AI and Green AI in Education: Examining Student Engagement, Infrastructure, Utilization, and Sustainable Leadership in Government and Private Secondary-level Schools of Raebareli, Uttar Pradesh

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Abstract
This study investigates the integration of Artificial Intelligence (AI) and Green AI in secondary education, specifically within Raebareli, Uttar Pradesh. Utilizing a sequential mixed-methods approach, the research combines quantitative survey data from students and teachers with qualitative insights from educators and school leaders. Quantitative techniques, including descriptive analysis, correlation, and regression, were employed to assess the relationship between AI integration, student engagement, and technological adaptability. Qualitative findings were analyzed to understand leadership practices, infrastructural challenges, and sustainability awareness.
The results indicate that AI-supported learning positively influences students' academic engagement and technological adaptability. However, disparities in digital infrastructure, irregular internet connectivity, and limited teacher training restrict effective implementation, particularly in resource-constrained schools. Furthermore, awareness of Green AI practices—defined as environmentally sustainable approaches to technology use—remains low, reflecting limited familiarity with energy-efficient computing in education. The study highlights that the mere presence of digital resources is insufficient for meaningful AI integration; success depends on strategic leadership, proper planning, and continuous skill development. School leaders play a key role in fostering innovation and bridging infrastructural gaps. By contributing to the discourse on secondary education in Uttar Pradesh, this research offers practical implications for policymakers and educational leaders to align AI adoption with long-term environmental and educational goals.

Keywords: Artificial Intelligence, Digital Divide, Educational Leadership, Green AI, Secondary Education, Sustainability

Chapter 1: Introduction

1.1 Background of the Study

Artificial Intelligence (AI) is rapidly transforming modern education systems by enabling customized learning plans, tailored content, and evidence-based decision-making processes. In recent years, the growing adoption of educational technology (EdTech) has significantly altered instructional approaches, learner engagement, and institutional management practices. The use of AI-driven technologies, such as computer-based tutoring systems, digital assessment systems, and data-driven analytics, has enabled institutions to improve performance and streamline administrative processes. This digital transformation represents not merely a technological modernization but a fundamental shift in the education system, requiring a re-evaluation of conventional teaching methods. In developing economies like Uttar Pradesh, India, the incorporation of advanced technologies is gradually gaining attention. Government initiatives such as the National Education Policy (NEP) 2020 emphasize the importance of technology-enhanced learning spaces, ICT-integrated pedagogy, and the development of 21st-century skills among learners. The NEP 2020 specifically promotes a multimodal approach to ensure equitable digital access and improve the quality of education in underserved areas. However, despite these advantages, AI technologies require significant computational power and energy, raising environmental concerns and highlighting the importance of Green AI, which promotes energy-efficient and environmentally responsible AI practices (Schwartz et al., 2020).

1.2 Problem Statement

A significant gap persists between policy and implementation, particularly in rural areas like Raebareli, where inadequate facilities often hinder technological adoption. Urban schools generally have better access to digital resources, whereas rural schools face infrastructural constraints that hinder successful AI implementation (Government of Uttar Pradesh, 2023; Times of India, 2024).

Another emerging concern is the environmental impact of artificial intelligence technologies, specifically their ecological footprint. Machine learning models often require high computational power and extensive data operations, which contribute to high energy demand and increased carbon emissions. This has led to the development of the concept of Green AI, which focuses on designing low-power models and eco-responsible infrastructure that reduce ecological damage while maintaining computational accuracy.

Educational leadership plays a crucial role in influencing how emerging technologies are adopted within institutions. School leaders shape teacher training, policy implementation, infrastructure investment, and institutional vision. Strategic leadership is essential for harmonizing digital advances with national educational policies, such as the NEP 2020 framework. Effective leadership promotes long-term sustainability, technological transformation, innovation, and ecological accountability within the Indian education system (Ministry of Education, 2020). Therefore, this study focuses on secondary schools in Raebareli, Uttar Pradesh, to examine how management methods contribute to sustainable technological adoption.

1.3 Research Objectives

To examine the impact of AI integration in Secondary-level government and private schools on students' academic engagement and technological adaptability in Raebareli, Uttar Pradesh.

To analyze the relationship between AI infrastructure and the level of AI adoption in Secondary-level schools across Raebareli.

To examine the extent and nature of the use of AI and Green AI technologies in Senior Secondary schools in Raebareli, Uttar Pradesh.

To explore how strategic leadership influences the adoption of sustainable (Green AI) practices for climate resilience.

1.4 Research Questions

RQ1: To what extent does the integration of AI influence students' academic engagement and technological adaptability?

- RQ2: What is the relationship between the availability of AI infrastructure and the level of AI adoption?
- RQ3: In what ways are AI and Green AI technologies currently being implemented in secondary schools in Raebareli, Uttar Pradesh?
- RQ4: How does educational leadership contribute to promoting Green AI for climate resilience and environmental sustainability in schools?

1.5 Hypotheses

Hypothesis 1

- Null Hypothesis (H_0): There is no significant relationship between AI integration and students' academic engagement and technological adaptability.
- Alternative Hypothesis (H_1): There is a significant relationship between AI integration and students' academic engagement and technological adaptability.

