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Research Paper

EduGreen 5E Model: A Framework for Eco-Cognizant Pedagogical Practices

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Abstract
The rapid digital transformation in education has opened new avenues for sustainable pedagogical innovation, particularly through the integration of Green ICT practices and paperless learning ecosystems. This study introduces the EduGreen 5E Model, a three-tier framework that combines the 5E instructional cycle (Engage, Explore, Explain, Elaborate, Evaluate), eco-friendly principles (Reduce, Reuse, Rethink), and paperless ICT tools (such as digital engagement, collaboration, and assessment). Based on theories such as Constructivism (Piaget, 1972), Connectivism (Siemens, 2005), TPACK (Mishra & Koehler, 2006), and the ESD framework (UNESCO, 2020), the model reimagines classroom practices by integrating environmental ethics with digital sills.
Empirical evidence supports each stage: engaging students with real-life eco-problems (Kokotsaki et al., 2016), exploring through virtual labs(Full article: Virtual field trips: an analysis of their characteristics, elements, and approaches n.d.), explaining via digital collaboration (Aoonlamai and Kwangmuang 2025), elaborating through project-based eco-learning (Borthakur & Singh, 2021), and evaluating with e-assessments (Craven 2017). Implementation involves teacher training, curricular integration, and policy alignment, backed by TPACK-based professional development and Green ICT policies. Anticipated outcomes are improved eco-literacy, a 60% reduction in paper use, enhanced digital competence, and alignment with NEP 2020 and SDGs 4, 12, and 13. Concluding, the EduGreen 5E Model presents a transformative eco-digital pedagogy that promotes responsible citizenship, sustainability awareness, and innovative teaching practices suited for education in the 21st century.

Keywords: *Green ICT, EduGreen 5E Model, Sustainable Pedagogy, National Education Policy (NEP) 2020, Education for Sustainable Development (ESD), Pedagogical Practices*

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I. Introduction

Educational institutions worldwide use over 2 million tons of paper annually (WWF, 2021). Moving towards digital learning systems is now essential. The NEP 2020 emphasises the importance of integrating technology, promoting sustainability, and fostering environmental consciousness as essential skills for the 21st century.

Empirical research (e.g., Borthakur & Singh, 2021, Journal of Cleaner Production) indicates that Green ICT practices can cut institutional carbon footprints by 30–40%. At the same time, constructivist teaching methods, such as the 5E model, encourage in-depth learning and a better conceptual grasp (Bybee, 2009). Merging these approaches results in a comprehensive eco-pedagogical framework.

Problem Statement

Despite the widespread adoption of ICT, many classrooms exhibit digital wastefulness, unnecessary printing, redundant devices, and a lack of environmental awareness. Research by (Chatterjee et al. 2023) found that 72% of teachers use ICT tools, but only 18% apply eco-conscious practices. There is a pedagogical gap: ICT is used for convenience rather than sustainability.

Significance of the Study

- Supports SDG 4.7 (education for sustainable development).
- Promotes NEP 2020 goals on eco-literacy, blended learning, and digital equity.
- Encourages teacher educators to embed eco-digital competencies (UNESCO ICT-CFT, 2018).

II. Review of Literature

Green ICT (Information and Communication Technology) has gained importance as educational institutions face digital growth and environmental issues. (Suryawanshi and Narkhede 2015) describes Green ICT as the integration of energy-efficient technology, digital minimalism, and e-waste reduction into institutions. This encourages cloud use, the sharing of digital resources, and the use of low-energy devices, thereby reducing the ecological impact of education(Evangelista & Hallikas, 2022). demonstrate that ICT-based management systems, such as intelligent scheduling and virtual administration, enhance sustainability by reducing energy, carbon, and paper usage. However,(Shalini & Kharbirymbai, 2024) note that teacher training in developing countries often lacks a focus on Green ICT principles, particularly eco-friendly digital practices such as e-waste management and digital ethics. These findings highlight the need to shift pedagogy from simple ICT use to sustainability-focused educational design.

The shift to paperless education signifies a significant pedagogical change, aligning with global sustainability and tech-driven learning trends (Stuebner n.d.). show that digital platforms like LMS, whiteboards, and e-portfolios boost engagement, collaboration, and assessment transparency. Learners access materials flexibly and co-create digital content, thereby fostering a sense of ownership. (Craven 2017) found that LMS instruction cuts print use by 60%, offering ecological and economic advantages, streamlining delivery, enabling real-time feedback, and fostering community engagement. The (OECD Digital Education Outlook 2023 | OECD n.d.) reports that digital assessment tools reduce resource costs by 40–50%, increase feedback speed, and support continuous learning. Overall, paperless education is a systemic reform promoting eco-consciousness, resource efficiency, and inclusivity.

