Ethical considerations and challenges of integrating AI in sustainability: Teaching students a balanced risks narrative approach

Sue Cronshaw & Madeleine Pickles

Abstract: This chapter considers the role a balanced risks narrative can play in enhancing a students' understanding of the challenges of integrating AI in sustainability.

Keywords: Balanced Risks Narrative; Higher Education; AI-driven sustainability; Green AI

1. Introduction

In management research, AI is described as a new generation of technologies that can interact with their environment by: (a) collecting information from external sources (including natural language) or other computer systems; (b) interpreting this information through pattern recognition, rule induction, or event prediction; (c) producing outputs such as results, answers, or instructions for other systems; and (d) assessing the outcomes of their actions and refining decision processes to achieve specific objectives (Ferràs-Hernández, 2018). Sustainability refers to the responsible management and preservation of Earth's finite resources, ensuring their balance and availability to safeguard the planet for future generations (Kola-Olusanya, 2008; 2012). The irony in this definition, when considered alongside artificial intelligence (AI), lies in the fact that although AI is increasingly employed to advance sustainability across sectors by improving efficiency, reducing waste, and enabling smarter decisions, with the potential to address complex sustainability challenges (Leal et al., 2024:726), it simultaneously raises concerns about its own environmental impact. It is therefore considered a transformative technology with broad applications to many sectors (Rashid and Kausik, 2024). In recent years we have seen the emergence of the concept of Green AI (Akinsemolu 2025) demonstrating a dual focus on performance alongside sustainability, however the measurement of this is often demonstrated as energy efficiency (Verdecchia et al., 2023) rather than the lesser definitions of carbon footprint or ecological footprint. This limitation obscures the wider environmental and social costs of AI deployment. To explore these tensions, this chapter adopts an integrative literature review and conceptual synthesis as its methodological approach (Torraco, 2016). This method allows for the critical examination of scholarship on AI, sustainability, and pedagogy, and supports the development of a new conceptual framework. Sources were included if they addressed the intersection of AI with sustainability, pedagogy, or ethics, and excluded if they focused solely on technical AI development without relevance to education. By synthesising insights across these literatures, the study seeks to generate a framework that is both evidence-based and pedagogically grounded.

In light of these challenges, there is a pressing need to prepare future managers and students to critically evaluate AI's paradoxical role in sustainability and therefore the following aim and objectives were developed:

Research Aim: To design and evaluate a pedagogical framework that enables students to critically engage with the risks and opportunities of AI in sustainability.

Research Objectives:

1. To develop a pedagogical framework that supports students in adopting a balanced approach to the risks and benefits of AI for sustainability.
2. To identify educational strategies and interventions that can strengthen students' capacity to ensure AI contributes positively to sustainability rather than undermines it.

Several sectors face ethical tensions arising from the integration of AI into sustainability practices. For instance, applications in the circular economy (Bashynska 2025), healthcare (Mohammed, 2021), finance (Cao, 2022), farming (Mallinger & Baeza-Yates, 2024) and education (Holmes & Tuomi, 2022) reveal both the promise and the pitfalls of AI. These tensions include issues of data privacy, algorithmic bias, and unequal access, underscoring the need for robust regulations and governance structures. As Ibitoye et al. (2025) emphasize, responsible AI requires attention to socio-technical contexts as well as ethical principles. This then needs to be reflected in the sustainability teaching that occurs in Higher Education institutions, as there are pedagogical ethical concerns that need attending to when integrating AI driven sustainability into the curriculum as many students still consider sustainability to be predominantly environmentally focused (Zeegers & Clark 2014). The ethical challenges reflect the need for students to be more aware of the risks involved in AI-driven sustainability and the approaches needed for AI to support rather than undermine sustainable goals. This chapter addresses some of the key challenges facing educators in AI sustainability before exploring the role of a balanced risks narrative as a pedagogical approach. There is then a critique of two pedagogical frameworks that support interdisciplinary and ethical education and inform the creation of a seven stage AI Sustainability Pedagogical Framework to support student learning with balanced risks narratives. A discussion around teaching beyond the curriculum and a conclusion then follow.