Hypothesis 2

- Null Hypothesis (H_0): There is no significant relationship between AI infrastructure and the level of AI adoption in secondary schools of Raebareli.
- Alternative Hypothesis (H_1): There is a significant relationship between the availability of AI infrastructure and the level of AI adoption in secondary schools of Raebareli.

1.6 Significance of the Research

This study is significant in three ways:

- Academic Importance: It contributes to the limited literature on Green AI in education, particularly in the Indian context, by examining the intersection of AI, sustainability, and leadership.
- Policy Importance: The analysis provides insights for policymakers in Uttar Pradesh, highlighting the need to align AI adoption under the NEP 2020 with climate-conscious strategies.
- Practical Importance: The research identifies infrastructural and leadership barriers to AI adoption, offering actionable recommendations for institutions to integrate AI sustainably.

1.7 Scope of Research

The scope of this research is limited to government and private secondary-level schools in the Raebareli district, Uttar Pradesh. The study focuses on assessing AI infrastructure, its influence on adoption, and the role of leadership in promoting sustainable practices. It does not extend to primary schools, higher education institutions, or vocational training centers, and the findings are intended to inform stakeholders within similar socio-economic contexts.

Chapter 2: Literature Review

2.1 Introduction to the Chapter

Chapter Two provides a critical examination of existing literature at the intersection of Artificial Intelligence (AI) in education, Green AI, and educational leadership. The review begins by exploring the theoretical foundations of AI, analyzing its alignment with learning theories such as constructivism, behaviorism, and connectivism. It then examines the role of AI in personalized learning and the evolving responsibilities of teachers. Subsequently, the chapter addresses the environmental dimensions of digital technology, defining Green AI and discussing sustainable technological frameworks. Theoretical perspectives, including Ecological Modernization Theory (EMT), the Triple Bottom Line (TBL), and the Diffusion of Innovations, are integrated to frame the sustainability debate. Finally, the chapter evaluates leadership paradigms—specifically transformational and instructional leadership—within the context of technological adoption. The review concludes by identifying specific gaps in the current literature, particularly regarding the integration of AI and climate resilience in secondary schools within developing contexts like Uttar Pradesh.

2.2 Theoretical Foundations of AI in Education

Contemporary research underscores the transformative potential of artificial intelligence within the education sector. Holmes, Bialik, and Fadel (2019) argue that machine learning technologies can significantly enhance educational outcomes by facilitating personalized learning journeys. AI-based educational systems assess student learning metrics and modify instructional materials to help learners adapt to their individual learning paces. Similarly, Luckin et al. (2016) highlight that AI-powered tools can support educators by streamlining administrative duties and offering insights into student comprehension trends, thereby allowing teachers to focus on higher-order instructional activities.

The integration of AI into the classroom is supported by several learning theories. Constructivism is reflected in tools such as AutoTutor, where learners gain knowledge through active exploration and deduction. These adaptive systems align with Vygotsky's Zone of Proximal Development, offering guided assistance that adjusts to the student's current ability. Behaviorism is evident in platforms such as Duolingo and Byju's, which use repetition and rewards to reinforce learning. However, critics argue that such behaviorist approaches may bypass critical thinking in favor of measurable, surface-level results (Selwyn, 2019).

Connectivism (Siemens, 2005) suggests that knowledge is not confined to individuals but is distributed across networks. AI-powered chatbots and discussion forums facilitate global knowledge sharing. However, scholars caution that effective participation in digital learning networks is often lacking in marginalized areas, limiting the effectiveness of this approach in resource-constrained environments. The combined insight of these theories suggests that while AI holds promise, its effectiveness depends heavily on instructional design and contextual application.

2.3 Green AI and Sustainable Technologies

While AI provides significant educational benefits, its environmental impact is a growing concern. Green AI refers to practices designed to be energy-efficient and environmentally responsible. Large-scale AI models necessitate intensive processing power, resulting in increased energy usage and carbon emissions. Schwartz et al. (2020) highlight that training massive AI systems can emit as much carbon as five cars over their lifetimes, drawing attention to the ecological footprint of the technology sector.

To address this, the concept of Green AI promotes the development of power-saving algorithms, ethical data handling, and Green IT practices. Ecological Modernization Theory (EMT) suggests that technological breakthroughs and environmental preservation can co-exist when innovation is applied responsibly. In this study, EMT provides the rationale for deploying energy-efficient Green AI in schools without sacrificing digital advancement.

The Triple Bottom Line (TBL) framework emphasizes balancing social equity ("People"), educational outcomes ("Profit"), and environmental sustainability ("Planet"). In the context of Raebareli, this means ensuring that AI adoption does not solely serve elite urban centers but remains inclusive, affordable, and environmentally responsible. However, despite theoretical significance, Green AI remains largely unexplored in applied school-level education. Most existing studies focus on high-resourced urban environments, ignoring the specific challenges of rural schools in Northern India, where deficient infrastructure and a lack of understanding create impediments to adoption.

