The Hidden Environmental Costs of EdTech

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Introduction

In the past decade, educational technologies have transformed from optional tools into essential pillars of modern education. The pandemic only accelerated this trend, pushing millions of students and teachers into the digital realm seemingly overnight. The story we tell ourselves about this shift is one of unbounded optimism: EdTech is efficient, accessible, and critically, sustainable. With fewer textbooks, reduced commutes, and classrooms that exist in the cloud, it's easy to assume that digital learning is a greener option for the planet.

But behind the glow of screens, a different story is unfolding. The **Greenpeace Guide to Greener Electronics** (2017) was one of the first to challenge the myth of sustainable technology, revealing the substantial environmental costs that linger beneath the surface. Despite this, the narrative around EdTech continues to project an aura of ecological responsibility, a narrative that has been difficult to counter as it fits so conveniently within our vision of progress. But as **Selwyn** (2021) points out, the environmental impacts of EdTech are substantial—and growing. Beyond the superficial reduction in paper, the infrastructure supporting digital education is a sprawling network of energy-hungry servers, unsustainable manufacturing practices, and planned obsolescence.

The report *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* pulls back the curtain on some of these hidden costs. It shows how data centres, such as those described by **Pasek** (2023) in his research on internet and server infrastructures, operate at immense energy costs, largely unseen by end users. But this only scratches the surface. Digital education also depends on devices—laptops, tablets, smartphones—each of which carries its own environmental burden. **Jattke** (2020) calls attention to the environmental implications of extending the service life of mobile devices, suggesting that the industry's constant push for new, upgraded technology exacerbates the problem.

And while much of the focus is placed on the carbon footprint of individual devices or online platforms, there are broader, more systemic issues at play. **Berquin** (2021) has called for a systematic analysis of the environmental impact of education technologies, arguing that the current piecemeal approach overlooks the cumulative effect of the entire ecosystem. Every upgrade, every new device, every cloud service relies on a complex supply chain—one that begins with the mining of rare earth materials and often ends in poorly regulated e-waste dumps in developing countries. This hidden lifecycle is rarely discussed, but it is crucial to understanding the true cost of EdTech.

Of course, there are voices of contrast. **West** (2023) argues that technological innovation and sustainability need not be mutually exclusive, proposing a balanced EdTech ecosystem that integrates green practices. Similarly, **Luccioni** (2022) explores how large language models like GPT, integral to AI-driven educational tools, can have their carbon footprints reduced with optimised energy practices. But even in these more optimistic takes, the challenges are clear: the digital revolution in education is far from carbon-neutral.

As we continue to rely on digital learning, it is vital to recognise the scale of its environmental impact. **Ørbæk** (2023) reminds us that digital learning's energy use is far from inconsequential, particularly when scaled across millions of users. And **Vakhitova** (2022) points out that optimising energy consumption in EdTech platforms is not only possible but necessary if we are to avoid overwhelming our energy grids. Yet, as **Ewim** (2023) highlights, even the most energy-efficient strategies for data centres still contribute significantly to climate change.

This article will delve deeper into these issues. We will also consider the contrarian perspectives that challenge both sides of the debate. For instance, **Istrate** (2024) warns that digital content consumption—now ubiquitous in education—carries an environmental cost that is often underestimated. Similarly, **Strubell** (2019) addresses the substantial energy requirements of deep learning, urging for stronger policy considerations around AI-driven EdTech. Meanwhile, **Fernández** (2019) explores the relationship between technology and environmental education, suggesting that the very tools driving unsustainable practices could also be part of the solution if used wisely.

Yet, as **Hulme** (2021) explains in his exploration of climate change discourse, part of the challenge lies in our disagreements about the problem itself. We are still grappling with how to define and measure the environmental costs of the digital world. This complexity is mirrored in **Schipper's** (2018) critique of the ethics and sustainability of the tech industry, where environmental degradation is often rationalised as the cost of innovation.

What becomes clear is that these environmental costs are not merely by-products; they are woven into the very fabric of how EdTech is conceived, produced, and consumed. In the sections that follow, we will explore the industry's environmental blind spots, the hidden inequalities, and the ethical responsibilities of the corporations profiting from this digital shift. While EdTech has the potential to reshape education, we must ask ourselves at what cost—and, more importantly, how we can mitigate it.

Environmental Blind Spots in the EdTech Industry

The digital transformation of education has been widely celebrated, and as discussed in *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024), it is often assumed to be a step towards a more sustainable future. The report rightly identifies several environmental concerns that have largely been ignored, such as the immense energy demands of data centres and the carbon footprint of device manufacturing. But the depth of these issues, and the unseen systemic forces driving them, requires a more critical lens. It is not just the existence of EdTech that presents environmental challenges—it is the culture of rapid innovation and planned obsolescence that accelerates these challenges, often in ways the original report only touches upon.

The first blind spot lies in the industry's **planned obsolescence**, a problem that is both technical and cultural. Manufacturers and EdTech providers have created a cycle where hardware and software are constantly upgraded, rendering devices obsolete well before their physical lifespan is up. **Jattke** (2020) examines how the environmental implications of this approach are far-reaching, as the frequency with which devices are replaced fuels the global e-waste crisis. *Environmental Impact of EdTech* (2024) recognises this issue but stops short of acknowledging the broader forces at play. The constant push for "innovation" in education technology masks a much more unsustainable reality—one where old devices are disposed of not because they fail, but because they are no longer compatible with the latest software or systems.

