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Fostering a Sustainable Ecosystem in Digitised Higher Education Through Circular Economy Models

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ABSTRACT:
In recent studies of competency-based curriculum, there have been five key circular competencies in education: a. systematic thinking and problem solving, b. collaboration and ethical leadership, c. innovation and creativity, d. digital and technical literacy, e., sustainability awareness and global responsibility. These had been identified through research-based studies in India. We set out to assess to what extent this set of five competencies can be followed and implemented by integrating a circular economy. Circular economy (CE) models have revolutionised entrepreneurial sustainability by fostering resource efficiency, waste reduction, and innovation across various sectors. As the global shift toward sustainability redefines how businesses and institutions approach growth, CE has emerged as a transformative framework for minimising waste and creating long-term value. Concurrently, digital education advancements are pivotal in preparing entrepreneurs to embrace and implement these sustainable practices effectively. Artificial intelligence, blockchain, and immersive learning platforms are examples of emerging technologies that are changing educational approaches and making learning experiences more dynamic and accessible while meeting the changing needs of sustainable business. This paper explores the synergy between circular economy principles and digital education innovations, analysing their collective impact on transforming entrepreneurial sustainability. It highlights key strategies, technological advancements, and best practices that empower entrepreneurs to integrate sustainability into business models. Furthermore, the paper discusses challenges and opportunities within this paradigm shift, offering insights into how digital education can accelerate the adoption of circular economy frameworks. This study underscores the potential for a more resilient and regenerative entrepreneurial ecosystem by bridging the gap between sustainability and technological innovation.

Keywords: Circular economy, sustainable development, digital efficiency, education, entrepreneurial sustenance

Introduction

In the face of rapid technological advancements and escalating environmental concerns, entrepreneurial sustainability is undergoing a significant transformation. Businesses are increasingly shifting away from traditional linear economic models that follow a "take, make, dispose" approach and are instead embracing circular economy frameworks. These models emphasise resource efficiency, waste reduction, and regenerative processes, aligning with global sustainability goals while fostering innovation and long-term economic resilience. This transition reshapes industries and redefines businesses, compelling entrepreneurs to rethink their strategies and adopt sustainable practices.

Alongside this economic shift, digital education equips entrepreneurs with the necessary skills and knowledge to navigate this evolving landscape. The way that sustainable business practices are taught and applied is being entirely transformed by emerging technologies like blockchain, artificial intelligence (AI), and immersive learning platforms. Through the integration of cutting-edge digital education resources with the concepts of the circular economy, entrepreneurs can produce creative solutions that promote sustainable growth and have a long-lasting positive influence on the environment and the global economy.

However, despite the promise of the circular digital economy, its benefits may be more constrained than often perceived. The complete impact of the shift from a linear to a circular model in the digital sphere depends on several variables, including infrastructure, legislative support, and technological readiness. While the circular digital economy offers potential advantages like resource efficiency, cost savings, innovation in business models, data-driven sustainability, and regulatory alignment, these benefits can only be fully realised if systemic barriers are addressed.

The sustainability crisis, which includes climate change, biodiversity loss, overusing natural resources, and pollution, needs action now. The most important action is stopping endless consumption and transitioning from a linear economy towards a carbon-neutral circular economy (CE). Integrating CE into society and the global economy requires complex and dynamic (systemic) changes in technical and behavioural aspects. (Bertassini et al. 2021) These changes involve every sector of society. In order to create a more sustainable society, people must understand the importance of decreasing their consumption. Furthermore, there is a need to increase knowledge of the CE and new solutions in society and our everyday lives. Without concrete tools, it is hard to change our daily routines. It has been shown that progress in environmental awareness contributes to decreasing environmental impacts (cf., e.g. Shen and Wang 2022; Venghaus, Henseleit, and Belka 2022). Therefore, environmental thinking should be included at all levels of education. Children and youths are well aware of the global state of the environment and want to be part of the solution, not part of the problem. For that to happen, they need education on environmental problems and solutions.