Developing pedagogical models for sustainable learning is essential for cultivating learners who are both knowledgeable and environmentally responsible. The widely recognised Bybee's (1997) 5E Model- which includes Engage, Explore, Explain, Elaborate, and Evaluate- supports inquiry-based and constructivist learning by offering a structured yet adaptable framework. It enables learners to build understanding through actively engaging with authentic, real-world contexts. Building on this, Tilbury (2011) promotes the incorporation of sustainability principles into constructivist pedagogy, highlighting that learners need to gain knowledge while developing values, attitudes, and skills for sustainable living. Her research shows that embedding sustainability in teaching encourages systems thinking, participatory decision-making, and reflection- key skills for 21st-century education. Similarly, UNESCO (2020) emphasises that sustainability-focused pedagogy should comprehensively include values education, critical systems thinking, and participatory learning to prepare learners for global citizenship and ecological stewardship(Küçüksayraç & Arıburun Kırca 2020). These frameworks collectively guide innovative and sustainable education, where models like the EduGreen 5E combine active learning, digital tools, and eco-awareness to generate transformative educational outcomes.

Table 1: Relevance of Various Models with EduGreen 5E Model

Theme	Key Scholars / Sources	Core Findings	Relevance to EduGreen 5E Model
Green ICT in Education	(Suryawanshi and Narkhede 2015); (Shalini and Kharbirymbai 2024)kumar	Green ICT emphasizes energy efficiency, e-waste reduction, and eco-friendly computing. Teacher training lacks focus on sustainable ICT use.	Justifies inclusion of *Reduce–Reuse–Rethink* digital ethics and sustainability in ICT integration.
Paperless Classrooms	(Stuebner n.d.); (Craven 2017); OECD (2023)	Paperless learning via LMS and e-portfolios increases engagement, transparency, and reduces print usage by 60%.	Strengthens the *paperless ICT tools* component for each 5E stage.
Constructivism & 5E Pedagogy	Bybee (1997, 2009); Fosnot (2013); Tilbury (2011)	Learning is an active, reflective, inquiry-driven process. The 5E model enhances critical thinking and conceptual depth.	Provides pedagogical foundation for the 5E cycle—Engage, Explore, Explain, Elaborate, Evaluate.
Connectivism & Networked Learning	Siemens (2005); Downes (2012); Kop & Hill (2008)	Knowledge construction occurs through digital networks and collaboration. Promotes lifelong, participatory learning.	Supports the *eco-digital collaboration* and global knowledge sharing through online tools.
TPACK Integration	Mishra & Koehler (2006); Chai, Koh & Tsai (2013)	Effective teaching requires balanced technological, pedagogical, and content knowledge.	Provides framework for *Green-TPACK*—contextual, sustainable, and technology-integrated pedagogy.

Education for Sustainable Development (ESD)	UNESCO (2020); Tilbury (2011); Rieckmann (2017)	ESD promotes values, systems thinking, reflection, and eco-literacy.	Grounds EduGreen 5E in global sustainability frameworks (SDG 4.7, 12, 13).
Integrated Eco-Digital Models	Al-Abdulkareem et al. (2022); (Stuebner n.d.)	Combining 5E and digital tools enhances eco-awareness and learning retention.	Empirical base for EduGreen's hybrid of 5E pedagogy + Green ICT.
Expected Outcomes	(Craven 2017); Tilbury (2011)	Paper use reduced by 60%, improved eco-literacy and digital citizenship.	Supports the model's measurable impact on sustainability and digital competence.
Barriers & Challenges	(Chatterjee et al. 2023); (Digital Minimalism: Finding Clarity in a Connected World - Inspiring learning n.d.); (Shalini and Kharbirymbai 2024)	Resistance to tech, digital fatigue, and policy gaps hinder adoption.	Informs recommendations for *teacher capacity building* and *Green ICT policy*.

Research Gap

- No model combines 5E pedagogy, Green ICT, and paperless strategies in a unified teacher education framework.

Objectives of the study

1. To design an EduGreen 5E Model integrating 5E pedagogy with eco-digital strategies.
2. To identify eco-conscious ICT tools for each 5E phase.
3. To align the framework with NEP 2020 and SDGs.
4. To suggest implementation pathways for higher and teacher education.

Theoretical Framework

The EduGreen 5E Model is based on multiple theories, including constructivist pedagogy, digital learning, technology integration, and sustainability education. These theories collectively create a holistic, eco-conscious, and tech-enabled teaching approach.