2.4 Digital Leadership in Education

Educational leadership is a critical factor in determining student success. Scholars like Leithwood et al. (2004) argue that leadership extends beyond administrative functions to encompass long-term visioning, organizational climate, and the improvement of learning outcomes. In the context of AI adoption, transformational leadership is particularly relevant. Leaders who adopt this approach inspire and empower teams to surpass routine performance standards and adopt new methodologies. Transformational leaders can integrate AI in a manner that achieves both educational and sustainability goals.

However, existing literature identifies a leadership gap. Many school leaders in resource-constrained environments focus on technology for "exam-centric" results while remaining "environmentally blind" to the energy costs of these tools. There is limited field observation on how local principals in Uttar Pradesh interpret and implement technological transformations. This study addresses this gap by examining the readiness of school leadership in Raebareli to manage the dual challenges of rapid AI implementation and ecological responsibility. The literature suggests that without sustainability-oriented leadership, AI integration may widen the digital divide and harm local ecosystems.

2.5 Theoretical Framework

The theoretical framework of this study combines perspectives from technology adoption, sustainability, and leadership studies to explore how AI can be incorporated into secondary schools. The framework is supported by three core theories: Ecological Modernization Theory (EMT), the Diffusion of Innovations Theory, and the Triple Bottom Line (TBL) approach.

Ecological Modernization Theory (EMT) suggests that technological innovation can address environmental challenges when implemented efficiently and responsibly. The concept of Green AI reflects this idea by encouraging energy-efficient algorithms and optimized computing practices that support environmentally sustainable technologies in education.

The Diffusion of Innovations Theory describes how new ideas and technologies spread within organizations. According to this theory, AI adoption in schools depends on factors such as leadership support, awareness, and perceived benefits. This explains why some schools adopt AI faster than others and highlights the role of early adopters in influencing lagging institutions.

The Triple Bottom Line approach emphasizes a balance of three dimensions: social impact, environmental responsibility, and economic efficiency. Applied to the education sector, this perspective proposes that implementing AI technologies should aim not only to improve teaching and learning but also to consider environmental sustainability and the responsible use of resources.

Additionally, leadership theories, particularly transformational and distributed leadership, highlight the role of school leaders in guiding institutional change, supporting sustainable development goals, and encouraging technology adoption.

2.6 Conceptual Framework

The conceptual framework of this study identifies digital infrastructure, school leadership, and teacher readiness as the key determinants influencing AI integration in secondary schools. These elements collectively contribute to student engagement and the ability to adapt to technological advancements. Furthermore, Green AI is considered a moderating variable that shapes the sustainability of AI implementation. The framework suggests that strong institutional leadership and adequate infrastructure improve AI adoption, whereas awareness of sustainable practices ensures the environmentally responsible use of technology.

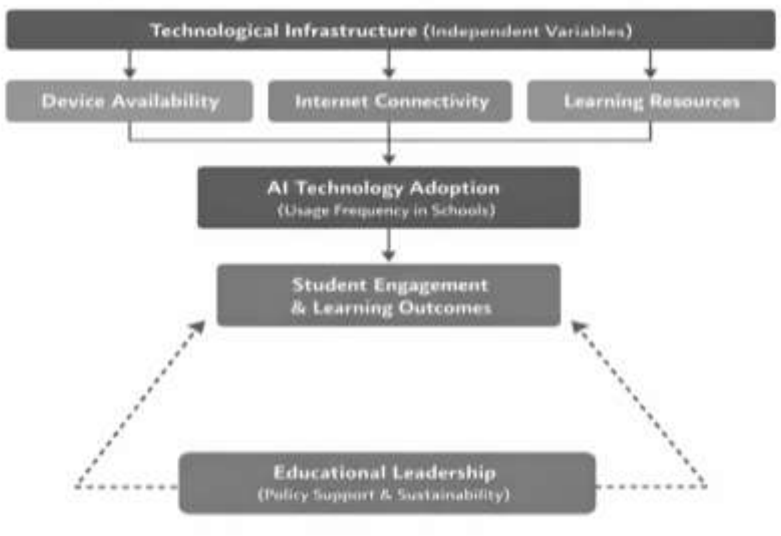

Figure 1: Conceptual Framework of the Study showing the relationship between AI Infrastructure, Leadership, and Student Engagement.

2.7 Literature Gap

Despite the growing body of research on AI in education, significant gaps remain, particularly within the context of developing regions:

1. Lack of Empirical Evidence in Uttar Pradesh: There is a scarcity of empirical studies examining the specific impact of AI integration on student engagement and technological adaptability within the secondary education system of Uttar Pradesh.
2. Leadership Implementation Gap: Existing literature often overlooks the practical readiness of school leaders in rural India to implement Green AI. There is insufficient research on how leadership training influences the adoption of sustainable technologies.
3. Missing AI–Climate Resilience Linkage: Few studies explore the intersection of AI and climate resilience in schools. The concept of Green AI is rarely discussed in the context of school-level infrastructure and policy in developing economies.
4. Rural–Urban Disparities: While the digital divide is well-documented, there is limited research specifically comparing how infrastructural constraints in rural areas like Raebareli affect the utilization of AI compared to semi-urban counterparts.
5. Green AI Awareness in Education: Most literature on Green AI focuses on technical algorithms or corporate sustainability. There is a notable absence of research regarding awareness and application of Green AI principles among teachers and school administrators.