Adopting circular digital economy models can yield several benefits: reusing and recycling digital infrastructure like refurbished electronics and cloud-based solutions can reduce electronic waste. However, challenges remain with material recovery and limited recycling facilities. Businesses can lower operational costs by extending product life cycles and improving resource efficiency, but high initial investments in circular practices pose barriers. The rise of subscription-based services and product-as-a-service models offers new sustainable business opportunities, though consumer adoption and cultural resistance are uncertainties. Technologies like AI and blockchain enhance supply chain transparency and track circularity metrics, optimising resource use despite their energy-intensive infrastructure. Companies integrating circular economy principles may better comply with emerging sustainability regulations, though navigating these frameworks can be costly and time-consuming for SMEs.

A fully functional circular digital economy requires overcoming economic, technological, and behavioural barriers through policy support, innovation, and collaboration.

TRANSFORMATION OF HIGHER EDUCATION TO DIGITISED DISRUPTION

Universities experienced a widespread shift to online learning as a result of the social distancing measures enforced by COVID-19 and the necessity to continue providing educational services during the crisis (Krishnamurthy, 2020). Teachers around the world had to quickly modify their lesson plans and delivery strategies for online distribution (Dwivedi et al., 2020). This shift was sudden and necessitated, marking a period of global experimentation with remote learning (Govindarajan & Srivastava, 2020). Some scholars have referred to this approach as "emergency online education" (Marinoni et al., 2020). The transition presented significant challenges for students, who required technical support, and faculty and university administrators, who had to restructure campus operations quickly. Although digital transformation in higher education was already underway, the pandemic significantly accelerated the process, bringing fundamental changes in just a few weeks.

This shift in education necessitates profound changes in teaching methodologies, essential skills, and assessment strategies, a reality that most higher education institutions now acknowledge (Jensen, 2019). In a virtual learning environment, universities must move away from traditional lecture-based instruction toward more interactive, problem-based learning approaches that actively engage students (Marinoni et al., 2020). This transition from in-person to digital education will have lasting effects on the learning experience, requiring new methods for assessing student progress and reassessing the skills and competencies needed in this new setting (Jensen, 2019). Given that social distancing measures will persist for some time, educational institutions must comprehensively redesign their services to adapt to this evolving landscape.

To create an effective online learning environment, universities must develop digital learning methodologies, establish robust support systems, and provide appropriate tools and resources (Krishnamurthy, 2020). Successful digital education requires a reliable technological infrastructure, including platforms like Blackboard, Moodle, and Microsoft Teams, as well as powerful servers capable of handling increased virtual workloads. Faculty and students must also receive adequate training to utilise these tools effectively. Many universities have partnered with technology providers such as Microsoft to offer digital resources, including Office and Teams, to enhance their online presence. Various online communication platforms and digital solutions have been leveraged to support teaching and learning during the pandemic (Mishra et al., 2020).

A recent study conducted in a university setting identified the most used technologies during lockdown, including university web platforms, instant messaging tools (WhatsApp, Telegram), video conferencing software (Zoom, Skype, Google Meet, Google Hangouts), and educational apps like Google Classroom. Other tools like email and phone communication were essential in maintaining personalised student support. Additional platforms like Cisco WebEx, GoToMeeting, Microsoft Teams, Monosnap, Loom, and OBS were widely utilised. These digital tools offer diverse teaching capabilities, including live video lectures, content sharing (slides, videos, presentations), interactive chat discussions, debate forums, group workspaces, virtual supervision of practical tasks, student assessments, and tutoring sessions. Furthermore, these technologies can be used synchronously and asynchronously, allowing flexibility in

instructional delivery.

However, the success of online learning depends not only on the availability of technology but also on the application of effective pedagogical strategies. To keep students engaged, instructors must thoughtfully design audiovisual materials, structure student workload, and choose the most appropriate tools for each activity—whether for tutoring, interactive discussions, or assessments. Dynamic and engaging sessions should incorporate collaborative tools and active learning methodologies that foster interaction between students and faculty. Peer collaboration and interactive learning approaches have proven essential in maintaining student engagement in remote learning settings.

Assessment strategies are critical to this new educational framework and are the foundation for measuring student learning outcomes. Various digital assessment methods have emerged during the pandemic, each supported by specific technological tools. Table 1 summarises some key online assessment techniques and their corresponding digital resources. Beyond assessment, this article also explores additional factors educators must consider when designing compelling online learning experiences.