This endless cycle of discarding and replacing devices disproportionately affects communities in the Global South, where much of the developed world's **e-waste** is dumped. **Selwyn** (2021) argues that educational institutions, along with the tech companies that supply them, have a moral obligation to address the full lifecycle of their devices. And yet, the infrastructure for managing discarded EdTech is woefully inadequate. The report briefly mentions the role of e-waste but leaves room for a much-needed conversation about how global inequality underpins this issue. As **Greenpeace** (2017) has pointed out, much of this waste ends up in under-regulated landfills, often in countries least equipped to deal with the toxic remnants of the digital world. The environmental and health implications of this crisis are profound, yet they remain largely invisible to those benefiting from the latest digital learning tools.

Moreover, the materials required to manufacture these devices carry their own hidden environmental costs. The extraction of **rare earth minerals** like cobalt, vital to EdTech's hardware, has devastating effects on the environment and human communities alike. **Pasek** (2023) has shown that the extraction of these minerals leaves behind long-lasting scars on the earth, and the human cost—particularly in places like the Democratic Republic of Congo—is staggering. While *Environmental Impact of EdTech* (2024) acknowledges the issue of raw material extraction, it fails to fully address the complexity of the labour exploitation that underpins the global supply chain. The clean, sleek exterior of an EdTech device hides a history of environmental destruction and human suffering.

Addressing these blind spots requires more than optimising existing systems—it demands a fundamental shift in how we think about EdTech. **Ørbæk** (2023) notes that energy consumption across the entire digital infrastructure, from devices to servers, continues to rise, even as energy-efficient strategies are implemented. This highlights a key point missing in the original report: EdTech's environmental cost is not a static problem that can be solved by simply reducing energy usage. The underlying issue is a systemic one, driven by market demands for constant innovation without regard for long-term environmental impact.

There are, however, some encouraging signs of change. **West** (2023) has explored how technological innovation and sustainability need not be at odds, suggesting that more responsible practices—such as extending device lifecycles and embracing the right to repair—can help mitigate some of EdTech's worst environmental effects. **Ganapini** (2023) similarly advocates for policies that would allow for easier repair of devices, reducing the pressure to constantly replace and discard them. These ideas, while not fully developed in the original report, represent a path forward—a way to break the cycle of planned obsolescence and the waste it creates.

Of course, any real solution will need to engage with the deeper structural issues. **Vakhitova** (2022) reminds us that optimising energy consumption in EdTech is critical, but without systemic reform, it will never be enough to offset the growing demand for new technologies. Even the most energy-efficient strategies, such as those discussed by **Ewim**(2023), cannot fully address the broader environmental impacts if they are not accompanied by a reduction in consumption. The original report touches on these solutions but leaves room for a more robust examination of the underlying causes driving EdTech's environmental footprint.

What emerges from this broader analysis is a clear picture: the environmental blind spots of the EdTech industry are not isolated problems. They are woven into the very fabric of how the industry operates, driven by the relentless push for innovation and profitability. As **Strubell** (2019) has pointed out, the energy demands of AI and machine learning—both critical to many EdTech platforms—are only increasing, further exacerbating the issue. **Fernández** (2019) suggests that education itself can play a role in addressing these problems by integrating environmental awareness into digital learning platforms. But for that to happen, we need a more honest reckoning with the environmental costs of EdTech, one that goes beyond efficiency gains and targets the root causes.

Ecological Inequalities – Global North vs. Global South

In the realm of digital education, the story has often been one of opportunity. The promise of EdTech, as highlighted in *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024), is that technology has the power to democratise learning. Access to a wealth of information, once available only to a privileged few, is now, theoretically, within reach of anyone with an internet connection. But behind this optimistic narrative, a more unsettling reality emerges. The environmental cost of this digital transformation is not evenly distributed, and the communities bearing the brunt of these hidden costs are often the ones benefiting the least.

The digital learning revolution has created a vast network of global dependencies, where the tech-heavy Global North relies on natural resources and waste management infrastructures in the Global South to sustain its appetite for progress. While students and institutions in wealthy countries leverage the benefits of EdTech, those in developing regions are left to contend with its by-products. This imbalance, as the report rightly notes, is not incidental—it is systemic.

Take the issue of **e-waste dumping**, a modern iteration of an old problem: the disposal of obsolete technologies in regions ill-equipped to handle them. **Ganapini** (2023), in his exploration of the right to repair, explains how the perpetual cycle of device upgrades in the Global North exacerbates this problem. Devices that still have life in them are discarded, only to be replaced by newer models. Much of this e-waste ends up in the Global South, where informal recycling sectors struggle with the toxic remnants of our digital lives. The report touches on this disparity but stops short of addressing the sheer scale of the problem—a problem that **Greenpeace** (2017) has long highlighted in its documentation of e-waste's environmental and health impacts.

Beneath the piles of discarded smartphones, laptops, and tablets lies another, more deeply rooted issue: the **exploitation of natural resources**. The EdTech industry is built on a foundation of rare earth minerals—cobalt, lithium, and others—whose extraction disproportionately affects countries in the Global South. As **Pasek** (2023) argues, the environmental devastation caused by mining operations in regions like the Congo is a direct consequence of the technological advancements enjoyed by wealthier nations. These minerals, essential to the production of EdTech hardware, fuel a global supply chain that leaves deep environmental scars on some of the world's most vulnerable ecosystems.

