# Leveraging Green AI Technology to Build Sustainable Schools: A Conceptual Model Based on AI Agents

Yiting Qiu[1,2*], Yihan Lu[1], Guoqing Xia[3], Md Munir Hayet Khan[2], Deshinta Arrova Dewi[4]

[1]Zhejiang Technical Institute of Economics, Hangzhou 310018, Zhejiang, China
[2]Faculty of Innovation and Technology Program, Engineering and Quantity Surveying, INTI International University, Nilai 71800, Negeri Sembilan, Malaysia
[3]Department of General Practice, Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University, Hangzhou310016, Zhejiang, China
[4]Faculty of Data Science and Information Technology, INTI International University, Nilai 71800, Negeri Sembilan, Malaysia

*Corresponding author:* Yiting Qiu, barbaraqiu@dingtalk.com

**Abstract:** The integration of Green Artificial Intelligence (AI) technologies into educational systems offers a promising avenue to enhance operational efficiency while addressing sustainability challenges. Through a rigorous three-phase methodology combining literature review, AI agent development, and participatory workshop-based case analysis, this paper highlights the pivotal role of AI agents, as applications of Green AI technologies, in driving transformative outcomes within schools. By directly improving self-learning efficiency and reducing learning costs for students, enhancing management and service efficiency, reducing labor costs for schools, as well as minimizing resource dependence for both teachers and students, AI agents create a foundation for sustainable operations. These direct effects generate positive spillover effects, cascading into broader outcomes, including innovation performance, economic efficiency, and environmental sustainability, aligning with the United Nations Sustainable Development Goals (SDGs). By presenting a comprehensive conceptual model, this study demonstrates the pathways through which Green AI contributes to sustainable development in education and emphasizes its critical role in bridging technological innovation with sustainability. This framework provides significant theoretical insights for further empirical research while offering actionable strategies for policymakers and educators to harness Green AI for building sustainable schools with a student-centered approach.

**Keywords:** Green AI technology; AI agents; Conceptual model; Spillover effects; Sustainable development

## 1. Introduction

The pursuit of sustainability in education has become a pressing global issue, particularly aligned with the United

Nations Sustainable Development Goals (SDGs) [1]. Building sustainable schools requires more than policy support and fund allocation; it demands the integration of innovative, technology-driven approaches. Green Artificial Intelligence (Green AI) has emerged as a vital enabler of sustainable practices by optimizing resource usage and reducing environmental impacts [2]. While Green AI has demonstrated significant potential in sectors like healthcare and industrial applications, its applications in educational sustainability remain inadequately explored. This research gap underscores the urgency of a systematic framework to explore its potential contributions.

To address this, this paper presents a conceptual model that examines Green AI's impact on developing sustainable schools and uses AI agents as an example to represent an innovative application of Green AI technologies [3]. These AI agents are equipped with diverse functionalities, including personalized learning support, multimodal intelligent communication, process automation, and knowledge generalization through advanced large models [4]. By improving operational efficiency, reducing costs, and minimizing reliance on traditional resources, AI agents actively drive sustainable education systems and establish student-centered educational practices [5]. This study fully demonstrates how Green AI technologies enable sustainable school development through direct and indirect pathways, thereby aligning with global sustainability goals.

## 2. Research questions

This paper aims to address the following research questions:

RQ1: What are the direct pathways through which Green AI impacts sustainability metrics such as innovation performance, environmental performance, and economic performance in schools?

RQ2: What are the indirect pathways through which Green AI affects sustainability metrics in schools?

RQ3: How can these direct and indirect impact pathways be integrated into a conceptual model to support the construction of sustainable schools?

By exploring these research questions, the study establishes a conceptual framework that serves as a theoretical and practical guide for leveraging Green AI in education. It highlights the synergy between technology-driven innovation and student-centered educational philosophies, offering a comprehensive perspective on how schools can achieve sustainable development goals.

## 3. Methodology

To explore the role of Green AI technology in building sustainable campuses, this study adopts a methodological approach combining "literature review", "AI agent development", and "case analysis", supported by successful applications of AI technology in campus scenarios. Using a participatory workshop model, the study aims to construct a scientifically rigorous and practically valuable framework by integrating theoretical and practical perspectives.

## 4. Literature review

The literature review focuses on three core themes: (1) the concept, advantages, and characteristics of Green AI technology and AI agents; (2) the integration and application of technological innovation and education within the framework of sustainable development; and (3) the potential of artificial intelligence technologies in educational paradigms, resource allocation, and management [1, 3, 6]. This systematic review synthesizes the latest research

and practices, emphasizing the value of Green AI in enhancing resource efficiency, optimizing campus resource management, and improving environmental performance [3]. It also explores how technology-driven, student-centered educational philosophies can catalyze the sustainability process on campus [2]. The findings provide a solid theoretical foundation for subsequent AI agent development, case analysis, and the design of participatory workshops by identifying both technological gaps and opportunities for innovation [7].