Table 1: | Various resources/methodologies for student assessment in online teaching

Assessment Methodologies	**Description**	**Supportive Technologies**
Diagnostic evaluation	Exercises, questionnaires, or tests that assess students' preconceptions, competencies, and information regarding the new topic	• Concept map • Questionnaires on the Web platform • Online questionnaires • Interactive and gamified presentations
Evaluations using video tags	Students answer different questions by adding tags to a YouTube video. The professor can review students' answers by examining the labels. This process can be performed in groups or individually (as individual tests where students do not share their annotations)	• Videos on YouTube or published on the Web platform • Video annotations • Questionnaires on the Web platform • Online questionnaires
Group and collaborative analysis	When not all exercises can be evaluated due to many students, one or more can work together. The evaluation may be anonymous or voluntary and sequenced so all students are evaluated. During evaluation, the exercises are shared so the students better understand the quality criteria and their application to specific cases.	• Online questionnaires • Rubrics • Questionnaire on the Web platform • Rubrics • Workshops on the Web platform • All tools available on the Web platform that allow sharing of this evaluation, e.g.,

			chat, and digital rubrics.
Self-assessments	The student analyses the work presented and evaluates it.		• Multiple response questionnaires on Web platform
360◦ evaluation	Contrasts evaluations of an individual or team exercise or tasks from different points of view: professor (hetero-evaluation) and/or students (co-evaluation or peer evaluation and self-evaluation)		• Rubrics
Objective tests	Exercises where students must select the correct answer or explanation to a problem from among several options		• Tools on the Web platform
Interviews	Interviews allow individual or group monitoring of a topic or topics and can be considered a continuous or final diagnostic evaluation.		
Ipsative assessment	Assessment that measures different moments of the process to assess progress. Students can observe their progress and achievements through repeated exercises and graphical representations of their evaluations.		• Online presentations • Videoconference platforms • Self-recorded videos by the student • Test reports, included in tasks, plus an anti-plagiarism tool on the Web platform Final evaluation Tests that students must take
Oral partial or final exams	Review of learning achievement at the end of a process. Enables validation of learning achieved during the process. Final or partial exams (need weighting) administered to students and graded or evaluated by the		

	professor (hetero-evaluation) and the other students (co-evaluation)		
Final evaluation	Tests that students must take		• Tests and reports that professors can publish on a Web platform and that can be combined with the anti-plagiarism tool and resolved through Videoconference platforms

EMERGING BARRIERS AND CHALLENGES IN DIGITISED EDUCATION

The disruptive impact of COVID-19 triggered a rapid transformation in education, necessitating an abrupt shift from traditional in-person teaching to online learning (Carolan et al., 2020). This transition was challenging, as students and professors faced various obstacles (Marinoni et al., 2020; Mishra et al., 2020). To ensure a smooth and practical transformation, universities must recognise these barriers and implement strategies to address them.

From the students' perspective, technical difficulties emerged as a significant challenge in adapting to online learning (Mishra et al., 2020). Additionally, online education has been shown to exacerbate the digital divide, disproportionately affecting students from disadvantaged socioeconomic backgrounds (Govindarajan & Srivastava, 2020). To bridge this gap, universities should allocate resources to provide all students with adequate IT infrastructure, reliable internet access, and technical support (Carolan et al., 2020). Moreover, students reported difficulties maintaining focus in a virtual setting, citing boredom, isolation, time management struggles, and a lack of self-discipline (Liang et al., 2020; Mishra et al., 2020).

Professors also faced challenges, particularly in designing courses that foster engagement in an online environment. Many struggled with isolation, highlighting the need to balance individualised, student-centred learning with collaborative virtual interactions (Carolan et al., 2020). The sudden transition to online teaching was stressful, especially for faculty members lacking prior experience or digital tool training (Dwivedi et al., 2020). Professors' varying levels of digital literacy further exacerbated the situation, with some more adept at using technology than others (Govindarajan & Srivastava, 2020). Key difficulties included mastering digital teaching tools, effective online communication, and the ability to troubleshoot technical issues during live sessions. However, as educators adapted, valuable lessons emerged, such as optimising their teaching environment, restructuring course content for online delivery, and incorporating interactive activities to enhance engagement (Dwivedi et al., 2020). Given the increasing adoption of hybrid learning models that combine in-person and online instruction, universities must ensure high-quality learning experiences for all students.