2. Teaching AI in Sustainability

There is much literature around the role of SDGs in HE, the positive integration of sustainability in the curriculum and the growth of universities becoming PRME signatories. Alongside this shift to a sustainability lens, is the focus on the use of AI in the classroom. Leal et al., (2025) emphasise AI's role as a positive pedagogic tool, highlighting it's capacity to provide students with interactive and immersive learning experiences. However, their work tends to privilege the opportunities of AI use, while neglecting the inherent tensions when AI is applied to sustainability. Students are taught how to use AI in their studies and the benefits of AI in sustainable practices, but less emphasis is placed on the negative combination of AI and sustainability. HE institutions have been criticised for not teaching students how to understand interconnected global issues (Henriksen et al., 2024). Our position aligns with this critique, as we contend that without pedagogical approaches that foreground both risks and benefits, AI's paradoxical role in sustainability remains insufficiently interrogated in higher education. Wali et al. (2017) position sustainable education as grounded in values-based principles; however, this orientation alone is insufficient when confronted with the tensions of AI-driven sustainability. Zonnchen et al. (2024) extend this argument by insisting on the need for higher education to equip students with analytical skills to understand and critique complex AI systems. Building on their perspectives, this research contends that sustainable education

must move beyond normative values and towards frameworks that actively engage students in evaluating AI's dual role as both a driver and underminer of sustainability.

One of the key ethical considerations is the hidden cost of AI and the paradox of (un) sustainability. The very technology designed to foster sustainability carries significant environmental and social costs. Potential concerns around energy consumption, carbon emissions, water for cooling, non-renewable energy resources, habitat destruction, water pollution, and geopolitical tensions highlight the underlying pressures that come with the use of AI. It is crucial that the lifecycle of AI systems, from design to use and disposal, embodies the principles it aims to promote. Ibitoye et al. (2025) explicitly question the fragility of responsible AI by foregrounding the hidden environmental and social costs embedded across the AI lifecycle, from design to disposal. Their analysis reinforces the paradox noted earlier: that AI simultaneously advances and undermines sustainability. Positioning this paradox within higher education, we argue that these contradictions should not be abstract concepts, but central elements of teaching through a balanced risks narrative.

3. Methodology:

This chapter is guided by the research aim of designing a pedagogical framework that enables students to critically engage with the risks and opportunities of AI in sustainability. To address this aim, two objectives were set: first, to develop a pedagogical framework that supports students in adopting a balanced approach to the risks and benefits of AI for sustainability; and second, to identify educational strategies and interventions that can strengthen students' capacity to ensure AI contributes positively to sustainability rather than undermines it.

To meet these objectives, the chapter employs a structured literature review and conceptual synthesis. This approach does not test hypotheses but is appropriate for developing theoretical and pedagogical models. Following Torraco's (2016) notion of the integrative literature review, the intention was not only to summarise existing studies but also to critique and combine them in order to propose new conceptual directions.

The review considered material published between 2008 and 2025, reflecting both foundational debates on sustainability education and more recent discussions of artificial intelligence, Green AI, and ethical governance. Sources were drawn from Scopus, Web of Science, and Google Scholar, with search terms including "AI and sustainability," "Green AI," "AI ethics in higher education," "interdisciplinary pedagogy," and "experiential learning." The review incorporated peer-reviewed journal articles, policy documents, and conference papers. Additional sources were identified using snowballing techniques from reference lists. Inclusion criteria were set to capture studies addressing AI applications with sustainability implications, higher education pedagogy, or ethical challenges in technology adoption. Studies focusing exclusively on technical AI development without relevance to sustainability or education were excluded.

The analysis progressed in three stages. First, the literature was mapped to identify how AI's role in sustainability has been discussed across management, education, environmental studies, and ethics. Second, pedagogical frameworks were evaluated, with particular attention given to Kolb's (1984) *Experiential Learning Cycle* and Utrecht University's *Four-Stage Model for Interdisciplinary Learning*. These were situated within wider debates on interdisciplinarity and

pedagogy (Klein, 2010; Szostak, 2016) to understand their relevance and limitations in addressing the paradoxes of AI-driven sustainability. Third, the insights from this review were synthesised into the AI Sustainability Pedagogical Framework, developed iteratively to ensure consistency with both established educational theory and the ethical challenges identified in the literature.

To ensure transparency and reproducibility, the timeframe, databases, keywords, and inclusion/exclusion criteria have been specified, providing a clear pathway for replication by other scholars. The methods employed are sufficient to address the research objectives, as they enable a rigorous synthesis of theory and evidence into a new pedagogical framework. Consistent with Torraco (2016), this integrative approach draws on past and present scholarship to propose a novel conceptual model that can inform both future research and practical teaching strategies. The resulting framework explicitly embeds a balanced risks narrative, preparing students to navigate the dual role of AI in sustainability as both a source of promise and a site of ethical and environmental tension.