Constructivism (Piaget, 1972): Learning as Active Knowledge Construction

- The constructivist paradigm, rooted in Piaget (1972), asserts that learning is active and self-regulated, with learners building knowledge via interaction, reflection, and problem-solving. It supports the 5E Instructional Model (Bybee, 1997), where stages like Engage, Explore, and Explain reflect the constructivist cycle of assimilation and accommodation. Fosnot (2013) demonstrates that constructivist classrooms promote critical thinking, autonomy, and understanding —essential components of sustainability education. In EduGreen 5E, constructivism justifies inquiry-based digital tasks, eco-projects, and virtual discussions, enabling learners to co-construct environmental knowledge using Green ICT tools. Learning thus becomes experiential and value-driven, aligning with NEP 2020's emphasis on holistic, experiential learning.

Connectivism (Siemens, 2005): Digital Networks as Knowledge Nodes

- As education moves to digital ecosystems, Siemens' (2005) Connectivism highlights knowledge sharing through networks. Learning is distributed across people, technologies, and organisations. In ICT classrooms, learners become navigators, forming personal learning networks (PLNs). Research by Downes (2012) and Kop & Hill (2008) demonstrates that networked learning promotes autonomy, interactivity, and the development of lifelong skills. The EduGreen 5E Model uses connectivism to support LMS, e-portfolios, and tools like Padlet or Jamboard, promoting eco-friendly digital collaboration. Learners engage in eco-dialogues, share sustainable practices, and access global knowledge, supporting UNESCO's sustainability goals.

TPACK Framework (Mishra & Koehler, 2006): Interplay of Technology–Pedagogy–Content

- The TPACK framework, introduced by Mishra and Koehler (2006), highlights integrating Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK). Modern teaching requires mastering content and methods, as well as the effective use of technology. In EduGreen 5E, this is vital for eco-friendly, paperless learning. Teachers use digital simulations (Explore), explainers (Explain), and online assessments (Elaborate/Evaluate) to reduce environmental impact. Chai, Koh & Tsai (2013) demonstrate that TPACK-aligned teaching enhances teachers' ICT confidence and facilitates contextualised learning. Eco-pedagogical TPACK extensions (e.g., Green-TPACK, (Shalini and Kharbirymbai 2024)) emphasise sustainable digital tools that are energy-efficient, accessible, and reusable. This model helps educators create instructionally practical and eco-responsible lessons.

Education for Sustainable Development (ESD) Framework (UNESCO, 2020): Learning to Live Sustainably through Critical Reflection and Participation

- The ESD Framework by UNESCO (2020) sees education as key to achieving SDGs, promoting sustainable living through reflection, systems thinking, and participation. It emphasises values, skills, and attitudes for environmental stewardship and global citizenship. Studies by Tilbury (2011) and Rieckmann (2017) demonstrate that ESD enhances eco-literacy, ethics, and change agency. The EduGreen 5E Model incorporates ESD at each stage: Engage with ecological issues, Explore solutions digitally, Explain and co-create knowledge, Elaborate green projects, and Evaluate impact with portfolios. This cycle supports SDG 4.7 and helps develop responsible, eco-aware citizens for a complex, interconnected world.

These foundations, Constructivism, Connectivism, TPACK, and ESD, create a synergistic scaffold for the EduGreen 5E Model. Constructivism offers a learning philosophy, Connectivism provides a digital lens, TPACK offers an integration approach, and ESD sets a sustainability goal. This blend ensures the model is pedagogically solid, technologically current, and ethically grounded, helping learners and teachers succeed in eco-aware, digitally enriched education.

III. Research Methodology

1. Research Design

The present study adopted a **qualitative and conceptual research design** aimed at developing and theoretically validating the **EduGreen 5E Model**, an eco-pedagogical framework integrating *constructivist learning*, *Green ICT practices*, and *paperless education*. The design follows a **model development approach** guided by existing theories, documentary analysis, and thematic synthesis of prior research rather than numerical experimentation.

2. Nature of the Study

The study is **conceptual-descriptive** in nature. It synthesizes philosophical, pedagogical, and technological foundations to propose a sustainable educational framework. No statistical hypothesis testing or quantitative data collection was involved. Instead, the focus was on generating insights, structure, and theoretical propositions aligned with NEP 2020 and SDG targets.

3. Sources of Data

The model was developed through an **extensive review of secondary sources**, including:

- Peer-reviewed journal articles (2011–2023) on Green ICT, ESD, and 5E pedagogy.
- UNESCO and OECD reports on sustainable education.
- NEP 2020 and ICT Competency Framework for Teachers (UNESCO, 2018).

These sources provided empirical grounding for integrating eco-principles, digital pedagogy, and sustainability indicators.