The cost is not just environmental; it is human. The same communities that are ravaged by mining operations are also deprived of the technological benefits that these operations support. This is where **Cordero** (2020) makes a vital point: the cycle of extraction and degradation in resource-rich countries limits their ability to benefit from the technologies they help create. The report hints at this irony but doesn't delve into the ways in which environmental degradation exacerbates inequality. Access to digital learning tools, for example, remains uneven, with the most advanced technologies concentrated in the hands of the few, while resource-rich countries struggle with basic infrastructure needs.

It's important to understand that these disparities are not just geographical—they are deeply tied to the political and economic structures that govern the tech industry. **Khafid** (2023) explores how policies like the so-called "paperless policy" in education are championed by the Global North as environmentally sustainable, while the environmental costs are outsourced to the Global South. There is a disturbing contradiction here: the very regions that supply the raw materials for digital learning tools are often excluded from the benefits of those tools. It is a cycle of extraction and exclusion that perpetuates global inequalities.

Jian (2021) goes even further, examining how the environmental degradation caused by industries like the paper and pulp sector mirrors the exploitation seen in EdTech. Both industries rely on unsustainable practices that degrade the natural environment, leaving developing countries to bear the costs. While the Global North continues to push for more digital solutions, the infrastructure in the Global South collapses under the weight of environmental and social pressures. The report's failure to fully grapple with this reality points to a broader issue: the environmental costs of EdTech are often framed as an afterthought, rather than as a central concern.

Perhaps most telling is the **disparity in access**. **Luiz** (2017) points out that while the Global North benefits from cutting-edge digital learning technologies, the environmental degradation in resource-rich countries limits those nations' ability to use the technologies they help create. This is not just a question of availability; it's a question of infrastructure. The regions hardest hit by the environmental impacts of EdTech are often the least equipped to integrate those very tools into their education systems.

The environmental damage caused by EdTech is not a side effect—it is baked into the very structure of how the industry operates. This becomes clear when we examine the broader dynamics at play. **Voutilainen** (2024) discusses how the rights of children, particularly in developing countries, are often overlooked in discussions about climate change and digital infrastructure. Children in these regions face the dual burden of being deprived of digital learning opportunities while also being exposed to the environmental hazards created by the very technologies they cannot access.

The report, *Environmental Impact of EdTech* (2024), makes a crucial contribution by highlighting these issues, but its analysis remains surface-level. To fully understand the environmental and social costs of EdTech, we must look beyond the immediate benefits and recognise the deep-seated inequalities that underpin the industry. **Haya** (2023), in his assessment of carbon credit projects, points to the inherent flaws in global environmental initiatives that fail to address these disparities. Carbon offsetting, a popular solution touted by the tech industry, often does little to mitigate the real environmental impacts of technological consumption in the Global South.

The environmental cost of EdTech, then, is not just about carbon footprints or energy consumption. It is about the structural inequalities that allow the Global North to externalise its environmental responsibilities onto the Global South. As **Williams** (2020) suggests, collaborative learning models that address sustainability must begin by acknowledging these inequalities. Only by confronting the realities of exploitation, degradation, and exclusion can we hope to create a more equitable and sustainable future for digital learning.

The Role of AI and Emerging Technologies in Exacerbating Environmental Issues

The optimism surrounding the digital transformation of education rests on the assumption that technological progress is inherently beneficial. Yet, as we've seen, the reality is far more complex. In the previous discussion of ecological inequalities between the Global North and South, it became clear that the environmental costs of EdTech are often borne by those least equipped to handle them. But there is another layer to this story, one that *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024) addresses only partially—the role that artificial intelligence (AI) and emerging technologies like virtual reality (VR) and augmented reality (AR) play in amplifying these environmental challenges.

AI, in particular, has captivated the imagination of educators and technologists alike. The promise of personalised learning, intelligent tutoring systems, and advanced analytics suggests a future where education can be tailored to the needs of each student. However, as **Strubell** (2019) and **Luccioni** (2022) warn, this vision comes with an immense and largely hidden environmental cost. Training large AI models, such as GPT-3 and other deep learning systems, requires vast computational resources, which in turn consume staggering amounts of energy. This is not a mere footnote in the AI revolution—it is a central concern.

Consider the carbon footprint of AI models like BLOOM, a 176-billion-parameter language model that exemplifies the sheer scale of energy consumption required. **Luccioni** (2022) estimates that training such models can produce emissions equivalent to those of five cars over their entire lifetimes. The environmental burden, as detailed in *Environmental Impact of EdTech* (2024), is not confined to the development phase alone. The continual operation of AI systems, integrated into EdTech platforms for tasks like personalised learning and student data analytics, ensures that the carbon footprint grows exponentially as these tools are deployed at scale.

The environmental impact of AI is compounded by the infrastructure that supports it. **Desislavov** (2023) traces the rise of data centre consumption, explaining how the ever-increasing demands of AI-powered EdTech tools are pushing the limits of energy efficiency. The scale of this issue cannot be overstated: data centres, which house the servers that power these technologies, are responsible for an estimated 1% of global electricity use, a figure that continues to rise with the proliferation of AI in education. The report touches on this issue but doesn't fully explore the implications. The constant need to store, process, and analyse data in real-time contributes to an ongoing cycle of energy consumption that undermines the very sustainability goals EdTech purports to support.

