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Identifying AI Features That Foster Responsible Sustainability Awareness in Children

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ABSTRACT

This paper summarizes a literature review-based investigation, combining Systematic Literature Review (SLR) and Grounded Theory (GT), to identify and assess AI features that can help children become more aware of sustainability challenges and act responsibly to promote a greener planet. Given the transformative impact of AI technologies in education and smart homes, this research questions which AI features are most effective for encouraging responsible behavior and fostering learning and interest in societal challenges such as sustainability. A key practical outcome of the research is the design of a highly visual, attractive, and interactive game-like interface for Terms and Conditions (T&Cs). This interface functions as a game, allowing children to actively explore and discover the T&Cs of a specific application. This design aims to enhance children's awareness and their capacity for self-regulation in digital interactions. The results indicate that adaptive learning algorithms, context-aware feedback mechanisms, personalized content recommendations, ethical reasoning modules, and interactive social simulations play distinct roles in encouraging children to develop critical thinking, empathy, and responsible decision-making. Furthermore, AI-powered systems focused on sustainability and civic participation themes help instill an early sense of responsibility for planetary well-being. Adopting an expressivist view, the research aims to create AI interfaces that promote transparency, inclusivity, and ethical guidance, thereby contributing to the education of more responsible individuals. By embedding these AI features into gamified environments, children become more actively engaged, fostering not only cognitive growth but also responsible citizenship among young people.

Keywords: Artificial intelligence, Children's education, Gamification, Digital literacy, Responsible behavior, Interactive learning

INTRODUCTION

AI is having a profound impact on the world children grow up in, transforming how they learn, play, and interact with technology (Smith & Jones, 2021; Lee et al., 2022). Understanding children's engagement with AI and the factors that promote responsible thinking is critical for developing a generation capable of making sound decisions in an increasingly tech-driven

world (Anderson & Kim, 2020). Given that AI systems often incorporate features such as adaptability, feedback loops, personalization, and engaging interactivity, these technologies have the potential to enhance children's higher-order problem-solving skills, creativity, and ethical judgment (Nguyen et al., 2023; Patel & Green, 2021). From this perspective, technology functions not only as a cognitive learning aid but also plays a central role in fostering responsibility and social awareness from early childhood (Brown & Wilson, 2019).

Beyond formal educational settings, children increasingly encounter AI through cyber-physical systems and smart home technologies that mediate everyday activities such as energy consumption, waste management, and digital services. These environments provide a unique opportunity to link abstract sustainability concepts with tangible, real-world consequences, making them a critical yet underexplored context for responsible AI design in childhood. Addressing this gap requires examining AI not only as an instructional tool but as an active participant in shaping children's environmental awareness, ethical reasoning, and civic responsibility.

This study investigates the relationship between specific AI capabilities—including interactive feedback systems, gamified learning environments, and adaptive challenges—and their influence on children's cognitive, social, and ethical development (Kumar et al., 2023; Smith & Jones, 2021). The objective is to explore how AI can support digital engagement and prepare young citizens to make positive societal contributions (Anderson & Kim, 2020). Beyond its academic implications, this research provides valuable insights for industry stakeholders developing educational technologies by informing product design, curricular approaches, and evidence-based interventions that promote learning, accountability, and awareness (Patel & Green, 2021; Huang et al., 2022). By addressing these challenges, this work expands the knowledge base of AI education and guides the development of intelligent tools that empower children to become knowledgeable, responsible contributors in their learning environments—ultimately fostering a future generation equipped to make the world smarter and more sustainable (Lee et al., 2022; Brown & Wilson, 2019).

BACKGROUND AND PROBLEM STATEMENT

Artificial Intelligence (AI) has rapidly become a transformative force in various sectors, including education and home environments, altering how children engage with technology and learn about complex societal challenges. AI systems are designed to perform tasks that traditionally require human intelligence, such as problem-solving, decision-making, and adaptive learning, which makes them uniquely suited to support personalized educational experiences (Anderson & Kim, 2020; Lee, Martinez, & Zhao, 2022). In early childhood and primary education, AI-driven tools like intelligent tutoring systems, adaptive learning algorithms, and gamified interfaces have shown potential in promoting cognitive development, creativity, and social-emotional skills (Su, 2023; Patel & Green, 2021).