The subsequent sections of this chapter—examining the balanced risks narrative, reviewing pedagogical frameworks, and applying these to AI-sustainability contexts—are each structured to directly address the research objectives. In particular, the development of the AI Sustainability Pedagogical Framework responds to Objective 1, while the analysis of educational strategies and teaching beyond the curriculum responds to Objective 2.

4. Balanced Risks Narrative

This section addresses objective 1, which is to develop a pedagogical framework that supports students in adopting a balanced approach to the risks and benefits of AI for sustainability. By outlining the concept of a balanced risks narrative, it establishes the conceptual foundation for embedding both opportunities and challenges of AI into higher education teaching. A balanced risks narrative advocates for an approach to AI risk governance that acknowledges both the positives and immediate societal risks posed by AI. It encourages finding meaningful connections between the two, and suggests that addressing them in tandem can lead to more comprehensive and effective risk mitigation strategies and policies. This approach is not one that should be developed in isolation. Collective sense-making (Ibitoye et al 2025) would ensure that not only the immediate and more long term benefits can be identified, it also allows for current and emerging risks to be highlighted, identifying uncertainty whilst supporting responsible regulation and transparency. Thus identifying strategies for AI-driven sustainability that are nuanced and evidence-based.

There are many ethical challenges that are derived from the use of AI-driven sustainability. A key driver for this is inclusive innovation, ensuring diverse voices are represented in AI development, especially those of vulnerable communities. This prevents algorithmic bias which would otherwise reinforce discrimination in health, education, and public services. Using a balanced risks narrative would support checking for bias and making AI design more inclusive. Using sustainability-aligned metrics would also provide a balanced view of the impact of AI. A balanced risk narrative would consider the economic impact alongside the social, ecological and environmental, therefore addressing the likely events alongside the unprecedented outcomes, providing a clearer forecasting model for future strategy.

5. Pedagogical Frameworks for Interdisciplinary and Ethical Education

This section further develops objective 1 by critically evaluating existing pedagogical models—namely Kolb's Experiential Learning Cycle and Utrecht University's Four-Stage Interdisciplinary Model—that inform the creation of the AI Sustainability Pedagogical Framework. In doing so, it links theory to the design of a framework that can respond to the paradoxes of AI-driven sustainability.

To effectively teach higher education students about the complex interplay of AI and sustainability, particularly in balancing risks and benefits, it is crucial to leverage robust pedagogical frameworks. Interdisciplinary teaching has long been recognised as a way of integrating knowledge and methods from multiple academic disciplines to address complex problems (Szostak, 2015). However, as Borrego and Newswander (2010) caution, interdisciplinary approaches often falter without clear scaffolding for students to make sense of diverse perspectives. Against this backdrop, two models were selected to inform the development of our framework. The framework was inductively derived from the synthesis of two pedagogical models (Kolb, 1984; Utrecht University Four-Stage Model), insights from interdisciplinary education literature (Szostak, 2016; Klein, 2010), and empirical studies of AI in sustainability (Leal Filho et al., 2025; Ibitoye et al., 2025). Each stage reflects recurring themes identified in the literature review, ensuring that the model is both evidence-based and pedagogically grounded."

The Four Stage Model for Interdisciplinary Learning (Utrecht University) proposes that educators adopt a structure that allows students to process the complexities of a topic with a critical, multi-dimensional approach. The first stage is disciplinary grounding, which refers to having a foundational understanding of a discipline, including how knowledge within it is developed, validated, and communicated, developing a critical approach, rather than simply acquiring information. Perspective taking is the second stage which involves examining a problem through the lens of each relevant discipline and recognizing both their shared and differing viewpoints and limitations. In the third stage students need to learn to discover common ground, identifying shared concepts, methodologies, or problems across disciplines before embarking on the fourth stage of integrating perspectives. This four-stage schema gives a clear path for curriculum design but it assumes a fairly linear progression, which is not always the case with student learning. There also needs to be an acknowledgement of the challenges involved when integrating disciplines and the potential that each subject could be explored in less depth.

Kolbs Experiential Learning Cycle (1984) was also considered to inform our framework as it aligns well with approaches of problem-based learning and interdisciplinary project work and includes reflection and application as much as knowledge acquisition. The cycle determines that people learn best through continuous action and reflection, rather than by passively receiving information. The stages begin with concrete experience which is learning by doing, followed by reflective observation, reflecting on what happened and considering different perspectives. The next stage in the cycle is abstract conceptualization when learners can develop theories or concepts from their reflections, then active experimentation which allows learners to apply what they have learned to new situations. Each stage is repeated through iterative cycles and helps educators design activities that balance experience, reflection, theory, and application. Informed by the 2 models above, we have developed a 7 stage AI Sustainability Pedagogical Framework to support student learning with balanced risks narratives.