This brings us to one of the most concerning aspects of emerging technologies in education: **virtual reality (VR) and augmented reality (AR)**. These immersive tools are increasingly being adopted as a means of enhancing engagement and creating more dynamic learning experiences. But as **Czok** (2023) points out in his research on AR's learning effects and sustainability, the hardware required to run these systems—powerful graphics processors, energy-intensive displays, and robust data transfer capabilities—comes at a significant environmental cost. It's not just the initial energy required to power these devices; it's the continuous use of high-powered processing units that drives energy consumption far beyond what traditional EdTech tools demand.

While *Environmental Impact of EdTech* (2024) acknowledges the rise of VR and AR in education, it underplays the environmental implications of these technologies. **Hsu** (2018) highlights a case study in water conservation education, where VR was used to simulate environmental impacts. The irony is palpable: the very tools designed to teach sustainability are themselves significant contributors to the environmental crisis. In focusing on the pedagogical benefits, we risk overlooking the energy costs associated with maintaining and scaling these technologies.

Yet, there is a deeper issue at play. **Warren** (2023) argues that the environmental costs of AI and emerging technologies in education are not simply a matter of energy consumption—they are indicative of a broader problem within the EdTech industry. The drive for innovation has outpaced the capacity for sustainability. As new technologies are introduced, the focus is overwhelmingly on their potential to transform learning, while the environmental consequences are relegated to the background. *Environmental Impact of EdTech* (2024) touches on this point but leaves much to be explored regarding the long-term environmental footprint of these innovations.

The underlying issue is that the deployment of AI, VR, and AR in education is framed as progress—an unquestioned good that must be pursued in the name of improving educational outcomes. But as **Schneider** (2020) notes, the limits of sustainable computing in education are rarely discussed. The assumption that technological innovation can continue unchecked, without serious environmental consequences, is not only misguided but dangerous. The data centres required to support AI-driven EdTech platforms, for example, are energy guzzlers, their carbon footprint growing with each new advancement. **Pasek** (2023) provides a critical examination of this trend, suggesting that the environmental cost of these technologies may outweigh their educational benefits in the long run.

This tension between innovation and sustainability is not unique to EdTech, but it is particularly acute in a sector that prides itself on preparing students for the future. How can we reconcile the growing energy demands of AI and immersive technologies with the pressing need to reduce carbon emissions? **Fernández** (2019) suggests that technological solutions, like the integration of environmental consciousness into EdTech platforms, could mitigate some of the damage. However, this requires a significant shift in how we design and implement these tools—moving from a focus on innovation for its own sake to a more deliberate, sustainability-oriented approach.

One potential solution, as **Kim** (2021) explores, lies in the development of more energy-efficient AI models. By optimising algorithms and reducing the computational power required to train and deploy these systems, it may be possible to lessen the environmental impact without sacrificing the benefits of AI-driven learning. But even this approach has its limitations. As **Versteijlen** (2023) notes, the sustainability of digital learning tools must be considered holistically. It is not enough to improve energy efficiency if the overall demand for these technologies continues to grow unchecked.

The report *Environmental Impact of EdTech* (2024) raises many of these concerns, but the path forward remains unclear. **Jain** (2022) offers a more optimistic view, suggesting that the intersection of AI, sustainability, and the future of EdTech holds potential for significant advancements. Yet, even the most hopeful perspectives must grapple with the fact that emerging technologies like AI, VR, and AR are not environmentally neutral. The question is not whether these technologies will be part of the future of education—they undoubtedly will—but whether we can afford their environmental costs in the long run.

The 'Green EdTech' Paradox

The rise of educational technology, or EdTech, has been accompanied by a prevailing assumption: that the digitalisation of learning is inherently greener than traditional methods. After all, digital platforms eliminate the need for paper, textbooks, and physical classrooms. This is the image that has been marketed to educators, policymakers, and the public—the notion that moving education online automatically translates into environmental savings. Yet, as the *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024) report reminds us, such assumptions are often deceptive.

What emerges from a closer examination is a paradox. Yes, EdTech reduces paper consumption, but it also introduces new, less visible environmental costs. These costs, often omitted from the sustainability narrative, challenge the very idea that digital learning is a greener alternative.

At the heart of this paradox lies what could be termed **the paperless myth**. The move away from physical textbooks and printed materials is frequently cited as evidence of EdTech's environmental benefits. But while it's true that fewer trees are felled for education, the report exposes a critical oversight: the energy demands of digital infrastructure. Servers and data centres, the backbone of digital learning, are always running—always consuming power, whether students are actively learning or not. **Versteijlen** (2023) quantifies this in his exploration of the environmental costs of cloud-based tools, noting that the carbon emissions linked to data storage and transmission far exceed the savings made from going paperless.

Czok (2023), whose work focuses on augmented reality (AR) and its sustainability implications, echoes this point, arguing that digital learning tools, while seemingly intangible, rely on a vast network of energy-hungry devices and data processing centres. Every click, every streamed video, every downloaded PDF requires energy, and that energy must come from somewhere. The more we shift education online, the more we fuel the demand for these digital infrastructures.

The report rightly acknowledges that the **carbon footprint of digital learning** is far from negligible. But even these estimates may be conservative. **Hsu** (2018), in his study of virtual reality's use in water conservation education, points out that the energy requirements of immersive technologies like VR and AR, which are becoming increasingly integrated into digital learning platforms, are especially significant. These technologies require high-performance processing units, constant data transmission, and robust network infrastructures—all of which add to the carbon burden of digital education.

