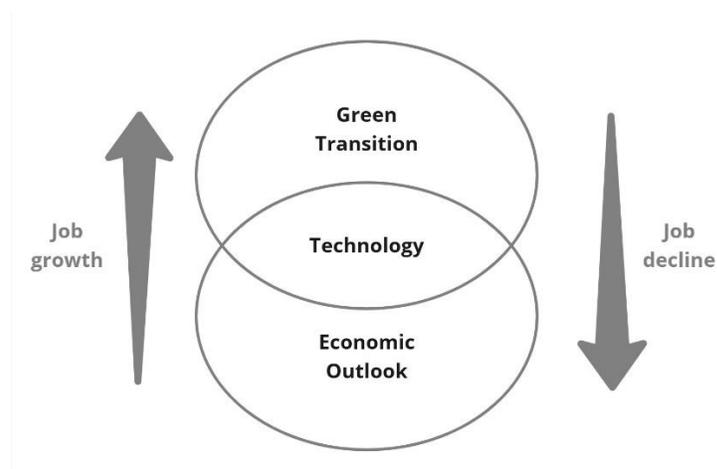
comprehension of principles, methodologies, processes, systems, and content that collectively support effective learning. Addressing barriers, such as gaps in technological literacy, is essential to enable seamless implementation and ensure accessibility. Effective e-learning environments are designed to foster engagement and adaptability by mitigating technological obstacles and supporting users with varied levels of digital proficiency (Sridharan, Deng & Corbitt, 2010).

Following the traditional formal education pathways universities are also worth noting. They can play a pivotal role structurally building upon school education towards developing entrepreneurship ecosystems by bridging academia, industry, and government to foster knowledge exchange and economic advancement. This tripartite collaboration is instrumental in supporting regional economic growth, as it facilitates the commercialization of academic knowledge and strengthens the integration of innovative research into practice, ultimately advancing entrepreneurship and regional development (Belitski & Heron, 2017; Bedó, Erdős & Pittaway, 2020). This leads the way to an ecosystem approach to education that promotes lifelong learning through active cooperation between educational institutions, businesses, and governmental bodies. This model supports the cultivation of a generation equipped to lead and sustain digital and green transitions, fostering resilience, adaptability, and a culture of continuous learning critical for addressing future challenges (Kanke & Eremina, 2022). When contextualizing in the surrounding public area, all stakeholders must develop dynamic capabilities to identify, seize, and reconfigure opportunities effectively. This type of ecosystem orchestration requires configuring strategic partnerships, developing cohesive value propositions, and establishing governance structures that align stakeholder objectives, ensuring agility and responsiveness in rapidly changing environments (Linde, Sjödin, Parida & Wincent, 2021). Here it's worth mentioning the digital ecosystems and the Digital Twin paradigm that offer a flexible, integrated framework that can inform and accelerate responses to global sustainability challenges. Digital Twins, representing physical assets in a digital format, provide decision-makers with actionable insights into environmental impacts and sustainability goals, allowing for more efficient planning, monitoring, and adaptation (Nativi, Mazzetti & Craglia, 2021). They also enable dynamic, real-time sustainability assessments in educational buildings, optimizing energy efficiency and environmental quality throughout the building's lifecycle. Such continuous assessment supports environmentally sustainable practices, contributing to the operational and ecological efficiency (Tagliabue, Cecconi, Maltese, Rinaldi, Ciribini & Flammioni, 2021).

3.2 Organizational learning and learning-driven organizations

For organizations to sustain innovation and creativity, learning should be embedded at every level—individual, team, and organizational. Achieving this involves reconfiguring organizational structures to prioritize continuous learning and encourage adaptation to new technologies. This approach supports the development of a learning-driven culture that integrates knowledge-sharing practices, enhances responsiveness to industry shifts, and promotes collective knowledge growth (Garad & Gold, 2019). Addressing the challenges in large-scale skill development requires a focus on innovation and coordinated stakeholder involvement. Frameworks such as TRIZ (Theory of Inventive Problem Solving) offer structured approaches to creating integrated skill-development ecosystems that enhance employability and workforce quality. These models promote collaborative problem-solving, ensuring that skill-development initiatives are both relevant and responsive to evolving industry demands (Shrotriya & Dhir, 2018). And also, in response to the key drivers of job change which are interconnected to the dual transition as well (World Economic Forum, 2023). While the green transition has a higher impact on job growth, the technology development has a controversial effect with initiating job growth for some and job decline for others.