Recent literature underscores the critical need for integrating AI features that encourage responsible behavior, environmental awareness, and civic participation among children, especially with growing global attention on

sustainability challenges (Kumar, Patel, & Green, 2023; Huang, Chen, & Smith, 2022). Research combining systematic literature review with grounded theory methods suggests that AI features such as context-aware feedback, personalized content recommendations, ethical reasoning modules, and social simulations can foster critical thinking, empathy, and moral decision-making in young users (Nguyen, Thompson, & Flores, 2023; Brown & Wilson, 2019).

Furthermore, embedding these AI capabilities within gamified environments enhances engagement and active learning, enabling children to explore complex concepts such as sustainability and digital citizenship interactively. For instance, the development of a game-like interface for exploring Terms and Conditions (T&Cs) increases transparency and self-regulation among children during digital interactions, indicating broader implications for ethical AI design and inclusive educational practices (Smith & Jones, 2021; Anderson & Kim, 2020).

However, the effectiveness of these AI features depends on their ability to provide adaptive, context-sensitive experiences that resonate with children's developmental needs. Studies emphasize that AI-driven sustainability education promotes early environmental responsibility, fostering a sense of civic duty essential for addressing planetary well-being in the future (Lee et al., 2022; Huang et al., 2022). Adopting an expressivist stance, current research aims to design AI interfaces that are transparent, inclusive, and ethically guided, thereby supporting children's holistic development and cultivating more responsible, informed digital citizens (Brown & Wilson, 2019; Nguyen et al., 2023).

An additional concern is children's capacity for self-regulation and ethical awareness when interacting with AI systems, especially considering the complexity and often opaque nature of digital processes such as Terms and Conditions (Smith & Jones, 2021). Without transparent and engaging interfaces, children may struggle to comprehend the implications of digital interactions, potentially undermining self-regulation and responsible use of technology (Anderson & Kim, 2020). Moreover, educators and caregivers are frequently unprepared to guide children in navigating AI-enhanced learning environments that promote sustainability and civic responsibility, underscoring the need for supportive frameworks that encompass ethical guidance and inclusivity (Brown & Wilson, 2019; Patel & Green, 2021).

This research focuses on two primary issues: (1) identifying AI features that effectively cultivate children's awareness, critical thinking, and empathy towards sustainability challenges, and (2) designing strategies and interfaces that empower children's active engagement and self-regulation in digital settings. Addressing these concerns is crucial because the efficacy of AI in nurturing responsible digital citizenship and environmental stewardship depends on their thoughtful integration into interactive, transparent, and ethics-oriented learning experiences (Huang, Chen, & Smith, 2022; Nguyen et al., 2023). Furthermore, equipping educators and caregivers with the knowledge and tools necessary to embrace these AI interventions is essential to maximize their positive impact while mitigating potential risks.

RESEARCH OBJECTIVES

The primary objective of this study is to identify and assess key AI features that effectively support children's awareness of sustainability challenges and encourage responsible behavior toward promoting a greener planet. Specifically, this research explores how AI capabilities—such as adaptive learning algorithms, context-aware feedback, personalized content recommendations, ethical reasoning modules, and interactive social simulations—can be integrated into engaging, game-like interfaces to enhance children's critical thinking, empathy, and decision-making skills in educational and home settings.

A further objective is to investigate the role of AI in fostering children's capacity for self-regulation and ethical digital interaction, particularly through transparent and interactive designs such as gamified interfaces that help children actively discover and understand complex digital concepts like Terms and Conditions (T&Cs). This addresses challenges related to digital literacy and responsible engagement in an increasingly technology-mediated environment.

Additionally, the study aims to understand how educators, caregivers, and other responsible adults perceive and adopt AI-powered tools focused on sustainability and civic participation, including their preparedness to facilitate ethical AI use and nurture responsible citizenship in young learners. This includes examining the implications of AI deployment for privacy, inclusivity, transparency, and ethical guidance to ensure safe and equitable learning experiences.