## 5. AI agent development

To translate theoretical assumptions into practical applications, this study developed a series of AI agents tailored to diverse campus scenarios. These agents were designed to address specific challenges such as resource management, academic advising, digital platform navigation, and moral education. The AI-enabled tools drew on principles of Green AI technology to optimize energy efficiency and minimize computational waste during operations. This phase also emphasized the usability of AI tools to ensure both students and teachers could easily integrate them into their daily academic and administrative activities [8]. Over 20 AI agents were deployed, collectively serving more than 2,300 users, providing both valuable data and an experiential foundation for further analysis.

## 6. Case analysis: participatory workshop-based approach

Building on the results of the literature review and AI agent development, this study employed participatory case analysis to validate theoretical assumptions against practical results. Through workshops that engaged users directly, the value of AI agents in campus sustainability was thoroughly examined. Discussions gathered perspectives on the synergies among green technology, performance, and sustainable development. Students focused on how AI agents could optimize learning experiences, improve learning efficiency, and reduce learning costs. Teachers, on the other hand, explored the potential of AI tools to foster educational innovation and resource optimization from a managerial perspective while promoting waste reduction and fostering green campus environments. This multi-layered participatory approach constructed a comprehensive analytical framework linking practical application, technological development, and user feedback. Case data and workshop findings were synthesized to evaluate the feasibility and future potential of Green AI in real campus scenarios, offering both theoretical insights and practical guidelines for fostering sustainable, technology-driven, and student-centered campuses. This three-phase methodology—spanning literature review, AI agent development, and participatory case analysis—outlines the pathways by which Green AI technology can contribute to educational systems and sustainable development frameworks. It also lays the groundwork for further exploration of green educational technologies.

## 7. Conceptual model design and discussion

### 7.1. Green AI technique, efficiency, and innovation performance

H1: The application of AI agents directly improves learning efficiency of students and promotes innovation performance, leading to sustainable development.

AI agents, as a core application of Green AI technologies, significantly enhance students' learning efficiency through various practical functions and mechanisms. Their value is reflected in three key aspects. First, AI agents

provide personalized and adaptive learning experiences through human-AI interaction, acting as round-the-clock virtual learning mentors [9]. For instance, they offer step-by-step explanations of complex problems and generate tailored exercises to reinforce understanding and encourage critical thinking. This student-centered approach not only improves comprehension and problem-solving skills but also compensates for the time and resource limitations inherent in traditional education systems [3].

Second, AI agents leverage internal knowledge bases and the generalization capabilities of large language models to deliver precise academic guidance and foster diverse intellectual exploration [4]. They can quickly address specific student queries with accurate responses while simultaneously facilitating brainstorming and divergent thinking. This guided learning approach cultivates creativity and critical reasoning, enabling students to thrive in dynamic, multidimensional learning environments [4].

Lastly, the accessibility of AI agents significantly reduces barriers to quality education in under-resourced regions. With minimal requirements such as electricity and internet access, AI agents provide instant access to knowledge and learning methods. This accessibility is particularly impactful in addressing disparities in education, as it bridges the digital divide and empowers students in underserved areas to realize their learning potential [10]. By democratizing access to resources, AI agents also contribute to greater educational equity.

Thus, through personalized academic support, intellectual stimulation, and resource accessibility, AI agents directly enhance students' learning efficiency across multiple dimensions, leveraging the strengths of Green AI to address diverse educational challenges.

H2: The application of AI agents directly improves management and service efficiency and promotes innovation performance, leading to sustainable development.

The development and application of AI agents help consolidate the teaching experience of educators and the operational expertise of administrative staff. This significantly enhances schools' management and service efficiency. First, AI agents can serve as digital extensions of teachers, providing targeted academic support on demand. They ensure students have access to virtual mentors 24/7 to resolve their queries anytime, anywhere [4]. Second, AI agents integrate knowledge bases to address questions related to academic standards and procedural requirements. They reduce repetitive and mundane administrative tasks, giving teachers and staff more time and energy to focus on innovative projects.

Third, AI agents are powered by continuously upgraded large language models [4]. These models support rich multimodal interactions and improve the precision and breadth of responses. This makes up for knowledge gaps that human teachers or administrators may have. Furthermore, by automating repetitive workflows and enabling scalable solutions, AI agents foster sustainable innovation within schools. They promote smarter resource allocation and long-term operational efficiency [10]. In summary, the effective use of AI agents greatly enhances school management and services, making them more efficient, intelligent, and sustainable.