At an institutional level, the emergency shift to remote teaching fundamentally disrupted traditional university operations (Krishnamurthy, 2020). Moving toward a sustainable digital education model requires universities to rethink teaching methodologies, redesign assessments, and provide faculty training. Moreover, successful digital transformation depends on fostering a participatory culture where students, professors, and administrators collaborate to refine and

improve online education (Carolan et al., 2020). However, universities also face financial and infrastructural constraints. Public institutions, in particular, must contend with shrinking budgets and declining enrollments due to economic uncertainty (Krishnamurthy, 2020). Enhancing IT infrastructure is another pressing concern, necessitating strategic investments to support digital transformation efforts.

Despite these challenges, universities remain optimistic about the future of digital education. A recent European Higher Education Area survey revealed that 92% of universities plan to explore new teaching methods, while 75% aim to enhance digital capabilities beyond the crisis (European University Association, 2020). To ensure long-term success, institutions must prioritise improvements in technological infrastructure and equitable access to digital resources, requiring financial investments for meaningful transformation (Jensen, 2019). Additionally, leadership and institutional support are crucial in guiding faculty, students, and technical staff through the transition. The increasing reliance on digital learning also raises ethical concerns regarding data security and privacy, which universities must address by establishing transparent policies and codes of conduct (Jensen, 2019). By proactively addressing these challenges, higher education can evolve into a more resilient and inclusive digital learning ecosystem.

Circular economy

The concept of the circular economy (CE) dates back to the 1980s, originating from two interconnected ideas: a closed-loop economy and the "design to redesign" approach. CE focuses on managing and restoring biochemical and material cycles while promoting recycling. It is built on three key pillars—social, economic, and environmental sustainability. This economic model ensures that planning, resourcing, procurement, production, and reprocessing are structured to enhance ecosystem health and human well-being (Murray, Skene, and Haynes, 2017). As a restorative and regenerative system, In order to reduce waste production, CE seeks to preserve the value of goods, materials, and resources for as long as feasible (Ranta et al., 2018).

The term "circular economy" is used in two primary ways. First, as a goal, it represents pursuing a carbon-neutral global economy that sustainably utilises natural resources within the Earth's ecological limits. Second, it serves as a tool—an actionable framework for creating a more sustainable future for humanity and the environment. As a tool, CE includes various business models, such as product-as-a-service, product-life extension, sharing platforms, renewability, and resource efficiency through recycling (Sitra's Circular Economy Playbook for Finnish SMEs, 2018). CE seeks to keep resources circulated for as long as possible(Benachio et al., 2020).

Sustainable development

The Brundtland Commission Report on the Environment and Development from 1987 included one of the first and most thorough definitions of sustainable development. According to the report, sustainable development is the process through which investments, resource use, technology developments, and institutional reforms satisfy "the needs of the present without compromising the ability of future generations to meet their own needs." It also emphasises that promoting sustainable development is a political decision (Brundtland WCED, 1987).

Since its publication, the concept of sustainable development has become widely recognised. Concerns about sustainability were largely viewed as scientific and technological challenges in Rio de Janeiro, Brazil, during the 1992 United Nations Conference on Environment and Development (UNCED). The conference led to the adoption of Agenda 21, the Rio Declaration on Environment and Development, and the Statement of Principles for the Sustainable Management of Forests, endorsed by over 178 governments. Agenda 21 is structured into four sections: Social and Economic Dimensions; Conservation and Management of Resources for

Development; Strengthening the Role of Major Groups; and Means of Implementation, with a strong emphasis on education, public awareness, and training (UN Agenda 21).

In 2015, the United Nations introduced the resolution *Changing the World: The Sustainable Development* Agenda of 2030, which set forth 17 Sustainable Development Goals (SDGs). As discussed earlier, the circular economy (CE) represents a new global economic model vital in achieving all 17 SDGs. Specifically, CE is instrumental in promoting health and well-being, ensuring clean water, and fostering sustainable consumption. Additionally, it is essential for addressing climate change, preserving oceans and seas, and protecting terrestrial ecosystems. Achieving these objectives requires strong international cooperation, making SDG 17—*Strengthen the means of implementation and revitalise the global partnership for sustainable development*—the most crucial goal.