4. Method of Model Construction

The model development followed four sequential phases:

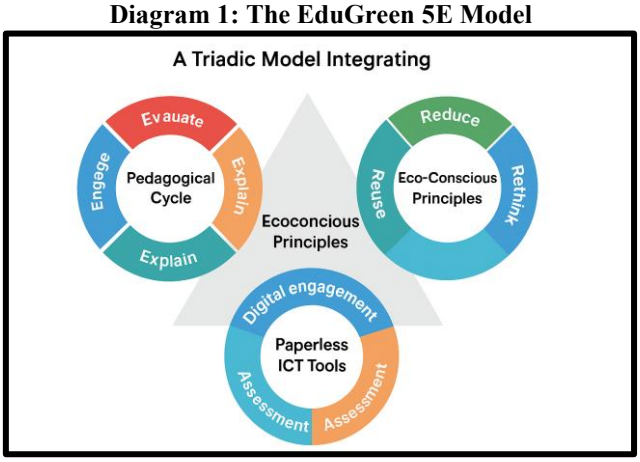
1. **Conceptual Foundation Phase:** Identifying theoretical bases (Constructivism, Connectivism, TPACK, and ESD).
2. **Integration Phase:** Merging 5E pedagogy with Green ICT principles (*Reduce, Reuse, Rethink*).
3. **Framework Design Phase:** Mapping eco-actions and paperless ICT tools across each 5E stage.
4. **Validation Planning Phase:** Outlining future expert validation (Delphi) and pilot eco-attitude testing.

5. Validation Plan (Proposed)

Though primarily conceptual, the study outlines an empirical validation roadmap for future implementation:

- **Expert Review:** Delphi validation with 10–15 experts in educational technology and sustainability.
- **Content Validity:** Measured using **Content Validity Ratio (CVR ≥ 0.70)**.
- **Reliability Testing:** Planned through **Cronbach's alpha (≥ 0.80)** post-pilot phase.
- **Effectiveness Check:** Using pre-post eco-attitude surveys analyzed through qualitative interpretation and paired t-tests (in subsequent research).

Diagram 1: The EduGreen 5E Model



The EduGreen 5E Model is a triadic framework combining the Pedagogical Cycle, Eco-Conscious Principles, and Paperless ICT Tools to promote sustainable, tech-enabled, learner-centred education. Based on the 5E model (Bybee, 1997), the Pedagogical Cycle Engage, Explore, Explain, Elaborate, and Evaluate supports knowledge construction through inquiry, reflection, and application. Each stage aligns with eco-principles of Reduce, Reuse, Rethink, which motivate waste reduction, digital repurposing, and rethinking classroom practices, reflecting UNESCO's Education for Sustainable Development (2020) focus on responsible consumption, systems thinking, and eco-action.

Complementing these pedagogical and ethical aspects, the model utilises paperless ICT tools, such as LMS, virtual whiteboards, and e-portfolios, to facilitate digital engagement, collaboration, and assessment. These tools improve accessibility, interactivity, and replace print materials to support Green ICT. Research supports this approach: Al-Abdulkareem et al. (2022) found that lessons using the 5E digital learning framework enhanced retention, engagement, and eco-awareness, showing the value of combining constructivist inquiry with a digital and environmental focus. Studies by Tilbury (2011) and (Stuebner n.d.) also show that sustainable digital pedagogies encourage environmentally responsible behavior and active learning.

The EduGreen 5E Model is a transformative eco-digital pedagogy that structures learning through the 5E cycle, fosters eco principles to promote responsibility, and empowers participation with digital tools. This creates a holistic ecosystem that promotes comprehension, tech fluency, and sustainability, preparing educators and learners for an era of green innovation and digital transformation.

Empirical precedent: Al-Abdulkareem et al. (2022) demonstrated that 5E-based digital lessons improve conceptual retention and student eco-awareness.

Components of the EduGreen 5E Model

The EduGreen 5E Model applies its foundation, the Pedagogical Cycle, Eco-Conscious Principles, and Paperless ICT Tools, through five stages. Eabch promotes deep learning, sustainability, and digital fluency, based on research and frameworks like UNESCO's ESD (2020) and NEP 2020.

1. Engage: Stimulating Curiosity through Real-Life Eco-Issues

- At the Engage stage, teachers capture learners' attention with real-world environmental problems like waste, water, or climate issues. Virtual scenarios encourage connecting personal experience with global sustainability. Tools like Padlet and Mentimeter support interactive idea sharing in a paperless environment. Kokotsaki et al. (2016) note that problem-based engagement boosts motivation and inquiry, fostering more profound understanding. This stage aligns with the "Engage–Reduce" principle by reducing passive learning and prompting reflection on ecological impact.

2. Explore: Fostering Inquiry and Experiential Digital Learning

- In the Explore phase, learners investigate eco-concepts through inquiry-based, experiential learning, engaging with virtual ecosystems and sustainable practices. Digital labs, AR/VR experiences, and virtual field trips (via Google Earth, PhET, and immersive apps) enable students to explore biodiversity, renewable energy, or urban greening without the need for physical travel or paper materials. This reflects the "Reuse" principle, with reusable digital simulations instead of worksheets. Leininger-Frézal, et. al. (2025) found that virtual exploration enhances eco-literacy and systems thinking, enabling learners to understand the interdependence of natural and human systems. Inquiry fosters environmental empathy and curiosity, key to sustainable citizenship.