## 7.2. Green AI technique, resource dependence and environmental performance

H3: The application of AI agents directly reduces management and service in school and promotes environment performance, leading to sustainable development

The application of AI agents significantly reduces resource reliance and enhances environmental performance by reshaping workflows, centralizing information, and streamlining education and management support [11]. First, AI agents promote paperless and digital-first operations, ensuring that tasks like academic grading, assignments,

exercises, creating mind maps, team collaboration, and communication are entirely digitized. This comprehensive transformation drastically reduces the use of physical resources such as paper, printing supplies, and office consumables, thereby cutting down on waste and aligning institutions with sustainability goals [11].

Second, they enhance the efficiency of information usage by centralizing data storage and providing personalized, on-demand access to academic and organizational resources. By eliminating the need for redundant physical or digital copies, AI agents prevent unnecessary duplication while meeting diverse user needs with precision. Third, AI agents elevate operational efficiency through scalable, reusable virtual services that replace traditional methods of manual academic advising or repetitive administrative processes. Such AI-powered solutions deploy seamlessly across different contexts without increasing the strain on physical infrastructure or escalating material consumption [12]. This approach not only improves service delivery but also fosters sustainable systems.

In summary, the integration of AI agents establishes a robust framework for reducing resource demands, optimizing environmental performance, and supporting the development of eco-friendly, sustainable institutions.

## 7.3. Green AI technique, costs and economic performance

H4: The application of AI Agents directly reduces learning costs of students and promotes economic performance, leading to sustainable development

AI agents effectively reduce learning costs while promoting sustainable development through technological innovation and resource efficiency [5]. Firstly, AI teaching assistants and similar tools largely replace the need for private tutors. For example, AI systems like Doubao, which support multilingual learning through voice interaction, enable self-study, reducing both tutoring and transportation costs. Secondly, AI agents provide multimodal digital learning resources, such as interactive courseware, exercises, and assessments, replacing expensive physical textbooks and workbooks [13]. These tools allow students to learn and practice in a more flexible and adaptive way, eliminating unnecessary spending while streamlining study processes. Additionally, AI agents utilize cloud service platforms to store and manage digital resources, significantly reducing knowledge management and storage costs [14]. By advancing digital-first, cost-efficient, and eco-friendly educational practices, AI agents not only alleviate financial burdens but also contribute to sustainable development by minimizing the environmental impact associated with traditional learning resources.

H5: The application of AI Agents directly reduces labor costs of school and promotes economic performance, leading to sustainable development

AI agents, through intelligent and automated technologies, help schools significantly reduce labor costs while enabling a lightweight and low-cost operation model that aligns with the principles of a sustainable green campus. Firstly, AI agents can replace routine and repetitive tasks, thereby reducing the need for low-skill, low-creativity labor and significantly cutting associated personnel budgets [15]. This allows schools to allocate more resources to higher-value areas, such as innovative teaching methods and student development. Secondly, AI agent-driven automation optimizes task allocation and improves execution efficiency, shortening the time and resources required for tasks and further reducing labor demands [15]. Additionally, digital teams composed of multiple AI agents can autonomously collaborate to complete complex tasks, achieving seamless and highly efficient workflows. This intelligent collaboration not only enhances productivity but also substantially reduces staffing costs. By promoting a lightweight operational structure and minimizing unnecessary resource consumption, AI agents contribute to the

vision of a truly sustainable green campus, balancing cost-efficiency with environmental responsibility.

## 7.4. Green AI technique, student-oriented education and sustainable development

H6: The application of AI agents promotes sustainable development of education through student-oriented transformation

AI agents have emerged as timely and essential technological enablers of student-oriented transformation, playing a critical role in advancing the sustainable development of education. First, AI agents leverage big data and natural language processing to deliver personalized, adaptive, and tailored learning experiences, breaking away from traditional, one-size-fits-all teaching methods [3, 4, 15]. By dynamically addressing individual student needs, these technologies optimize learning outcomes and foster a more student-centered approach to education. Second, AI agents promote accessibility and inclusivity by offering tools such as real-time language translation, adaptive interfaces, and assistive technologies [13, 15]. These innovations ensure that students with diverse abilities, needs, and languages can equitably access learning resources, creating a fair and supportive educational system. Lastly, AI agents enhance future readiness by improving AI literacy and equipping students with essential skills such as prompt engineering, responsible AI usage, and basic AI development [15–18].