Figure 1. Impact on job growth and decline



3.3 Pathways for digital and green transition

Public authorities and businesses should prioritize the identification of ecosystems and the adoption of platform-based transitions to facilitate large-scale industrial transformations within cities and regions. This strategic approach enables radical innovation, particularly through “leapfrogging,” where technological advancements can help cities bypass outdated practices and accelerate progress toward digital and green goals (Komninos, 2022). Here open innovation frameworks can be instrumental in enhancing sustainable learning ecosystems by fostering a dual emphasis on digital transformation and green governance. Public policy should aim to create an environment that nurtures open innovation, with a particular focus on engaging diverse stakeholders – including community members, academia, industry, and government – to fully harness collective expertise and potential for sustainable growth (Costa & Matias, 2020).

3.4 Digital platforms as a bridge for addressing the skills gap

Increasingly, digital learning platforms are evolving to address the needs of both individual learners and business enterprises, positioning themselves as integral resources for personal and professional development. Notable platforms, such as Coursera, FutureLearn, and Udemy, exemplify this dual-focus approach by strategically catering to diverse stakeholders while maintaining relevance and usability. Established as a leader in online education, Coursera partners with renowned universities and institutions worldwide to offer a wide range of courses, specializations, and degree programs. The platform leverages its affiliations with academia to provide rigorous, research-based content, catering to both individual learners seeking personal development and businesses aiming to upskill their workforce. Coursera’s model prioritizes accessibility and scalability, allowing learners across various fields to gain credentials from reputable institutions and stay competitive in a rapidly changing job market (Coursera, 2024). FutureLearn, takes a collaborative approach to online learning by engaging with universities, cultural institutions, and industry partners. The platform emphasizes the integration of social learning, encouraging interaction among learners to deepen understanding and foster collaborative skills. FutureLearn’s offerings range from short courses to full degrees, with a curriculum that reflects both academic rigor and practical relevance (FutureLearn, 2024). Udemy distinguishes itself as a more open, market-driven platform that enables a vast network of individual instructors and industry experts to create and share courses across diverse subjects. While less academically structured, Udemy’s model facilitates rapid course development and a

highly responsive curriculum that adapts to trending skills and emerging fields. Udemy's accessibility and broad subject range make it a valuable resource for lifelong learners and organizations seeking cost-effective, on-demand training solutions, thereby supporting a continuous learning culture in both personal and professional contexts (Udemy, 2024).

4. Discussion

Building learning ecosystems in alignment of digital and green transitions underscores the critical need for adaptability, sustainability, and cross-sectoral collaboration, aiming to foster responsive and future-ready organizations and individuals. This comprehensive approach situated learning not merely as a process of knowledge acquisition but as an adaptive ecosystem capable of navigating and addressing multifaceted societal and environmental challenges. A key insight centers on the importance of stakeholder inclusion, particularly in formal education. Engaging diverse groups within professional learning communities builds resilience and supports innovation, which are essential for navigating disruptions. By actively participating as co-creators, stakeholders cultivate shared ownership over educational outcomes, aligning with broader social and environmental goals. The concept of “mass collaboration” is pivotal here, as it shifts learning away from teacher-centered models, empowering learners to participate in a more democratic, self-directed process of knowledge creation and application. Such an approach does not only enhance engagement but also fortifies a culture of adaptability and collaboration critical for long-term sustainability. Further, the interconnection between educational institutions, industry, and government in developing entrepreneurial ecosystems reveals the role of universities as pivotal agents of regional development. By facilitating the commercialization of academic knowledge and embedding digital and environmental considerations into entrepreneurial curricula, these institutions cultivate a workforce attuned to the needs of evolving economies. This triadic collaboration model strengthens the educational ecosystem's capacity to support sustainable development by enabling continuous, lifelong learning pathways. The resulting ecosystem supports individuals in acquiring competencies, encouraging resilience and regional adaptability.