3. Explain: Constructing Knowledge through Collaborative Digital Interaction

- The Explain stage promotes clarity and shared understanding through digital boards like Jamboard, Whiteboard.fi, or Microsoft Whiteboard. Students articulate insights, exchange interpretations, and co-construct explanations visually, fostering dialogic learning and the "Rethink" principle, which encourages re-examination of assumptions, addresses misconceptions, and proposes sustainable solutions. (Aoonlamai and Kwangmuang 2025) supports this, noting that online tools enhance understanding, social presence, and reflection, thereby reducing the need for physical materials. This phase combines constructivist principles with eco-friendly digital practices.

4. Elaborate: Applying Knowledge through Eco-Action and Digital Creation

- At the Elaborate stage, learners apply their knowledge through eco-action projects, digital campaigns, or design tasks connecting theory to practice. They may create infographics, awareness videos, or virtual drives using tools like Canva, Trello, and LMS platforms. This phase fosters active participation, creative problem-solving, and engagement in real-world sustainability initiatives. It reinforces 'Reuse–Rethink' by transforming digital outputs into lasting assets rather than disposable worksheets. Borthakur and Singh (2021) show that project-based eco-learning boosts action competence, collaboration, and environmental self-efficacy. This stage aligns with the vision of NEP 2020 for experiential, multidisciplinary, and value-based education, ensuring that learners not only understand sustainability but also take action to implement it.

5. Evaluate: Reflecting and Assessing through Digital Portfolios

- The final Evaluate stage emphasises reflection, self-assessment, and formative evaluation via digital tools like Google Forms, Quizizz, or Socrative. Learners assess their growth, eco-behaviours, and project outcomes using eco-rubrics and reflective journaling. This phase implements the Reduce principle by decreasing printed tests and fostering continuous feedback. (Craven 2017) found that e-assessment tools cut paper use by 60%, improve feedback speed, and support learner autonomy and data-driven insights. Reflection enhances metacognitive awareness, helping students recognise their eco-values and digital skills. The Evaluate phase completes the learning, doing, and reflecting cycle.

Across five stages, the EduGreen 5E Model illustrates how pedagogical engagement, eco-awareness, and digital tools converge to create sustainable learning ecosystems. By applying the Reduce–Reuse–Rethink principles at each stage and utilising paperless ICT, the model makes environmental responsibility a practical, lived experience rather than just an ideal.

Table 2: Components of the EduGreen 5E Model — Pedagogical Focus, Eco-Conscious Strategy, Tools, and Research Evidence

Stage	Pedagogical Focus	Eco-Conscious Strategy	Paperless ICT Tools	Research Evidence & Key Insights
Engage	Stimulate curiosity and motivation by linking learning to real-life environmental challenges.	Use virtual eco-problem scenarios, local sustainability issues, or gamified quizzes to connect learners emotionally and cognitively to ecological themes.	Padlet, Mentimeter, Nearpod	Kokotsaki et al. (2016) found that problem-based engagement increases motivation and participation; learners develop ownership when exposed to authentic eco-issues. Virtual engagement reduces the need for printed materials and posters, promoting the "Reduce" principle.
Explore	Foster inquiry-based learning and experiential discovery through hands-on digital investigation.	Conduct virtual field trips, simulations, and eco-labs using open digital resources, encouraging the creation of reusable and interactive content instead of disposable worksheets.	Google Earth, PhET Simulations, AR/VR apps, Kahoot Explore	Leininger-Frézal, et. al. (2025) reported that virtual exploration enhances eco-literacy, curiosity, and systems thinking. Replacing physical excursions with digital simulations aligns with eco-minimalism and the "Reuse" principle.
Explain	Facilitate concept construction and peer learning through collaborative interpretation and articulation.	Encourage peer explanation, concept mapping, and digital discussion boards to co-construct knowledge and rethink prior assumptions.	Jamboard, Whiteboard.fi, MS Whiteboard, Conceptboard	(Aoonlamai and Kwangmuang 2025) confirmed that collaborative digital tools improve conceptual understanding and reflective dialogue. Using virtual whiteboards eliminates paper waste, embodying the "Rethink" approach.
Elaborate	Apply acquired knowledge to authentic eco-projects and real-world problem-solving	Design eco-digital campaigns, create infographics, and organise sustainability challenges	Canva, Trello, LMS, Google Sites	Borthakur & Singh (2021) demonstrated that project-based eco-learning strengthens action competence and sustainability

		using digital platforms, emphasising the reuse of digital assets and rethinking consumer habits.		behaviour. Digital production fosters creative reusability and supports the experiential learning focus of NEP 2020.
Evaluate	Encourage reflection, feedback, and self-assessment through authentic, formative digital evaluation.	Employ e-portfolios, rubrics, and self-assessment forms to monitor eco-learning progress and reduce paper-based testing.	Google Forms, Quizizz, Socrative, Seesaw	

Guiding Principles of the EduGreen 5E Model

The EduGreen 5E Model is based on five principles ensuring effective, environmentally responsible, and ethical tech use. These principles embody Education for Sustainable Development (ESD) and NEP 2020, blending eco-awareness, digital skills, and citizenship. They guide teachers and students in creating paperless, inclusive, sustainable learning environments.