These competencies enable students to succeed in an AI-driven world, positioning them for success in emerging industries and job markets. By fostering innovation, inclusivity, and future readiness, AI agents enable a student-oriented transformation that advances the sustainable development of education in an ever-evolving global context.

## 7.5. Green AI technique, technological innovation and sustainable development

H7: The application of AI agents promotes sustainable development of education through technological innovation

AI agents play a pivotal role in driving the sustainable development of education by advancing technological innovation in three key areas. First, AI agents revolutionize the development of educational tools by automating repetitive tasks, analyzing diverse learner data, and modeling pedagogical strategies[1, 5, 19]. This accelerates the creation of adaptive learning platforms, intelligent tutoring systems, and personalized feedback solutions, significantly reducing development cycles and enabling swift adaptation to diverse educational needs [15]. Second, AI agents enhance creativity in teaching and learning by facilitating the design of interactive, immersive, and gamified learning experiences. Their ability to dynamically interact with both educators and learners allows for real-time adjustments in content delivery and problem-solving, fostering engagement and innovation within the educational ecosystem [2].

Furthermore, AI agents actively support students in hands-on exploration of fields such as robotics, machine learning, and digital technology, helping them develop practical skills and innovative thinking to address real-world challenges [3, 15]. Lastly, AI agents provide adaptive and accessible technologies, ensuring diverse learners, including those with special educational needs, can engage with advanced tools to develop technological literacy and problem-solving capabilities for an AI-driven future [5, 12]. Together, these contributions position AI agents as transformative enablers of technological advancement, ensuring the education sector evolves sustainably to meet the demands of an ever-changing world.

Therefore, based on the research questions and hypotheses, this study proposes a conceptual framework (**Figure 1**) that encompasses both direct and indirect pathways to reveal how Green AI technology contributes to sustainable development in education. First, Green AI technology affects learning efficiency, management

and service efficiency, resource dependence, learning costs, and labor costs through direct pathways (H1–H5), leading to improvements in innovation performance, environmental performance, and economic performance. Additionally, student-oriented educational transformation and technological innovation, driven by Green AI technology (H6, H7), serve as indirect pathways to support and empower the transformation of educational systems. Together, these pathways form an integrated model that links Green AI technology, technological innovation, educational reform, and sustainability goals, providing theoretical foundations and practical guidance for building sustainable schools.
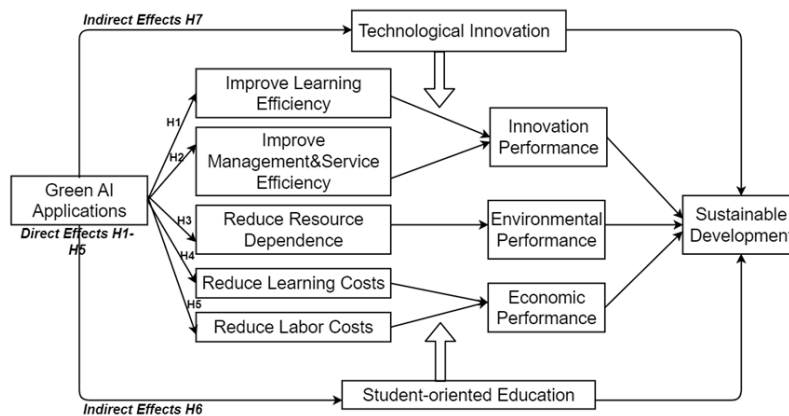


**Figure 1.** Conceptual model of green AI technique for promoting sustainable development in education

## 7.6. Conclusion and Future Work

This study presents a comprehensive conceptual framework that elucidates the transformative role of Green AI technology, particularly through AI agents, in fostering sustainable development within educational institutions. Through a rigorous three-phase methodology combining literature review, AI agent development, and participatory workshop-based case analysis, our research demonstrates that AI agents contribute to sustainability metrics via both direct and indirect pathways. The direct pathways encompass enhanced learning and management efficiency, reduced resource dependence, and optimized cost structures, while indirect pathways operate through student-oriented transformation and technological innovation [12, 20]. Notably, the positive spillover effects extend beyond the educational domain, creating cascading benefits for innovation performance, environmental sustainability, and economic efficiency across the broader educational ecosystem [5, 21]. Future research endeavors should prioritize: empirical validation of the proposed framework through large-scale quantitative studies; investigation of implementation barriers across diverse educational contexts; development of standardized sustainability impact metrics; examination of long-term effects on student outcomes; and assessment of scalability across different educational levels. This research not only bridges the theoretical gap in understanding Green AI's role in educational sustainability but also provides practical insights for educational institutions pursuing sustainable development goals.

## Funding

## Disclosure statement

The authors declare no conflict of interest.

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