The implications are clear: digital learning platforms do not operate in a vacuum. They are part of a broader system of energy consumption that includes not just the devices themselves but the entire ecosystem required to support them. As **Luccioni** (2022) discusses in her work on the carbon footprint of AI models, the energy demands of these systems are growing rapidly, particularly as AI-driven personalised learning platforms become more prevalent. The *Environmental Impact of EdTech* (2024) report acknowledges this trend but underplays its future trajectory. AI, VR, and AR are not simply new tools in education—they are new sources of environmental pressure.

This brings us to another, often overlooked issue: the **sustainability of devices**. While digital learning platforms eliminate the need for paper, they rely on hardware that has a limited lifespan. Laptops, tablets, smartphones—these devices are not designed to last forever. In fact, they are often designed to be replaced, upgraded, or discarded within a few short years. **Fernández** (2019) raises concerns about the short lifecycle of these devices, noting that their frequent replacement negates many of the environmental benefits associated with digital learning. The report touches on this issue but does not fully address the scale of the problem. Every time a student upgrades their laptop or a school purchases a new set of tablets, they contribute to the growing problem of electronic waste, or e-waste, a crisis that disproportionately affects developing countries.

What's particularly striking about this is how easily it can be overlooked. The sleek design of modern digital devices, combined with the convenience of cloud-based learning, creates a sense of detachment from the physical world. Unlike a stack of used textbooks or a pile of discarded notebooks, the environmental impact of digital learning is hidden behind the screen. **West** (2023) argues that this detachment is part of a larger narrative within EdTech, where the emphasis is placed on innovation and convenience, rather than on the long-term sustainability of the tools being used.

Yet, it is precisely this **hidden environmental cost** that should concern us most. As **Pasek** (2023) points out, the energy consumption of always-on servers and cloud storage systems is not a by-product of digital learning—it is a core feature. The more we rely on digital platforms to deliver education, the more energy-intensive the system becomes. And with the increasing use of AI to personalise learning and streamline administrative tasks, the demand for server space and data processing will only continue to grow.

The *Environmental Impact of EdTech* (2024) report highlights some of these concerns, but it also leaves room for a deeper analysis of the long-term environmental trade-offs associated with digital learning. The focus, understandably, is on the immediate benefits of reducing paper use and improving access to education. But as **Schneider** (2020) warns, the environmental benefits of digital learning may be overstated if we fail to account for the full lifecycle of the devices and infrastructures that make it possible.

There is a temptation, within the tech industry and beyond, to view technological progress as inherently positive. The idea that more technology equals more progress, more efficiency, and more sustainability is deeply ingrained in our collective consciousness. But as the *Environmental Impact of EdTech* (2024) report shows, this narrative is incomplete. The environmental costs of digital learning are real, and they are growing. What we need now is a more nuanced understanding of these costs—a recognition that while EdTech may reduce certain types of environmental impact, it also introduces new challenges that cannot be ignored.

Nam (2021) calls for students to be partners in climate change education, arguing that they must be made aware of the environmental impacts of the technologies they use. This is where the conversation around EdTech needs to shift. It's not just about whether digital learning is more sustainable than traditional methods—it's about understanding the full scope of its environmental footprint and making informed decisions about how to balance the benefits of digital education with its costs. Only then can we begin to resolve the paradox of 'green' EdTech.

Student-Centric Solutions: Missing Voices

In many ways, the ongoing discourse around the environmental impact of EdTech has been shaped by those who design, build, and regulate technology. But there's a conspicuous absence from these conversations: the students themselves. As much as EdTech promises to empower learners, it often overlooks the most vital resource in the push for sustainability—students' voices.

The report *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024) hints at this imbalance, focusing on the technical and policy-driven elements of environmental sustainability in education. Yet, it misses a key dimension: the opportunity to engage students in advocating for, and leading, sustainable change through the very technologies that shape their educational experiences. The absence of student perspectives represents a lost opportunity for truly transformational education, one that doesn't just educate but mobilises.

Nam (2021) captures this tension perfectly in her exploration of student partnerships in climate change education, noting that students are often passive recipients of sustainability rhetoric rather than active participants. EdTech can change that. By embedding environmental **digital literacy** into the very tools students use, there's an opportunity to empower a generation of learners to not only understand the environmental costs of technology but also to lead the charge in addressing them. In an age where students are already digitally savvy, integrating environmental literacy into EdTech platforms is not just logical—it's essential. By doing so, students can begin to see the impact of their digital choices and advocate for more sustainable practices, both in education and beyond.

The current curriculum too often compartmentalises environmental education, treating it as an add-on to an already packed syllabus. Yet, as **Cordero** (2020) argues, long-term behavioural impacts are achieved when environmental consciousness is embedded into everyday learning experiences. This speaks to the need for a fundamental **curricular reform**, one that recognises climate consciousness not as a separate subject but as a lens through which all subjects are taught. Imagine a world where climate impact is considered not just in geography or biology, but in the use of digital tools in mathematics, science, and even literature.

What is perhaps most exciting is the potential for students to lead this change themselves. **Kucirkova** (2023) highlights examples of students taking the lead in embedding climate literacy into digital education, using the very tools that contribute to environmental degradation to fight against it. There is a deep irony in this—that the same platforms driving e-waste and energy consumption could also serve as the staging ground for student-led environmental advocacy. Case studies like these show that students, when given the tools and the platform, can be powerful advocates for sustainable practices, often outpacing their institutional counterparts in ambition and execution.