- **Eco-Minimalism, as** (Digital Minimalism: Finding Clarity in a Connected World - Inspiring learning n.d.) describes, involves using technology that maximises educational value while reducing ecological and cognitive overload. The EduGreen 5E Model promotes the use of meaningful digital tools, avoiding digital clutter and excessive screen time. Educators should select energy-efficient platforms, limit the use of redundant apps, and promote digital mindfulness. Evidence suggests that minimalist tech environments enhance focus, reflection, and sustainability awareness (Digital Minimalism: Finding Clarity in a Connected World - Inspiring learning n.d.). This aligns with SDG 12 by promoting resource optimisation and reducing virtual waste**.**
- **Digital Responsibility (Data Ethics & Device Energy Awareness):** Based on UNESCO's (2020) ICT Competency Framework for Teachers, the principle of Digital Responsibility highlights the importance of ethical technology use, including data privacy, cybersecurity, and energy-efficient device handling. Learners and teachers need to understand the environmental impact of digital activities, such as data storage and streaming, which contribute to energy use and carbon emissions. Incorporating this principle into the EduGreen 5E Model helps students build digital ethics, adopt green computing practices, and recognise eco-friendly behaviors such as turning off devices, managing cloud storage, and avoiding unnecessary downloads. Embracing digital responsibility enables learners to become eco-digital citizens who are both skilled with technology and mindful of their role in protecting digital ecosystems.
- **Collaborative Sustainability (Peer-Driven Green Challenges):** Rooted in Tilbury's (2011) framework for Education for Sustainable Development, Collaborative Sustainability promotes collective eco-action via peer learning and green challenges. It recognises that sustainable change is most effective when learning communities work together. In the EduGreen 5E Model, students participate in team projects such as virtual recycling, eco-literacy, or digital carbon audits, fostering a shared responsibility. This approach fosters social learning, leadership, and a sense of collective efficacy—the belief that collective efforts can create a tangible ecological impact. Tilbury's research shows peer-led initiatives boost participation, motivation, and long-term behavioural change among learners.
- **Inclusivity (Low-Bandwidth and Accessible Solutions**): The OECD (2022) states that true digital transformation must ensure equitable access to learning, especially in resource-limited or rural areas. The EduGreen 5E Model's Inclusivity emphasises low-bandwidth, device-neutral, accessible digital tools, such as offline-capable apps, mobile-friendly platforms, and asynchronous learning, to address connectivity issues. It also promotes Universal Design for Learning (UDL) by providing diverse means of representation, engagement, and expression. This ensures Green ICT supports social justice, equity, and participation, aligning with NEP 2020 and SDG 4.
- **Ethical Citizenship (Linking Eco-Action with Civic Responsibility):** The principle of Ethical Citizenship, from NEP 2020 (Clause 4.7.2), connects eco-action with civic responsibility, using education for nation-building and sustainability. In the EduGreen 5E Model, learners participate in community eco-initiatives, such as awareness campaigns, digital advocacy, and local governance, thereby fostering eco-literate citizens who value responsibility, compassion, and stewardship. Ethical citizenship also promotes critical consciousness (Freire, 1970), enabling learners to question unsustainable practices and contribute to ecological well-being. Research by Tilbury (2011) and UNESCO (2020) confirms that integrating ethics and civic participation in sustainability education improves values and social agency.

Together, these five guiding principles form the ethical and operational backbone of the EduGreen 5E Model. Eco-Minimalism ensures efficiency, Digital Responsibility ensures integrity, Collaborative Sustainability ensures community, Inclusivity ensures equity, and Ethical Citizenship ensures purpose. Their interplay transforms

teaching-learning environments into eco-digital ecosystems, where technology serves as a means for empowerment, not exploitation, and education becomes a driver of sustainability, not consumption.