This study aims to bridge these gaps by providing context-specific insights into AI adoption, sustainability practices, and leadership challenges in secondary schools in Raebareli.

3.0 Methodology

3.1 Introduction

This study employs a sequential mixed-methods research design to investigate the integration of Artificial Intelligence (AI) and Green AI in secondary schools. The methodology combines quantitative data analysis to measure relationships between variables and qualitative thematic analysis to explore leadership practices and contextual barriers. This triangulation approach enhances the validity of the findings by providing a comprehensive understanding of the technological and pedagogical landscape in Raebareli, Uttar Pradesh.

3.2 Research Design

The study adopts a **sequential explanatory design**, characterized by the collection and analysis of quantitative data followed by the collection and analysis of qualitative data. The rationale for this design is to use qualitative data to explain and elaborate on the quantitative results.

- **Phase 1 (Quantitative)**: Structured surveys were administered to students and teachers to quantify AI infrastructure, usage levels, student engagement, and technological adaptability. Statistical tests, including correlation and regression, were used to test the research hypotheses.
- **Phase 2 (Qualitative)**: Semi-structured interviews and Focus Group Discussions (FGDs) were conducted with school leaders and selected teachers. This phase aimed to deepen the understanding of the statistical trends observed in Phase 1, specifically regarding leadership challenges, the "digital divide," and awareness of Green AI.

3.3 Research Location

The study was conducted in the **Raebareli district of Uttar Pradesh**, India. This location was selected due to its mix of rural and semi-urban educational settings, which provides a distinct context for examining the digital divide and infrastructural disparities. The district presents a suitable case study for analyzing how policy initiatives (like NEP 2020) are implemented in resource-constrained environments versus better-equipped private institutions.

3.4 Research Participants

The study population comprised stakeholders from government and private secondary schools in Raebareli. The participants included:

- **Students**: Enrolled in secondary grades (9-12) to assess engagement and adaptability.
- **Teachers:** To evaluate instructional practices and readiness for AI integration.
- **School Leaders** (Principals/Administrators): To provide insights into policy implementation, infrastructure management, and strategic vision.

Inclusion Criteria: Participants were required to be actively involved in teaching or administration at the secondary level. Exclusion Criteria: Primary school staff and non-teaching administrative staff without direct involvement in academic planning were excluded to ensure relevance to the research objectives.

3.5 Data Collection Methods

Data were collected using the following instruments:

1. **Survey Questionnaire:** A structured Likert-scale instrument was designed to gather quantitative data on demographics, device availability, internet connectivity, frequency of AI tool usage, and student engagement levels.
2. **Semi-Structured Interviews**: An interview protocol was developed for school leaders to explore their perceptions of AI, barriers to adoption, and knowledge of sustainability practices.
3. **Focus Group Discussions (FGDs):** Separate FGDs were held with teachers to discuss shared challenges regarding training and infrastructure.

3.6 Sample Size and Sampling Technique

A total of **120 respondents** participated in the quantitative phase. The sampling technique utilized was **stratified sampling** to ensure representation from both government and private schools, as well as rural and semi-urban locations. Within these strata, **purposive sampling** was used to select participants who had direct exposure to digital tools or were in decision-making roles.

3.7 Data Analysis

Quantitative Analysis:

Quantitative data were analyzed using **SPSS (Statistical Package for the Social Sciences).**

- **Descriptive Statistics:** Mean, Standard Deviation (SD), and frequencies were used to summarize demographic data and general trends.
- **Reliability Testing**: Cronbach's Alpha was calculated to ensure the internal consistency of the survey instrument.
- **Inferential Statistics**:
  - **Pearson's Correlation:** Used to assess the strength and direction of relationships between variables (e.g., infrastructure availability and AI adoption).
  - **Linear Regression:** Employed to determine the predictive power of independent variables (infrastructure) on dependent variables (student engagement/adaptability).
  - **Hypothesis Testing**: Null hypotheses were tested at a 0.05 significance level.

Qualitative Analysis:

Qualitative data from interviews and FGDs were transcribed and analyzed using **NVivo software.** The analysis followed **Braun and Clarke's (2006) six-step thematic analysis** framework:

1. **Familiarization**: Reading and re-reading transcripts.
2. **Coding**: Generating initial codes for interesting features of the data.
3. **Searching for Themes**: Collating codes into potential themes.
4. **Reviewing Themes**: Checking if the themes work in relation to the coded extracts and the entire data set.
5. **Defining and Naming Themes**: Ongoing analysis to refine the specifics of each theme.
6. **Producing the Report**: Final analysis and write-up.