6. Application to AI-Sustainability Context

This section advances objective 1 by presenting the AI Sustainability Pedagogical Framework and illustrating its application to the paradox of AI in sustainability. By demonstrating how students can critically engage with both the benefits and risks of AI, it provides a practical outcome of the framework-building process. Combining insights from the interdisciplinary and ethical pedagogical frameworks, we propose a model as per figure 1 for teaching that adopts a balanced-risks approach to the paradox of AI in sustainability. This responds directly to Klein's (2010) call for pedagogical designs that help students grapple with the contested and uncertain nature of interdisciplinary knowledge. Unlike conventional models that privilege disciplinary silos, our framework is explicitly designed to expose students to the dual role of AI as both a driver of sustainable solutions and a source of environmental and ethical challenges. It begins with problem-based learning, where students explore real-world sustainability issues that AI might address, while also being encouraged to interrogate the inherent risks, for example, the optimisation of energy grids weighed against the energy consumption of AI itself. Interdisciplinary collaboration is central to this model, as it brings together students from different areas to foster holistic and multi-perspective learning. Ethical decision-making is embedded throughout the curriculum, prompting students to analyse trade-offs between AI's contributions to sustainability and its potential harms. Case studies and simulations further reinforce this process by illustrating AI's dichotomies in practice, allowing students to conduct risk–benefit analyses and propose balanced, responsible solutions. The model also promotes systems thinking, encouraging students to view AI and sustainability as interconnected domains where interventions in one area generate ripple effects elsewhere. Reflective practice provides opportunities for students to recognise their own assumptions and biases, while situating AI within broader ethical and societal debates. Finally, students are taught to consider the entire AI lifecycle, from data collection and model training to deployment and maintenance, with attention to environmental and ethical consequences at each stage. By integrating these strategies, the proposed model equips students with the knowledge, skills, and ethical compass to navigate the complexities of AI in sustainability, enabling them to engage with both its promise and its perils in a more informed and balanced manner.