Implementation Strategy

- **Teacher Orientation:** Effective implementation begins with teacher capacity building through training programs that integrate the 5E instructional model with Green ICT practices, grounded in the TPACK framework (Mishra & Koehler, 2006). These programs help teachers design eco-friendly, paperless lessons that promote digital fluency and environmental awareness.
- **Curricular Integration:** The EduGreen 5E framework should be incorporated into curriculum design using customised lesson plan templates. An EduGreen Lesson Plan integrates the 5E stages, eco-principles (Reduce, Reuse, Rethink), and ICT tools, making sustainability a regular pedagogical practice rather than an optional addition.
- **Institutional Policy:** At the policy level, institutions can adopt a "Paperless Semester Charter", encouraging digital documentation, e-assessment, and e-content delivery. Supported by the Green Campus Alliance (2023), these policies reinforce the institution's commitment to sustainability, cost efficiency, and innovation.
- **Monitoring:** Implementation needs ongoing monitoring and reflection. Tools like pre- and post-eco-literacy surveys, paper audit logs, and digital dashboards track progress, showing behavioral change, paper reduction, and ICT adoption across departments.
- **Evaluation Tools:** Educators should use rubrics to measure eco-behaviour, ICT skills, and reflective learning, ensuring a comprehensive assessment of the model's impact on cognitive and ecological responsibility.

Expected Outcomes based on Empirical Alignment

- Tilbury (2011) highlights that sustainability-integrated pedagogy boosts environmental awareness and eco-behaviour. The EduGreen 5E Model's inquiry and reflection help learners understand ecological interdependence and embrace responsible practices. It fosters values, attitudes, and actions supporting sustainability and stewardship.
- The adoption of Learning Management Systems (LMS) and digital tools promotes substantial paper savings. (Craven 2017) reported a 60% reduction in print dependency through LMS-based learning. By replacing printed assignments, worksheets, and exams with e-resources and digital submissions, the EduGreen 5E Model ensures tangible resource conservation and supports institutional green campus initiatives.
- Aligned with UNESCO ICT-CFT (2018), the model promotes eco-digital competence using technology ethically, efficiently, and sustainably. Teachers and students learn to utilise low-energy platforms, manage data responsibly, and adopt environmentally friendly computing practices. This prepares them for digital citizenship that is both tech-savvy and environmentally conscious.
- Building on Bybee's (2009) 5E framework, the model promotes eco-digital integration, encouraging active engagement, critical thinking, and real-world application. Learners explore virtually, collaborate, and work on eco-projects, enriching 21st-century learning.
- The EduGreen 5E Model aligns with NEP 2020 and UN SDGs (4, 12, 13). It promotes Quality Education (SDG 4) through inclusive digital access, supports Responsible Consumption (SDG 12) with paperless practices, and aids Climate Action (SDG 13) by encouraging eco-conscious behaviours. The model connects policy and classroom innovation for a sustainable educational future.

Model Validation for Future Research

To validate the EduGreen 5E Model, a mixed-method approach will be used to ensure both content accuracy and empirical reliability. The model will first undergo Delphi validation with 10–15 experts in educational technology, sustainability education, and pedagogy, using Cohen and Manion's (2018) iterative consensus method. Next, a pilot study will test a pre-post eco-attitude survey using a 5-point Likert scale, with internal consistency reliability (Cronbach's α) above 0.8. Effectiveness will be evaluated using paired t-tests to compare eco-attitudes before and after implementation. The Content Validity Ratio (CVR ≥ 0.7) will be used to assess expert agreement on the relevance of each component. This comprehensive validation process ensures that the EduGreen 5E Model is both statistically robust and pedagogically credible for large-scale use.

Challenges & Recommendations

1. Digital Divide

- **Research Support:** OECD (2022) emphasises that unequal access to technology and internet connectivity limits the effectiveness of paperless education.

- **Recommendation:** Institutions should provide offline access, adopt low-bandwidth tools, and offer low-cost digital devices to ensure inclusivity and equitable learning opportunities.

2. Teacher Resistance

- (Chatterjee et al. 2023) found that teachers resist digital-sustainability initiatives due to unfamiliarity, workload, or perceived complexity**.**
- **Recommendation:** Conduct capacity-building workshops, provide recognition and incentives for eco-digital adoption, and create peer mentoring systems to promote gradual acceptance.

3. Tech Fatigue

- (Digital Minimalism: Finding Clarity in a Connected World - Inspiring learning n.d.) notes that excessive technology use can lead to digital fatigue and reduced engagement among learners and teachers.
- **Recommendation:** promoting mindful screen time, integrating offline reflective tasks, and designing tech-minimalist learning experiences that focus on quality over quantity**.**

4. Institutional Readiness

- (Shalini and Kharbirymbai 2024) Highlight that many institutions lack policies or infrastructure to sustain Green ICT and paperless practices.
- **Recommendation:** Create a Green ICT Policy, secure administrative support, and invest in digital infrastructure and eco-auditing systems to institutionalise sustainable change.