3.8 Validity and Reliability

To ensure the rigor of the study, the following measures were implemented based on Guba and Lincoln's criteria:

- **Credibility**: Achieved through member checking, where preliminary findings were shared with a subset of participants to confirm accuracy.
- **Transferability**: Detailed descriptions of the research context and demographics were provided to allow readers to judge applicability to other settings.
- **Dependability**: An audit trail of methodological decisions and data analysis steps was maintained.
- **Confirmability**: Peer debriefing was conducted with colleagues to challenge biases and ensure findings were grounded in the data.

3.9 Ethical Considerations

Ethical clearance was obtained prior to data collection. The study adhered to the following ethical principles:

- **Informed Consent**: Participation was voluntary, and written consent was obtained from all adult participants (teachers/leaders). For students, assent was obtained along with parental consent.
- **Anonymity and Confidentiality**: All responses were anonymized; names of schools and individuals were replaced with codes in the reporting.
- **Non-Maleficence**: The research process ensured no harm or disruption to the regular school activities.

3.10 Anticipated Challenges and Mitigation Strategies

- **Challenge**: Potential low response rates from busy school leaders.
  - *Mitigation:* Appointments were scheduled in advance, and interview times were kept flexible.
- **Challenge**: Social desirability bias in surveys (participants answering what they think is "correct").
  - *Mitigation:* Surveys were administered confidentially, and qualitative probes were used to cross-verify quantitative claims.
- **Challenge**: Technical glitches during digital data entry.
  - *Mitigation:* Data was backed up regularly, and paper copies were maintained as a contingency.

4.0 Results and Discussion

4.1 Demographic Overview

The study sample comprised a balanced distribution of respondents from government and private secondary schools. As shown in Table 1, the sample included equal representation from government and private schools (50% each), with a near-even split between rural (48.3%) and semi-urban (51.7%) locations. This distribution provides a robust basis for comparative analysis between different school types and geographical settings.

Variable	Category	Frequency (n)	Percentage (%)
School Type	Government School	60	50.0
	Private School	60	50.0
Location	Rural	58	48.3
	Semi-Urban	62	51.7
Role of Respondents	Teachers	50	41.7
	Students	50	41.7
	Administrators	20	16.6
Total		120	100.0

Table 1: Sample Distribution of Respondents

Source: Author's field survey data

Gender composition was relatively balanced, with 54.2% male and 45.8% female respondents. Regarding experience, a significant portion of teachers (40%) had less than 5 years of teaching experience, indicating a relatively young workforce that might be more open to technological adoption, provided they receive adequate training. Access to devices was also assessed, revealing that while smartphone penetration is high (92.5%), access to advanced computing devices like laptops (45.0%) and smart boards (18.3%) remains limited, particularly in government schools.

4.2 Infrastructure and AI Usage Correlation

The quantitative results indicate a strong positive relationship between the availability of infrastructure and the level of AI adoption in schools. The correlation analysis was conducted to test the hypothesis that infrastructure availability is significantly related to AI integration. As shown in Table 2, the correlation between available devices and usage frequency was significant (r = 0.785). Similarly, connectivity (internet access) showed a strong positive correlation with usage (r = 0.750), as did the availability of learning resources (r = 0.730).

Table 2 *Correlation and Significance*

Variable	Correlation (r)	Significance (p-value)
Devices & Usage Frequency	0.785	p < 0.01
Connectivity & Usage	0.75	p < 0.01
Learning Resources & Usage	0.73	p < 0.01
	0.73	p < 0.01
Total		p < 0.01

Table 2: Infrastructure and AI Usage Correlation Results
Source: Author's field survey data

The Pearson correlation analysis revealed a strong positive relationship between institutional infrastructure and AI utilization. The highest correlation was observed between Device Availability and Usage Frequency (r = 0.785, p < 0.01), indicating that physical access to hardware is the primary determinant of AI adoption. Furthermore, Internet Connectivity (r = 0.750) and Learning Resources (r = 0.730) also showed statistically significant positive correlations, suggesting that a holistic infrastructural approach is required to facilitate digital transformation in the sampled schools.
These findings suggest that the physical availability of technology is a primary determinant of AI integration. The scatter plots in Figure 1 and Figure 2 visualize these strong relationships. Schools with better device availability and internet connectivity reported significantly higher usage of AI tools for educational purposes.

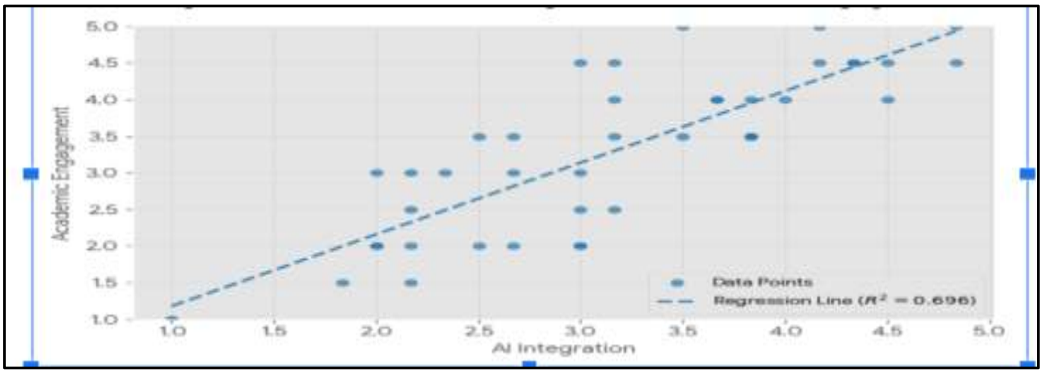

Figure 1. Devices & Usage Frequency (r = 0.785)
Source: Author's field survey data.