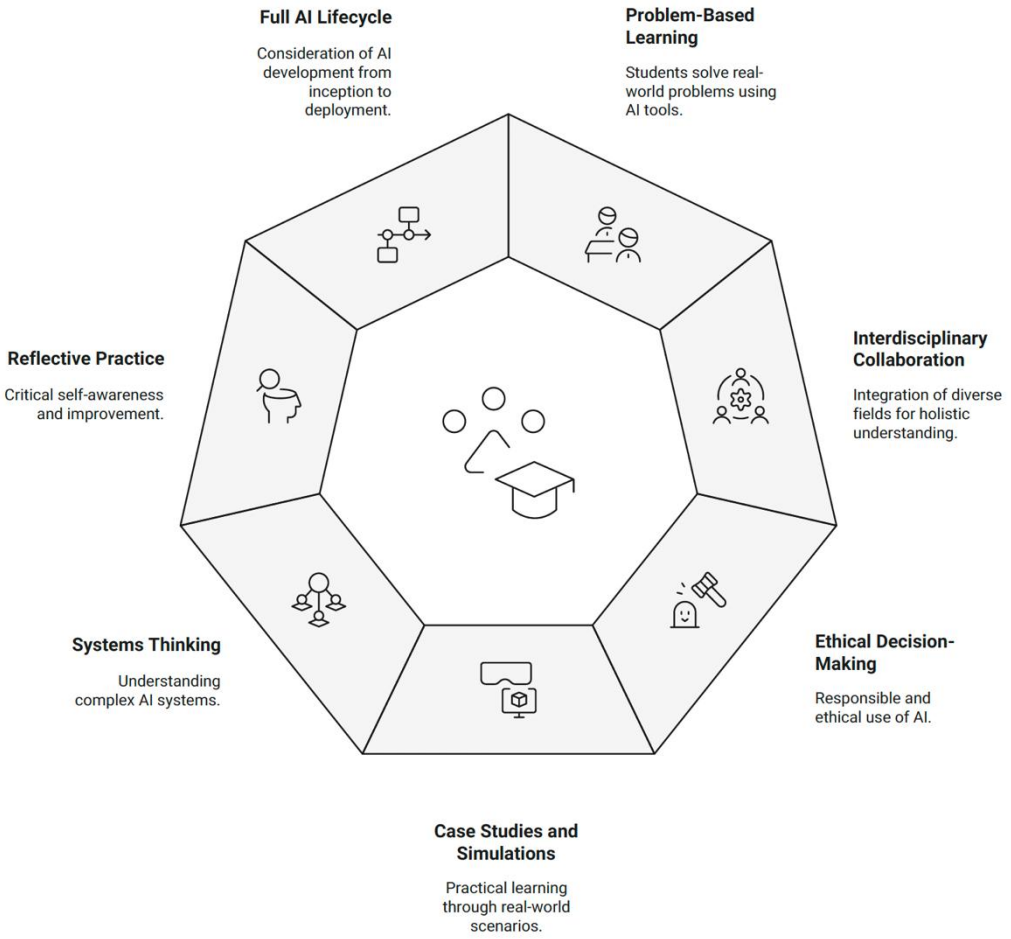


Figure1: AI-Sustainability pedagogical framework

7. Teaching beyond the curriculum for a balanced risks approach

This section responds to objective 2, which is to identify educational strategies and interventions that can strengthen students' capacity to ensure AI contributes positively to sustainability rather than undermines it. By considering approaches that extend beyond formal curriculum design, it highlights strategies for fostering critical curiosity, forecasting, and robust decision-making in students. Students are often given case studies to work from, and are tasked with identifying the problems that are highlighted within the paper. What, as educators, we do less of, is to ask students to forecast, to think about information they haven't been given, to read between the lines and identify potential future implications for organisations and markets. Encouraging curiosity in students is a crucial factor in teaching, instilling a thirst for the whole picture, rather than accepting what they have to hand. This is what is needed for a balanced risks approach, seeking out information that may contradict what has been decided, but in doing

so, it provides a clearer and therefore more robust and informed strategy for future development and growth.

Every sustainability intervention carries associated costs, limitations, or unintended consequences. It is important that students are taught to identify and analyse these inevitable trade-offs in sustainability decisions. Preparing students for the underlying tensions that are inevitable in an AI driven environment is an essential facet of teaching sustainability in HE. Students need to be encouraged to restructure their current perspectives on AI (Henriksen et al., 2024) to consider the possibilities of AI-driven sustainability being part of the problem as well as part of the solution. The holistic nature of this approach, encourages a view that departs from more traditional pedagogical perspectives on sustainability and AI, taking students through a process of analysis and creative thinking, forecasting potential problems that go beyond the outcomes of efficiency through AI use. Encouraging students to consider the negative impact of AI-driven sustainability, provides them with the tools to engage in a balanced risks narrative, recognising there may be unwanted outcomes, but allowing these to sit alongside the benefits, to assess the strategic value in proceeding with an initiative.

Within higher education, it is essential that students are equipped to critically interrogate both the benefits and risks of deploying AI for sustainability, with transparency forming a central principle of this process. By fostering the ability to assess not only the potential efficiencies and innovations AI can deliver but also the ethical, social, and environmental challenges it introduces, educators can prepare graduates to make informed, evidence-based, and ethically responsible decisions (Henriksen et al., 2024). Transparency is widely recognized as a fundamental prerequisite for building trust, ensuring accountability, and promoting fairness in AI systems (The Future of Life Institute, 2017).

Getting AI governance right represents one of the most consequential challenges of our time. It requires a commitment to mutual learning and dialogue, drawing on lessons and good practices emerging from diverse jurisdictions worldwide. By sharing experiences and approaches across cultural, political, and regulatory contexts, policymakers and educators can co-develop governance frameworks that are inclusive, adaptable, and responsive to the rapidly evolving landscape of AI (UNESCO, 2023). UNESCO's *Recommendation on the Ethics of Artificial Intelligence* (2021) positions human rights as the foundation for ethical AI governance, foregrounding principles such as dignity, fairness, non-discrimination, and equality. These principles provide a valuable scaffold for teaching AI ethics in higher education, where students must be encouraged to critically evaluate the societal implications of emerging technologies. By adopting a human rights lens, educators can guide students to interrogate real-world AI applications—such as recruitment algorithms, predictive policing tools, or healthcare diagnostics—by asking whose rights are protected, who benefits, and who may be disadvantaged. Pedagogical strategies might include scenario-based learning and role-play exercises (Schrier, 2014) in which students take on the perspectives of policymakers, developers, and civil society actors to negotiate governance dilemmas that balance innovation with rights protection (Henriksen, Mishra, & Stern, 2024).