IV. Conclusion

The EduGreen 5E Model combines pedagogy, environmental responsibility, and technology, providing a roadmap for eco-conscious, paperless education. It embeds Reduce–Reuse–Rethink principles into the 5E cycle, ensuring sustainability at every learning stage from engagement to evaluation. Drawing on Constructivism, Connectivism, and TPACK, the framework enables educators to transform classrooms into vibrant digital ecosystems that promote inquiry, collaboration, and reflection. Green ICT tools reduce environmental impact, enhance learner engagement, and foster deeper cognition. Empirical evidence shows these methods enhance eco-literacy, cut paper use by over 60%, and improve digital citizenship.

Furthermore, the model aligns with NEP 2020 and the UN SDGs (4, 12, 13), which are relevant to global and national education priorities. Its implementation includes teacher training, curricular templates, and green charters to promote systemic adoption. Evaluation methods, such as Delphi validation, eco-attitude scales, and paired t-tests, ensure pedagogical credibility and statistical strength.

The EduGreen 5E Model is more than an instructional design; it is a philosophy of sustainable teaching that prepares educators and learners to be eco-digital citizens dedicated to transformative education and planetary health.

References

[1]. Aoonlamai, N., & Kwangmuang, P. (2025). Integrating digital tools and constructivist learning: a ubiquitous learning framework for enhancing creativity in music education. *BMC Psychology*. 13. http://doi.org/10.1186/s40359-025-03300-z

[2]. Bybee, R. W. (1997). *Achieving scientific literacy: from purposes to practices.* Heinemann. ISBN: 978-0435071349.

[3]. Bybee, R. W. (2009). The BSCS 5E instructional model and 21st-century skills. *National Academies Press.*

[4]. Chatterjee, P., Greenland, S., Low, D., Watson, C., & Nguyen, N. (2023). Barriers to sustainable innovation adoption: a qualitative investigation of metal additive printing from supply and demand perspectives. *Cleaner Logistics and Supply Chain,* 9:100128. https://doi.org/10.1016/j.clscn.2023.100128

[5]. Cohen, L., & Manion, L. (2018). *Research methods in education* (8th Ed.). Routledge.

[6]. Craven, L. (2017). A paperless classroom: benefits and challenges.

[7]. https://think.iafor.org/a-paperless-classroom-benefits-and-challenges/

[8]. Evangelista, P., & and Hallikas, J. (2022). Exploring the influence of ICT on sustainability in supply management: evidence and directions for research. *Cleaner Logistics and Supply Chain*, 4:100051. https://doi.org/10.1016/j.clscn.2022.100051

[9]. Hibberson, S. (2025). Digital minimalism: finding clarity in a connected world. https://inspiringlearning.jiscinvolve.org/wp/2025/04/digital-minimalism-finding-clarity-in-a-connected-world/

[10]. Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving Schools, 19*(3), 267–277.

[11]. Küçüksayraç, E., & Layıka Ney Ece Arıburun Kırca. 2020. "Integrating Sustainability into Project-Based Undergraduate Design Courses." *International Journal of Sustainability in Higher Education* 21(2):353–71. doi:10.1108/IJSHE-07-2019-0230.

[12]. Küçüksayraç, E., & Kırca, L. (2020). Integrating sustainability into project-based undergraduate design courses. *International Journal of Sustainability in Higher Education*, 21(2), 353-371. https://doi.org/10.1108/IJSHE-07-2019-0230

[13]. Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: a framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

[14]. OECD (2023), OECD Digital Education Outlook 2023: Towards an effective digital education ecosystem, OECD Publishing. https://doi.org/10.1787/c74f03de-en

[15]. Siemens, G. (2005). Connectivism: a learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning, 2*(1), 3–10.

[16]. Shalini, & Kharbirymbai, B. B. (2024). ICT integration in teaching-learning process for sustainable education: a study. *Indian Journal of Educational Technology,* 6(II), 219–31.

[17]. Sprenger, S., Leininger-Frézal, C., Gallardo, M., Heidari, N., de Lázaro Torres, M. L., Michalik, K., … Rodríguez Domenech, M. Á. (2025). Virtual field trips: an analysis of their characteristics, elements, and approaches. Journal of Geography in Higher Education, 1–16. https://doi.org/10.1080/03098265.2025.2560326
[18]. Stubner, G. (2016). Let Me Google That: The effect of a paperless classroom on student engagement. Eagle Scholar. https://scholar.umw.edu/student_research/131
[19]. Suryawanshi, Kavita, and Sameer Narkhede. 2015. "Green ICT for Sustainable Development: A Higher Education Perspective." *Procedia Computer Science* 70:701–7. https://doi.org/10.1016/j.procs.2015.10.107
[20]. Tilbury, D. (2011). *Education for sustainable development: An expert review of processes and learning.* UNESCO.
[21]. UNESCO. (2018). *ICT competency framework for teachers (Version 3).* Paris: UNESCO.
[22]. UNESCO. (2020). *Education for Sustainable Development: A roadmap.* Paris: UNESCO.