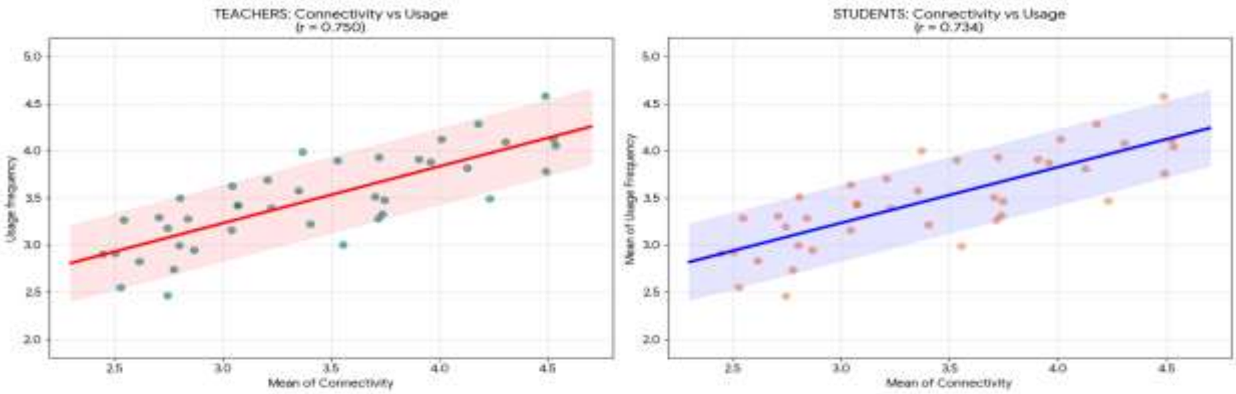

Figure 2. Connectivity & Usage (r = 0.750)
Source: Author's field survey data.

The regression analysis further confirmed that infrastructure availability significantly predicts AI adoption ($F(1, 118) = 45.32$, $p < .001$). The R^2 value indicated that infrastructure availability explained approximately 62% of the variance in AI usage frequency. These findings align with Rogers' (1962) Diffusion of Innovations theory, suggesting that the adoption of new technologies depends heavily on the availability of necessary support systems.

4.3 Student Engagement and Technological Adaptability

Findings indicate that artificial intelligence technologies have a positive influence on student engagement. Descriptive statistics revealed that 78% of students agreed or strongly agreed that AI-based learning platforms made classroom activities more interactive. The mean scores for engagement indicators ranged from 3.9 to 4.2 on a 5-point scale, suggesting high perceived benefits among students.

Teachers echoed these sentiments, noting that AI systems helped them monitor student progress more effectively through adaptive learning platforms and personalized feedback systems. However, the benefits were not uniform. The study revealed a noticeable difference between rural and semi-urban schools. Urban schools in the district marked higher engagement with AI due to better infrastructure, such as functional computer laboratories. In contrast, rural schools struggled with frequent power outages and scarce digital resources, which obstructed effective AI integration. This disparity highlights the "Digital Divide" as a critical barrier to equity in education.

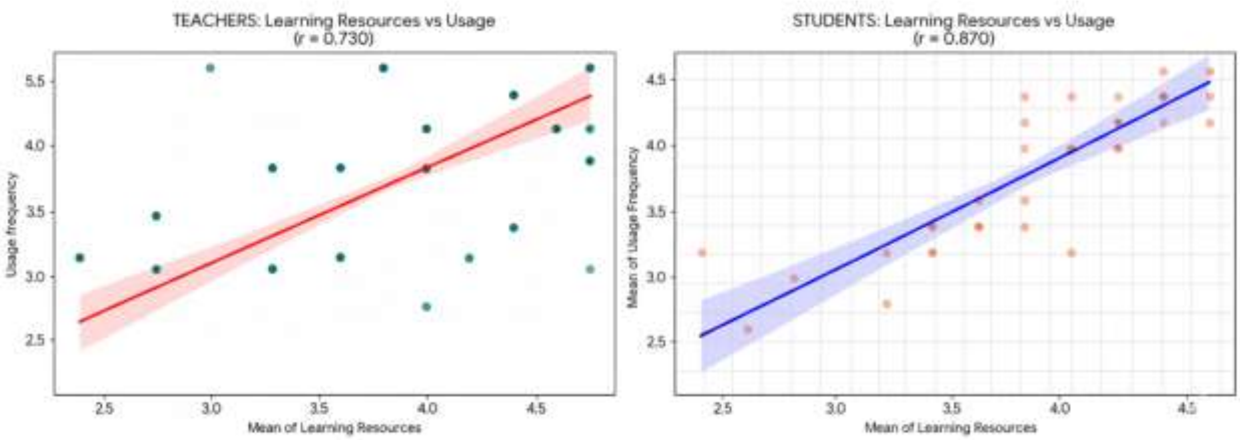

Figure 3. Learning Resources & Usage Frequency (r = 0.730)
Source: Author's field survey data.