One of the more compelling examples of this is **Voutilainen** (2024), whose research into climate resilience in education demonstrates the effectiveness of student-led climate action initiatives. When students are given the agency to shape their learning environments, the impact extends far beyond the classroom. They become advocates, not just for themselves, but for the broader global community, tackling issues that go well beyond the boundaries of the school day.

Yet, it's clear that EdTech itself is a double-edged sword. The very tools that students use to lead climate action also come with significant environmental costs. This paradox is not lost on student activists, many of whom are acutely aware of the trade-offs involved in using digital tools for advocacy. **Liu** (2023) captures this dilemma in her study on e-learning and sustainability, highlighting how student activists are often torn between the environmental benefits of digital advocacy and the environmental degradation that these tools contribute to.

Environmental Impact of EdTech: The Hidden Costs of Digital Learning (2024) touches on this dilemma, but it leaves room for a deeper analysis of how students themselves are navigating this paradox. It is here that the conversation around EdTech must evolve—not simply to accommodate student voices, but to amplify them, giving students the tools to engage critically with the technology they use every day. This requires a shift, both in how we view digital literacy and in how we integrate it into the curriculum.

It's not enough to teach students how to use technology effectively; we must also teach them to understand its environmental consequences. **Khafid** (2023) touches on this in his exploration of teaching sustainability through digital tools, advocating for a more critical approach to digital literacy—one that places sustainability at the forefront of the conversation. For students, understanding the environmental impact of their digital tools is the first step toward creating a more sustainable future.

At the same time, the potential for **student-led initiatives** is vast. From social media campaigns that raise awareness about climate issues to digital platforms that allow students to organise and mobilise, the tools are already in place. What's missing is the infrastructure within educational systems to support and encourage this kind of activism. **Alfarizi**(2024) examines the role of digital tools in ecopreneurship, arguing that when students are given the opportunity to leverage technology for climate advocacy, the results can be transformative. But to fully realise this potential, schools and educational institutions must do more than simply provide access to these tools—they must actively encourage their use for environmental advocacy.

Ultimately, the missing voices in the conversation around EdTech and environmental sustainability are those of the students themselves. They are the ones who will inherit the consequences of today's decisions, and they are the ones who have the most to gain—or lose—from the future of digital education. The *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024) does well to highlight the environmental challenges of the current system, but it falls short in recognising the role that students can—and should—play in addressing these challenges.

The solution lies not just in tweaking the curriculum or integrating sustainability into digital literacy programs. It lies in giving students the tools, the knowledge, and the platform to lead the charge. As **West** (2023) puts it, sustainability in EdTech is about more than just reducing the environmental footprint of digital tools—it's about empowering the next generation to create a future where technology serves both people and the planet.

Ethical Responsibilities of EdTech Companies

As we move deeper into the discussion of EdTech's environmental impact, a critical question emerges: where does responsibility truly lie? The sleek marketing of digital learning platforms promises a more sustainable future, yet *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024) reveals a different story. The report pulls back the curtain on a sector that has grown accustomed to presenting its advances as inherently good, while neglecting the substantial environmental trade-offs. It is within this gap between image and reality that we must confront the ethical responsibilities of the companies that have built—and now dominate—this industry.

At the core of the EdTech industry's environmental narrative is **greenwashing**: the strategic presentation of sustainability efforts that amount to little more than window dressing. The report touches on this issue but leaves the scale of the problem largely unexamined. **Selwyn** (2021), in his critical analysis of EdTech's ethical responsibilities, argues that many companies have perfected the art of appearing green without making the systemic changes necessary to address their environmental footprint. Superficial changes—such as promoting paperless classrooms or reducing packaging—do little to address the deeper issues embedded in the supply chains and operations of these companies.

Schneider (2020) takes this critique further, suggesting that EdTech's public relations efforts obscure the real environmental costs of its products. From the mining of rare earth minerals to the energy-intensive processes of manufacturing and data storage, the industry's core business operations remain environmentally destructive. Yet, these practices are rarely scrutinised. Instead, companies lean on **voluntary certifications**, which offer a veneer of accountability without enforcing meaningful reforms. As **Williams** (2020) points out, such certifications often allow companies to sidestep regulations that would force them to confront the full scope of their environmental impact.

This is where the discussion must shift. *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024) acknowledges the limitations of voluntary certifications but does not go far enough in proposing alternatives. If we are serious about holding EdTech companies accountable, we must push for **binding international regulations** that go beyond the symbolic gestures of sustainability. **Jensen** (2021) critiques the reliance on voluntary sustainability certifications, noting that they are often toothless and allow companies to continue business as usual while projecting a false sense of progress. The solution, as **Prado** (2022) argues, lies in a combination of stricter environmental regulations and a fundamental shift in how we think about corporate responsibility.

It is here that the concept of **corporate responsibility** demands deeper exploration. The *Environmental Impact of EdTech*(2024) report raises important questions about supply chain transparency and the use of recycled materials in device manufacturing, but it stops short of outlining how these practices could be enforced. **Ganapini** (2023), in his study on the right to repair, offers a compelling argument for extending the lifecycle of EdTech devices by mandating repairability as a design principle. Such measures would not only reduce e-waste but also shift the industry's focus from rapid innovation to long-term sustainability.