Way Forward to Sustainable Digitised Education through Circular Economy Model

The rapid digitisation of education has transformed learning experiences, offering greater accessibility, flexibility, and innovation. However, challenges such as digital waste, resource consumption, accessibility gaps, and sustainability concerns must be addressed. A circular economy (CE) model provides a viable framework to mitigate these challenges by emphasising resource efficiency, waste reduction, and long-term sustainability.

Addressing E-Waste and Digital Resource Management

One of the key challenges of digitised education is the accumulation of electronic waste (e-waste) due to frequent upgrades of digital devices and infrastructure. The circular economy model promotes:

a. Refurbishing and recycling old devices to extend their lifecycle.
b. Encouraging e-learning platforms that optimise cloud-based storage, reducing the need for excessive hardware.
c. Adopting modular technology, where individual components of devices (such as batteries and processors) can be replaced instead of discarding entire units.

Reducing Carbon Footprint in Digital Learning

Online education relies on data centres, cloud computing, and digital infrastructure, all significant energy. A CE approach can help by:

a. Transitioning to renewable energy sources for powering educational platforms and institutions.
b. Implementing energy-efficient data centres and optimising cloud storage.
c. Promoting low-energy devices and eco-friendly learning tools.

Enhancing Accessibility and Digital Inclusivity

a. Despite the benefits of digital education, disparities in access to technology persist. The circular economy model can:
b. Encourage device-sharing programs to ensure underserved communities have access to digital learning tools.
c. Develop open-access educational resources to reduce dependency on expensive textbooks and proprietary software.
d. Implement community-based tech recycling initiatives to distribute functional but pre-owned devices to needy students.

Sustainable Curriculum and Green Education

To fully integrate circular economy principles, educational institutions must:

a. Incorporate sustainability-focused courses that educate students on circular economy models.
b. Foster practical learning experiences such as upcycling projects, sustainable entrepreneurship programs, and green technology innovation.
c. Encourage collaborations with industries that promote circular economy initiatives, ensuring students gain real-world exposure to sustainability practices.

Discussion

A global shift towards systemic change is essential, with a need to implement circular economy (CE) practices. One of the significant challenges in this transition is the lack of expertise, leading to a shortage of tools and actionable strategies. To address this, every individual must enhance their understanding of CE. As the world continues to evolve, education must adapt accordingly. The transition to a carbon-neutral circular economy places the education sector at the forefront, ensuring CE principles are taught, and up-to-date information is disseminated.

By combining physical, digital, and biological technology, the fourth industrial revolution—which is presently underway—builds upon the third. This cyber-physical transformation is rapidly reshaping industries, with mobile technology enabling global connectivity and artificial intelligence merging technological applications into our daily lives—from our bodies to the buildings we occupy (WEF, 2016). While this new era presents opportunities and challenges for education, the ongoing sustainability crisis remains unresolved. The key to addressing this crisis is not in technology alone but in changing human behaviour. While technological advancements will be necessary, they are not the ultimate solution—our ability to shift behaviours and adopt sustainable practices will determine our success in tackling this challenge. It is equally essential to educate specialists who deepen their expertise in specific fields while equipping them with the ability to collaborate across disciplines. Effective teamwork with experts from diverse fields is crucial for developing sustainable solutions, as systems and their solutions are often complex. Specialists are trained to navigate intricate challenges, but transitioning to a circular economy demands cross-sector collaboration and interdisciplinary cooperation. Without innovative approaches to collaboration, rethinking existing practices and implementing meaningful change becomes significantly more difficult, if not impossible. (Pajunen and Mäkikoskela 2017)

Conclusion

Integrating circular economy models into innovative digital education strategies presents a significant opportunity to foster sustainable entrepreneurship. However, this transition faces technological limitations, financial constraints, curriculum standardisation, and regulatory hurdles. Overcoming these barriers requires strategic planning, collaboration, and policy support, enabling educational institutions and businesses to build a more sustainable and resilient entrepreneurial ecosystem. Embracing circular economy principles in digital education is an option and a necessity for balancing economic growth with environmental responsibility. Achieving systemic change may be challenging, but it begins with grassroots efforts in education. Raising awareness and educating people are crucial for shifting consumption habits over time. When individuals understand the necessity and benefits of the circular economy, they are more likely to support and promote it. As one student noted, "Well-educated and informed citizens can prevent themselves from being ill, and a well-educated person also knows what is harmful to our environment and nature" (CE-2018-56).

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