4.4 Qualitative Insights: Leadership and Sustainability Gaps

While quantitative data highlighted the potential of AI, qualitative interviews revealed critical barriers regarding leadership and sustainability.

The Digital Divide emerged as a recurring theme in interviews was the disparity between rural and semi-urban schools. One administrator noted, "We have the vision, but the electricity cuts make it impossible to run smart classes for more than an hour." Rural schools struggled with frequent power outages, scarce digital resources, and inadequate teacher training.

Further, a significant finding was the limited awareness of Green AI practices. When asked about energy-efficient computing, 85% of respondents expressed unfamiliarity with the term. While participants recognized the importance of digital technologies, few were aware of the environmental implications associated with large-scale computing systems.

Leadership practices played a crucial role in determining success. However, qualitative insights revealed that leadership focus was often "exam-centric." As one teacher stated, "Our principal encourages anything that helps with board exam results, but sustainability is not a priority." There was a distinct lack of institutional frameworks targeting Green AI adoption.

These findings reveal an imbalance in the Triple Bottom Line (People, Planet, Profit). While the "People" aspect (student engagement) was being addressed, the "Planet" aspect was largely neglected. The lack of awareness regarding Green AI suggests that current leadership models are ill-equipped to handle the environmental costs of digital transformation. This supports the literature review's concern that educational leadership in developing regions often remains "environmentally blind."

5.0 Discussion and Synthesis

5.1 Introduction and Fulfillment of the Research Gap

This chapter synthesizes the quantitative and qualitative findings to answer the research questions and address the identified gaps in the literature. The study reveals three critical insights: first, AI integration significantly enhances student engagement and technological adaptability when mediated by teachers; second, infrastructure remains the primary predictor of AI adoption, exacerbating the rural-urban digital divide; and third, there is a profound "sustainability paradox" where schools adopt AI without awareness of its environmental impact (Green AI).

This research fills the literature gap by providing empirical evidence from the Raebareli district, a context often overlooked in global AI education discourse. Unlike studies conducted in high-resource Western environments, this study highlights how infrastructural deficits and "exam-centric" leadership models constrain the potential of AI in developing regions. Furthermore, it contributes to the "Integrated Green Education (IGE) Framework," which argues that without sustainability-oriented leadership, digital transformation in education may remain ecologically unsustainable.

5.2 Discussion of Findings Related to Student Outcomes and Equity (RQ1 & RQ2)

5.2.1 AI, Engagement, and Adaptability (RQ1)

The quantitative data confirms a strong positive relationship between AI integration and student engagement. This aligns with Holmes et al. (2019), who suggest that AI tools can make learning more interactive. However, the findings from Raebareli indicate that AI is not a standalone solution. Qualitative insights reveal that AI is most effective when mediated by teachers who use it to reduce administrative burdens and focus on mentorship. This supports Luckin et al. (2016), who view AI as an augmentation rather than a replacement of human intelligence.

Interestingly, the data also revealed gender differences in technological adaptability. Male students reported slightly higher confidence in using AI tools, reflecting broader digital gender gaps prevalent in Northern India. This suggests that AI interventions must be designed with gender-sensitive pedagogy to ensure equitable benefits for all students.

5.2.2 Infrastructure and Adoption (RQ2)

The findings confirm that infrastructure is the single strongest predictor of AI adoption, validating the Diffusion of Innovations Theory (Rogers, 1962). Schools with reliable electricity and high-speed internet act as "early adopters," while rural schools with poor connectivity act as "laggards." The correlation analysis showed that without physical access to devices and the internet, even the most willing teachers cannot integrate AI.

This finding has critical policy implications: merely distributing tablets or smart boards is insufficient without ensuring consistent electricity and broadband. The disparity between government and private schools in Raebareli highlights that the digital divide is not just about access to hardware, but about the reliability of the ecosystem required to run it.

5.3 Discussion of Findings Related to Sustainability and Utilization (RQ3 & RQ4)

5.3.1 The Utilization Gap: AI without Green AI (RQ3)

One of the most significant contributions of this study is the identification of the "Green AI Gap." While schools are eager to adopt AI, 85% of respondents were unfamiliar with the concept of Green AI. This finding critiques the Ecological Modernization Theory (EMT); while technology (AI) is present, it is not currently being harnessed to solve environmental challenges. Instead, it is contributing to energy consumption without the counterbalance of energy-efficient practices.

The lack of Green AI awareness represents a missed opportunity to link the National Education Policy (NEP) 2020's emphasis on environmental education with digital transformation. Schools are currently using AI for exam preparation rather than fostering climate resilience. This indicates a need for Green AI to be integrated into the curriculum, teaching students not just how to use AI, but how to use it responsibly.