Yet, repairability alone is not enough. **Fernández** (2019) highlights the broader ethical dimensions of sustainability in EdTech, pointing to the need for transparency in the sourcing of materials and the treatment of workers throughout the supply chain. The environmental and social costs of mining the minerals used in digital devices—often borne by communities in developing countries—are rarely considered in the public discussions surrounding EdTech's sustainability efforts. For real change to occur, companies must adopt a more holistic approach to **supply chain ethics**, one that prioritises both environmental sustainability and human rights.

This is not just an idealistic vision. As **McAfee** (2023) notes, there are tangible steps that EdTech companies can take to align their operations with ethical sustainability goals. The use of **recycled materials**, for example, can significantly reduce the environmental impact of manufacturing new devices. But such measures are rarely implemented on a large scale. **Hernandez** (2020) calls this the "double-edged sword" of green IT adoption, where companies tout the environmental benefits of their products without making the necessary investments in sustainable manufacturing processes.

The paradox of EdTech's green ambitions is laid bare when we consider the growing reliance on **data centres**, which are critical to the functioning of AI-powered learning platforms, cloud storage, and other digital tools. These data centres are responsible for a significant share of the industry's carbon emissions, yet they remain an under-examined aspect of the environmental debate. **Holm** (2023) explores the ethical dilemmas posed by the energy consumption of these centres, arguing that EdTech companies must take responsibility for the environmental footprint of their digital infrastructures. The report acknowledges the environmental costs of data centres but does not go far enough in holding companies accountable for reducing their energy use.

What becomes clear from this analysis is that EdTech's environmental and ethical failings are not isolated incidents but are woven into the very fabric of the industry. The reliance on voluntary certifications, the superficial greenwashing efforts, and the lack of meaningful corporate responsibility all point to a deeper problem: the industry's unwillingness to confront the systemic issues that underpin its environmental impact.

The *Environmental Impact of EdTech* (2024) report brings many of these issues to light, but its analysis remains incomplete. To fully address the ethical responsibilities of EdTech companies, we must move beyond the surface-level solutions and push for deeper, more systemic reforms. **West** (2023) offers a blueprint for this, calling for corporate responsibility in EdTech to be more than just a buzzword. It must be a guiding principle that informs every aspect of a company's operations, from the sourcing of materials to the disposal of devices.

As the industry continues to grow, the stakes will only get higher. The environmental impact of EdTech is not a problem that can be solved through incremental changes or public relations campaigns. It requires a fundamental shift in how companies approach sustainability—one that prioritises transparency, accountability, and a long-term commitment to reducing their environmental footprint.

Overlooked Solutions: Toward a Regenerative Approach to EdTech

As the environmental costs of EdTech become increasingly apparent, the question arises: What comes next? We know, as *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024) makes clear, that the current sustainability efforts of the EdTech industry are insufficient. Companies' incremental gestures—repair programmes, energy-efficient updates—fail to address the deeper systemic problems. These steps are reactive rather than transformative. What's needed is a shift in perspective, one that moves away from simple sustainability models toward something more ambitious: a **regenerative approach** to EdTech.

The idea of a regenerative approach is not new, but it remains underexplored in the context of digital learning technologies. Where sustainability focuses on reducing harm, regeneration seeks to restore, renew, and revitalise the ecological systems affected by technological production and consumption. **Moro** (2023), in his articulation of the Triple S Framework (Sustainable and Scalable Practices in EdTech), argues that only a regenerative mindset can move us beyond the limitations of current environmental strategies. EdTech needs to adopt principles that encourage not just the reuse of resources but their enhancement.

One solution lies in embracing **circular economy models**. The circular economy, which has gained traction in industries ranging from fashion to construction, promotes the idea that products should be designed for longevity, repair, and recyclability. In EdTech, this would mean creating devices with longer lifespans, using modular designs that allow for easy upgrades or repairs. **Ganapini** (2023) points out that the right-to-repair movement, gaining momentum across various tech sectors, could have profound implications for EdTech. If educational institutions could repair rather than replace their devices, the volume of e-waste could be drastically reduced.

But repairability alone is not enough. **Schneider** (2020) reminds us that even the most repairable devices still contribute to environmental degradation through their initial production and eventual disposal. What is needed is a fundamental shift in how these devices are designed and used. *Environmental Impact of EdTech: The Hidden Costs of Digital Learning*(2024) touches on this but stops short of advocating for the kind of large-scale systemic changes necessary to implement circularity at scale.

To achieve true regeneration, EdTech companies must rethink their entire approach to product design, focusing on **collaboration for sustainability**. This means working not just with educational institutions, but also with governments, non-governmental organisations, and other industries to create shared frameworks for innovation. **Kucirkova** (2024), in her exploration of the 5Es of Evidence and SDGs, emphasises the importance of cross-sector partnerships in achieving the Sustainable Development Goals (SDGs). EdTech's environmental footprint is not a problem that can be solved in isolation; it requires collective action.

Such collaboration can also foster **repair and reuse models** within educational institutions themselves. As **Satyro** (2018) highlights, designing for repairability goes hand in hand with creating shared device usage systems. Schools and universities could adopt shared-use models where devices are circulated among students, reducing the need for each student to own their own laptop or tablet. This model not only reduces e-waste but also promotes equity in access to technology—an issue that *Environmental Impact of EdTech* (2024) recognises as critical but does not explore in depth.