Organizational structures that prioritise continuous learning further illustrate the shift towards learning-driven organizations. Such entities are designed to integrate change as a foundational component, rather than a response to external pressures. Through structured knowledge-sharing practices and frameworks like TRIZ (Theory of Inventive Problem Solving), organizations develop skill ecosystems that respond dynamically to industry changes, ensuring that skill development is not only up-to-date but also anticipatory. These organizations model resilience, as they can recalibrate quickly in response to shifts brought on by digital and green imperatives, positioning themselves advantageously within competitive, innovation-driven landscapes.

In addition, the introduction of digital platforms as vehicles for addressing skills gaps speaks to the growing reliance on technology to democratize access to education and meeting formal, non-formal and informal education at one place. Platforms like Coursera, FutureLearn, and Udemy exemplify different models of online learning, each of which strategically meets the needs of various learner demographics and industry demands. By offering scalable, accessible learning opportunities, these platforms allow users across diverse socioeconomic backgrounds to upskill and reskill, thereby bridging the digital divide. This model is particularly valuable in the context of rapid technological change, where accessibility and agility are paramount.

In a larger public context, the orchestration of dynamic capabilities – such as identifying, seizing, and reconfiguring opportunities – forms the backbone of an ecosystem's resilience. The integration of tools like Digital Twins into this structure provides not only real-time data insights but also a robust framework for monitoring and refining sustainable practices. These digital models enhance decision-making by providing an ongoing assessment of environmental

impact, which is particularly relevant for educational buildings. Here, the continuous optimization of energy efficiency and environmental quality exemplifies how digital solutions can facilitate green transitions within learning ecosystems, grounding them in a practical, data-driven context.

Still, there are a lot of areas that may be overlooked or inadequately addressed due to assumptions, limitations in current practices, or unresolved contradictions within the framework. These blind spots can hinder the effectiveness, inclusivity, and sustainability of such ecosystems if not critically examined. One of the major ones is the *overemphasis on technology as a solution*. There is a tendency to view technology as a panacea for educational and environmental challenges. However, this perspective can obscure the fact that technology alone cannot address the root causes of issues like inequality, learner disengagement, or environmental degradation. Over reliance on technological solutions risks overshadowing the need for systemic changes in pedagogy, policy, and community engagement. Also, the *environmental impact of digital technologies*, such as the energy consumption of data centers, electronic waste, and resource-intensive production of devices, is often downplayed. There is a paradox in promoting green transitions through digital platforms that themselves contribute to carbon emissions. Without a clear commitment to sustainable practices within the digital infrastructure – such as low-energy data centers, sustainable device lifecycles, and carbon offsetting – digital learning ecosystems may inadvertently undermine their environmental objectives. Then, there is also the *neglect of socioeconomic and cultural barriers*. Although there is a recognized need for accessibility, discussions around scaling digital and green transitions often inadequately address the deep-rooted socioeconomic and cultural barriers that affect access and engagement. For instance, assumptions around learner readiness or technological access may ignore the realities of under-resourced communities, where infrastructure, digital literacy, and even electricity are inconsistent. Additionally, cultural differences in learning approaches and attitudes toward environmental sustainability may limit the effectiveness of one-size-fits-all models. And then there are the *assumptions about learner autonomy and motivation*. The push for personalized, self-directed learning models assumes that learners are motivated, self-disciplined, and equipped to navigate complex digital environments independently. However, many learners, particularly those without prior digital learning experience, may struggle with these demands. The risk is that those who lack intrinsic motivation or digital literacy skills may be left behind, resulting in a widening educational gap.

5. Conclusions

A framework for designing learning ecosystems aligned with digital and green transitions requires a comprehensive, multi-dimensional approach. By embedding principles of open innovation, adaptive technology, sustainability assessment, lifelong learning, and dynamic ecosystem management, learning environments can become resilient, adaptive, and responsive to regional and global needs. This framework can not only support the current digital and green imperatives but also positions learning ecosystems as integral components in advancing sustainable development, equipping individuals of all ages and organizations alike to thrive within an increasingly complex world.

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