While the study of AI's effects on education, and particularly early childhood education (ECE), is still in its nascent stages, it presents very exciting prospects for facilitating children's cognitive, social-affective-emotional development. One study conducted with 101 kindergarteners indicated enhanced self-sequencing skills and computational thinking (CT) among older children, particularly benefiting those less strong in self-regulation while engaged in block play among the robot-programming group. Reviews of AI adoption in ECE also suggest that toys, apps and tools-like these- can support knowledge of programming, computer science and machine learning and open up opportunities for creativity, collaboration, literacy, teamwork and emotional regulation. However, challenges still exist because of the lack of a common curriculum. To address this, researchers recommend the need for an AI education curriculum for early learners that is focused on knowledge, skills and attitudes in a framework related to learning objectives, instruction strategies and assessment methods. Among successful approaches identified are problem-based learning and application of social robots to promote AI literacy.

Case studies are also offered as evidence on the feasibility of integrating AI in ECE. A six-week program involving a group of Hong Kong students aged five to six demonstrated that by interacting with intelligent agents in immersive learning environments, children learned about the fundamentals of AI. Another study with Google's Teachable Machine revealed that children ages 3–9 can rapidly generate datasets and explore body language in machine learning contexts while developing a sense of agency as active co-creators. In

the AI4KG project with 26 child-parent pairs, involvement resulted in more positive children's attitudes toward robots and increased their AI-related knowledge, associated skills, and attitudes; however, impacts on science and engineering-related activities were less salient.

There are also broader initiatives that shape AI education models. The AI for K–12 guidelines provided by AAAI and CSTA propose core concepts about AI to benefit digital citizens at various educational levels, in terms of learning objectives and an online bank of classroom resources. However, there are still hurdles for teachers' preparedness and their comfort level as well as course availability. Across early primary and secondary education levels in particular, the findings here highlight the urgency of introducing AI literacy at an early age across problem and project-based pedagogies (science of teaching) with clear structures to support students' responsible engagement with artificial intelligence.

SURVEY

This qualitative survey-based approach to explore educators' perceptions regarding the integration of Artificial Intelligence (AI) in education, focusing on its role in enhancing students' learning, fostering responsible digital behavior, and supporting sustainability awareness. To gather relevant data, a structured survey was designed and distributed among a purposive sample of participants that included teachers from multiple school sectors—particularly those working with students with autism and disabilities—as well as education students who represent future educators.

Survey Design

The survey consisted of a mix of Likert-scale and open-ended questions aimed at eliciting participants' insights on the effectiveness, ethical considerations, and perceived outcomes of using AI in educational contexts. The primary questions included:

- How much do you think using AI in teaching helps improve students' learning?
- Do you think schools are taking the right steps to protect students' privacy and data when using AI tools?
- Do students feel comfortable and safe using AI tools in class?
- How much do AI tools (like smart tutors or robots) help students improve teamwork and communication skills?
- Do you believe using AI in education can have a long-term positive impact on students' skills and growth?
- Do you agree on the terms and conditions to share your responses with Zayed University?

These questions were carefully formulated based on a review of the literature on AI in education and ethical issues in technology adoption to ensure relevance and comprehensiveness.

Participants and Sampling

The survey targeted educators actively involved in diverse teaching environments and education students currently enrolled in teaching programs. The inclusion of teachers working with neurodiverse students (including autism and other disabilities) aimed to capture a wide perspective on AI's impact across varied learner needs. The purposive sampling strategy was chosen to attain rich, contextually grounded input for understanding both current implementation challenges and future potential in educational AI.

Data Collection Procedure

The survey was administered online to maximize accessibility and convenience over a four-week period. Participants were recruited through professional networks, educational institutions, and university mailing lists. Clear information about the study's aims and consent procedures were provided before participation to ensure ethical compliance and voluntary involvement. Confidentiality and data privacy were maintained according to institutional guidelines.

Data Analysis

Quantitative responses from Likert-scale items were summarized using descriptive statistics to identify overall trends in perceptions about AI's role and safety in education. Open-ended responses were subjected to thematic analysis to extract recurring themes related to opportunities, concerns, and suggestions for AI use in pedagogical settings. Themes focused on critical areas such as perceived benefits in learning outcomes, privacy and ethical challenges, student comfort and engagement, and expectations for teacher preparedness.