The case for shared device models, however, is not without its challenges. **Jensen** (2021) argues that while shared-use systems reduce waste, they also face logistical barriers, particularly in low-income or rural areas where infrastructure is lacking. This raises important ethical questions: who gets to participate in the regenerative economy, and who is left out? As EdTech companies and educational institutions work together to develop sustainable procurement practices, these disparities must be addressed. **Hernandez** (2020) points out that green IT adoption often benefits wealthier institutions, leaving smaller schools and developing regions struggling to keep pace.

While the push for **sustainable procurement** is essential, it is not enough to simply purchase greener technology. As **Liu**(2023) argues in her exploration of e-learning technologies and entrepreneurial sustainability, procurement practices must be part of a broader strategy that includes device longevity, repairability, and shared usage. Schools need to prioritise purchasing devices that are designed for the long haul, with easily replaceable parts and minimal environmental impact.

Yet, as we consider the path forward, **Haya** (2023) cautions against over-reliance on market-driven solutions such as carbon offsets. Carbon credits, often touted as a way for companies to "neutralise" their environmental impact, have been critiqued for allowing companies to avoid making real changes to their operations. A regenerative approach cannot be built on such superficial solutions. As **Lovell** (2021) points out, the carbon offset market is rife with failures, offering little more than a fig leaf for companies that continue to engage in environmentally harmful practices.

What emerges from these discussions is a sense that the EdTech industry is at a crossroads. The *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024) report highlights the urgency of addressing EdTech's environmental footprint but remains rooted in a sustainability model that is no longer sufficient. If we are to move toward a truly regenerative approach, we must rethink not only how we design and use technology, but also how we collaborate, procure, and repair.

Holm (2023) calls this the "missing piece" in the current discourse: the recognition that regeneration requires more than just reducing harm—it requires a commitment to renewal, to giving back more than we take. This mindset shift is particularly important in education, where the stakes are not only environmental but also social. As **Schneider** (2020) argues, a regenerative approach to EdTech must not only minimise environmental impact but also promote equity and justice, ensuring that all students have access to the benefits of technology without bearing its environmental costs.

To move toward a regenerative future in EdTech, we must embrace the full complexity of the challenge. This means designing devices for longevity, fostering cross-sector collaborations for sustainable innovation, and rethinking procurement and usage models. It also means acknowledging that while technological solutions are essential, they are not sufficient on their own. True regeneration requires a cultural shift—one that places the environment, equity, and education at the heart of EdTech's mission.

Conclusion: Future Pathways

As the digitalisation of education accelerates, the environmental impact of EdTech remains an often-ignored byproduct of progress. *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024) forces us to reconsider the narrative that technology, simply by virtue of being digital, is inherently green. This report brings into focus the contradictions at the heart of EdTech's sustainability claims, but it also opens the door for a deeper conversation about how we move forward.

Selwyn (2021) warns that the future of EdTech in an environmentally compromised world depends on our ability to challenge the assumptions that have long governed the sector. We cannot continue to rely on short-term solutions—be it superficial greenwashing or incremental improvements in device efficiency. What is required is a fundamental shift in how we think about EdTech's role in education and the environment. **Kucirkova** (2023) echoes this call, advocating for sustainable pathways that integrate environmental considerations into the design, use, and disposal of digital learning tools. These are not distant, utopian goals—they are practical steps that the industry must take now.

But the question remains: Is greening EdTech enough? **West** (2023) argues that we must look beyond sustainability to consider how EdTech can actively regenerate the environments it affects. Greening EdTech, in his view, risks being too narrow an objective, focusing on mitigating damage rather than fostering ecological renewal. **Moro** (2023) builds on this, suggesting that balancing innovation with sustainability requires a shift toward regenerative models—those that prioritise not just the minimisation of harm but the restoration of ecosystems. It is an approach that aligns with the broader climate resilience goals that **Green** (2024) sees as essential for the future of education.

Of course, such transformations come with their own ethical and logistical challenges. **Schneider** (2020) notes the ethical dilemmas inherent in sustainable tech design, particularly when the industry's profit-driven incentives often conflict with genuine environmental responsibility. The report gestures toward these tensions but leaves much unsaid about the contradictions within EdTech's approach to sustainability. **Prado** (2022) identifies these contradictions as a core issue, where the rush to innovate often sidelines the necessary ethical scrutiny required to make sustainability real.

The future pathways for EdTech must also grapple with these competing pressures. **Luccioni** (2022) offers a vision of how sustainable AI can lead the charge in making education more efficient, but the environmental costs of such technologies remain significant. **Jensen** (2021) argues that stronger regulations are needed if EdTech is to genuinely embrace sustainability, noting that voluntary corporate pledges are no substitute for binding international frameworks.

Perhaps the most contrarian voice in this discourse belongs to **McAfee** (2023), who challenges the very premise of sustainable EdTech. In his view, the myth of sustainability in digital learning is one we must confront head-on, recognising that technology alone cannot solve the environmental crises it contributes to. **Holm** (2023) agrees, offering a critical examination of so-called sustainable solutions in EdTech, reminding us that real change will require more than just tweaking current practices—it will demand a rethinking of the entire system.

In synthesising these critiques and future pathways, it becomes clear that the road ahead for EdTech is not simply about making greener choices. It is about questioning the fundamental assumptions that have driven the sector's growth, holding companies accountable for their environmental claims, and empowering students and educators to advocate for deeper, systemic change. As the *Environmental Impact of EdTech: The Hidden Costs of Digital Learning* (2024) report concludes, the challenge is not just about reducing harm; it is about reimagining what a sustainable—and ultimately regenerative—EdTech future might look like.

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