5.3.2 Leadership and the Triple Bottom Line Imbalance (RQ4)

The study found that leadership practices in Raebareli focus heavily on the "People" and "Profit" (exam results) aspects of the Triple Bottom Line (TBL), while neglecting the "Planet" aspect. Principals and administrators described AI adoption as a strategic move to improve board exam results rather than a sustainability initiative. This "exam-centric" focus creates a barrier to Green AI adoption.

While transformational leadership traits were observed in principals who championed new technology, these leaders often lacked the knowledge to connect technology with sustainability. This supports the literature that suggests leadership in developing regions is often "environmentally blind" regarding digital tools. The study argues that for true integration, school leaders must evolve into "Sustainable Technology Leaders" who can balance innovation with ecological responsibility.

5.4 Strengths, Limitations, and Theoretical Contribution

5.4.1 Strengths and Value Added

This study provides a robust mixed-methods analysis of AI in a resource-constrained context, combining the statistical rigor of regression analysis with the depth of thematic inquiry. The primary strength lies in its contextual richness, offering a realistic view of the challenges faced by schools in Uttar Pradesh. The development of the IGE Framework provides a novel theoretical lens for viewing the intersection of AI, sustainability, and leadership.

5.4.2 Limitations and Future Research Implications

The study is limited by its geographical scope, being confined to one district in Uttar Pradesh, which may affect the generalizability of the findings to other states. Methodologically, the study faced a limitation regarding the measurement of "Green AI," as no standardized validated tools exist for school-level environments; future research must develop specific metrics for energy-efficient computing in education.

5.5 Future Research Directions

Future studies should adopt a longitudinal approach to assess the long-term impact of AI on student learning outcomes beyond immediate engagement. Research should also explore policy-level implementation, specifically how state governments can regulate the energy consumption of educational technologies. Additionally, the ethical dimensions of AI, particularly data governance and algorithmic bias in the Indian context, require urgent academic attention.

6.0 Conclusion and Recommendations

6.1 Conclusion to the Research

This dissertation demonstrates that the integration of AI in secondary education is a double-edged sword. On one hand, it offers significant opportunities to enhance student engagement, support personalized learning, and improve technological adaptability. On the other hand, without equitable infrastructure and sustainability awareness, it risks widening the digital divide and increasing the carbon footprint of the education sector.

The study concludes that the "mere presence" of digital resources is insufficient. Success depends on a complex interplay of reliable infrastructure, continuous teacher training, and strategic leadership. Theoretically, the study confirms the relevance of the Diffusion of Innovations Theory and highlights an imbalance in the Triple Bottom Line approach within current school leadership practices. The long-term impact of this research lies in its advocacy for an "Integrated Green Education" model, where technology and sustainability are not treated as separate goals but as interconnected imperatives for the future of education in Uttar Pradesh.

6.2 Critical Impacts for Policy and Practice

6.2.1 Policy and Governance Recommendations

Infrastructure Equity: Policymakers must prioritize investments in digital infrastructure in rural and semi-urban areas, specifically focusing on reliable electricity and internet connectivity rather than just hardware procurement.

Green AI Standards: Educational policies should incorporate Green AI standards, requiring schools to audit the energy efficiency of their digital tools and prioritize energy-efficient devices.

Data Governance and Ethics: Given the rise of AI, clear guidelines on data privacy and AI ethics must be established to protect student data in government and private schools.

Monitoring and Evaluation (M&E): A dedicated M&E system should be established to track not just AI usage, but its environmental impact and learning outcomes.

6.2.2 Implications for School Leaders and Administrators

- Sustainable Technology Leadership: Leadership training programs must be updated to include modules on "Sustainable Technology Leadership," equipping principals to balance innovation with ecological responsibility.
- Teacher Motivation and Professional Development: Leaders must move beyond "exam-centric" visions and motivate teachers by providing continuous professional development that links AI usage to creative pedagogy and sustainability.
- Community Engagement: In rural areas, school leaders should actively engage the community to support digital initiatives, as community norms and support play a crucial role in the adoption of new technologies.

6.2.3 Suggestions for Teachers and Curriculum Development

- **Digital Literacy and AI Ethics**: The curriculum should move beyond basic ICT skills to include digital literacy and AI ethics, helping students understand the environmental and social implications of the tools they use.
- **Gender-Sensitive Pedagogy**: Teachers should adopt gender-sensitive pedagogical strategies when introducing AI tools to ensure that female students are equally empowered and confident in utilizing technology.
- **Green Pedagogy**: Teachers should act as role models for sustainability, incorporating lessons on energy conservation and the environmental impact of computing into their subject teaching.

6.3 Final Call to Action

The integration of AI in Uttar Pradesh's secondary schools is not merely a technological upgrade; it is a transformative journey that requires a collective commitment to equity and sustainability. To harness the full potential of AI, stakeholders must look beyond the immediate allure of digitization and build a resilient, environmentally conscious, and inclusive education system. By aligning technological adoption with the principles of Green AI and the vision of the NEP 2020, Raebareli can serve as a beacon for how developing regions can navigate the digital age responsibly, leaving a lasting legacy of sustainable innovation for future generations.

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