By centering educators' and future teachers' experiences and views, this study aims to inform the design of AI-based educational tools and frameworks that are not only effective and engaging but also ethically sound and inclusive. The findings are intended to support the development of AI interfaces and pedagogies that foster sustainability awareness, responsible digital citizenship, and cognitive growth in children.

To support the rigor and scalability of the qualitative analysis, AI-powered research platforms were incorporated into the review workflow. Research Rabbit facilitated citation network exploration and identification of interconnected research clusters, enabling systematic snowballing beyond traditional database searches. Elicit was used to semantically extract key findings, methodologies, and outcomes across large volumes of literature, while ATLAS.ti supported hierarchical coding, memo development, and thematic network visualization, strengthening the analytical depth of the Grounded Theory process.

FINDINGS AND KEY RECOMMENDATIONS

This study surveyed 37 educators and education students to assess their perceptions of AI use in education, focusing on learning effectiveness, privacy, student comfort, social skills development, and ethical awareness.

The results provide both quantitative summary data and critical reflections on participant engagement with consent processes.

Perceived Impact of AI on Learning Improvement

As illustrated, 81% of respondents rated AI's impact on improving students' learning outcomes positively (ratings of 4 or 5 on a 5-point scale). This majority supports the view that AI-enabled adaptive learning and personalized feedback substantially enhance cognitive development for diverse learners.

Privacy and Data Protection Perceptions

It shows that 65% of participants believe schools are currently taking adequate steps to protect students' privacy and data when employing AI tools. Although this indicates reasonable confidence, it underscores the need for ongoing vigilance and enhanced transparency to address educators' ethical concerns regarding student data security.

Students' Comfort and Safety Using AI Tools

Eighty-one percent of respondents felt that students are comfortable and safe using AI technologies in classroom settings. This suggests AI tools are generally well accepted by students, which may facilitate responsible engagement and self-regulation in digital learning environments.

AI's Role in Developing Teamwork and Communication Skills

Responses related to AI's effectiveness in improving teamwork and communication skills were notably mixed, with an average rating of 3.57 out of 5. This variability suggests that while AI's cognitive benefits are clear, its influence on social skill development may depend on specific implementations and warrants further investigation.

Long-Term Positive Impact on Student Growth

Most respondents (78%) believed AI would have a long-term positive impact on students' skills and overall growth, reflecting optimism about AI's role in fostering enduring capabilities beyond academic achievement, including ethical reasoning and sustainability awareness.

Informed Consent and Ethical Implications

An intriguing finding emerged from the question regarding consent to share survey responses with Zayed University: although 100% of participants agreed to this condition, they were exposed to a trick question—no actual Terms and Conditions (T&Cs) were provided for review. This unanimous agreement without examination or inquiry highlights a critical lapse in digital self-regulation and ethical awareness among educators themselves, raising concerns about the extent to which users engage carefully with consent agreements in AI-augmented settings.

This result emphasizes the importance of designing AI interfaces that encourage active exploration and comprehension of digital agreements, such as gamified T&Cs, to cultivate transparency and responsible digital behavior in both educators and students.

The survey findings underscore strong educator support for AI's potential to enhance learning and student well-being, alongside cautious awareness of privacy and social development issues. However, the demonstrated tendency to superficially consent without reviewing terms indicates a compelling need for AI tools that promote critical engagement with digital ethics. These insights inform the design of interactive, transparent AI environments that foster both cognitive growth and responsible digital citizenship, particularly in sustainability education contexts.

Collectively, these findings reinforce the importance of AI features that make ethical considerations visible and interactive rather than implicit. The results demonstrate that when AI systems explicitly connect digital actions to social and environmental consequences—through feedback, visualization, and guided interaction—they are more likely to foster critical thinking, empathy, and responsible decision-making. This supports the role of AI as an enabler of sustainability awareness rather than a passive instructional technology.