In addition, UNESCO's emphasis on mutual learning across jurisdictions offers opportunities for comparative analysis of global practices, enabling students to recognize the diverse cultural and political contexts in which AI governance unfolds (United Nations, 2023). Reflective assessments can further support this approach by encouraging students to evaluate whether specific AI systems uphold human rights and to grapple with the tensions between innovation and protection (Holmes & Tuomi, 2022).

In line with these considerations, the learning outcomes for higher education students extend across multiple levels of Bloom's taxonomy. At a foundational level, students should be able to identify and explain UNESCO's human-rights-based approach and its core principles of dignity, fairness, equality, and non-discrimination (UNESCO, 2021). Building on this understanding, they should be able to apply these principles to analyse practical cases and innovation of AI use in domains such as employment, law enforcement, and healthcare (George and Wooden, 2025). More advanced learning outcomes include the ability to compare how different jurisdictions implement human-rights principles in AI governance (UK Government, 2023) and to evaluate critically the extent to which specific AI systems uphold or undermine these principles (Leal Filho et al., 2025). At the highest level, students should be able to design their own recommendations, policy proposals, or project plans that integrate a human-rights perspective into the development and governance of AI for sustainability (Ibitoye, Nkwo, & Orji, 2025). Together, these outcomes ensure that graduates are not only conceptually informed about AI ethics but also capable of applying, critiquing, and creating human-rights-based solutions in practice.

8. Conclusion

The conclusion brings together the insights developed across the chapter in direct response to the two research objectives: the design of a pedagogical framework that embeds a balanced risks approach (Objective 1), and the identification of educational strategies that equip students to navigate AI's paradoxical role in sustainability (Objective 2).The ethical challenges across the three pillars of sustainability, social, economic and environment (van Wynsberghe, 2021) are becoming more apparent as the potential for AI in sustainability grows. This chapter has demonstrated the ethical considerations and challenges that are surfaced when integrating AI in sustainability education and highlights the role that a balanced risks narrative can have in a student's understanding of such challenges and policies, that ensure a safe and ethical approach for AI-driven sustainability initiatives. The AI Sustainability Pedagogical Framework provides a system of actions that can support student learning. By students understanding a balanced risks narrative approach, they can recognise the dual nature of AI, its transformative potential and its inherent risks, and how those risks and ethical implications associated with new approaches to sustainability can be explored and communicated to government agencies to ensure a transparent and cohesive framework for policy implementation. In line with our framework, AI can be understood as a new generation of technologies that actively interact with their environment: collecting and interpreting information, recognising patterns and predicting events, generating results or instructions, and continuously refining decision processes to achieve defined objectives (Ferràs-Hernández, 2018). When embedded within pedagogy that emphasises problem-solving, interdisciplinary collaboration, ethical reflection, and the full AI lifecycle, such capabilities position AI not merely as a technical tool, but as a transformative enabler for responsible and sustainable learning and practice.

This chapter is limited by its reliance on a conceptual literature review rather than empirical testing, meaning the proposed framework has not yet been validated in classroom practice. The scope of the review was bounded by specific databases, timeframes, and search terms, which may have excluded some relevant studies. In addition, the analysis focused primarily on two pedagogical models, leaving out other approaches that might also inform sustainability education. Finally, given the rapidly evolving nature of AI and sustainability, some issues discussed here may shift over time, and the framework should therefore be seen as adaptive and open to refinement.

Biographies: Dr. Madeleine Pickles is an Associate Professor in Organisational transformation and Teaching Innovation at Liverpool John Moores University. Her research explores the impact of digitalisation on education and the workplace, with particular interests in how emerging technologies reshape learning, teaching, and organisational practices. She has published on the use of gamification and experiential learning through simulations, examining their potential to enhance engagement, critical thinking, and problem-solving skills. Beyond her focus on technology-enhanced learning, Dr. Pickles also investigates sustainable education, pedagogical innovation, and the ways higher education can prepare students to navigate complex challenges such as artificial intelligence and sustainability.

Dr Sue Cronshaw is a Associate Professor in Digital Marketing Pedagogy at Liverpool John Moores University, a Senior Fellow of the Higher Education Academy, Associate Editor of International Journal of Organizational Analysis and a media commentator. Before moving into academia, she worked as a marketing professional in the media for ten years, specifically in the field of brand management. She has published work in the areas of inclusive education, digital communities and organizational ambidexterity. Her research interests include digital well being and innovative pedagogy.

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