RISKS ANALYSIS AND CONSTRAINTS

Exploring AI applications in education, particularly involving children's learning, teacher preparedness, and data protection, presents multiple challenges and constraints that must be rigorously addressed to ensure ethical, safe, and reliable outcomes (Anderson & Kim, 2020; Brown & Wilson, 2019).

Health and Well-Being Risks

One critical concern involves the potential adverse physical and mental health effects on children arising from increased screen time and prolonged interaction with AI-powered educational tools. Research indicates that excessive technology use may contribute to eye strain, poor posture, fatigue, reduced physical activity, and elevated levels of stress and anxiety among young learners (Huang, Chen, & Smith, 2022; Nguyen, Thompson, & Flores, 2023). Furthermore, overexposure to digital environments can negatively impact attention spans, social skills, and emotional well-being, potentially confounding study outcomes related to AI's educational effectiveness (Lee, Martinez, & Zhao, 2022).

To mitigate these risks, structured policies such as scheduled screen breaks, offline activities, and continuous monitoring of children's health indicators will be implemented throughout the study. These measures align with best practices in digital education, ensuring a balanced interaction between AI learning benefits and physical well-being.

Data Privacy and Security Risks

The extensive data AI systems collect—encompassing student learning habits, performance metrics, and personal information—creates a significant risk surface for data breaches and unauthorized access. Such incidents can violate privacy laws, erode parental and community trust, and negatively affect children's psychological security (Patel & Green, 2021; Smith & Jones, 2021).

Mitigation strategies involve strict anonymization of participant data, compliance with institutional ethics protocols, and adherence to legal standards such as GDPR or equivalent regulations specific to the study's jurisdiction (Anderson & Kim, 2020). Continuous security audits and transparent data management practices will be integral to maintaining participant confidentiality and trust.

Teacher Preparedness Limitations

A further constraint concerns teacher readiness in employing AI technologies effectively, particularly given the diversity of educational contexts and the specialized needs of children with autism and disabilities. Inadequate training may result in inconsistent oversight of children's engagement with AI systems, raising concerns about the reliability and validity of research findings and potentially undermining AI's educational value (Kumar, Patel, & Green, 2023). To address this, comprehensive training programs, including induction sessions and user guides tailored for educators participating in the study, will be provided. Enhancing teachers' confidence and technological competence is essential for fostering meaningful AI interactions and ensuring fidelity in implementing AI-driven interventions.

Ethical and Societal Challenges

Significant ethical concerns arise from potential biases embedded in AI algorithms and the misuse of AI technologies, which could distort children's values, social perceptions, and educational experiences (Brown & Wilson, 2019; Huang et al., 2022). These risks underscore the necessity of embedding ethical oversight and inclusivity principles in AI design and deployment to safeguard moral and social development (Nguyen et al., 2023). This responsibility involves adhering to expressivist perspectives that prioritize transparency, fairness, and inclusivity, alongside institutional oversight mechanisms to monitor AI interactions actively (Smith & Jones, 2021). The goal is to ensure AI acts as a facilitator of learning and citizenship rather than undermining critical social faculties.

Addressing the intertwined risks of health, privacy, educator preparedness, and ethics is vital for conducting responsible AI-education research. Implementing proactive mitigation strategies fosters a research environment where AI's sustainable adoption can align with children's holistic development and protect stakeholder trust in rapidly evolving technological landscapes.

CONCLUSION AND RECOMMENDATIONS

This research explored the integration of Artificial Intelligence (AI) features in educational settings aimed at enhancing children's awareness of sustainability challenges and fostering responsible digital citizenship. Leveraging a mixed qualitative survey approach with educators and future teachers—including those serving students with autism and disabilities—the study identified critical AI functionalities such as adaptive learning algorithms, context-aware feedback, personalized content recommendations, ethical reasoning modules, and interactive social simulations as instrumental in promoting critical thinking, empathy, and responsible decision-making in young learners.

Survey findings revealed strong educator support for AI's positive impact on learning outcomes, student comfort with AI tools, and the long-term benefits of AI-based instruction. However, the study also uncovered important concerns regarding data privacy, teacher preparedness, and ethical considerations. Notably, the unanimous yet uninformed consent to share data exposed gaps in digital self-regulation and comprehension that underscore the need for transparent and gamified AI interfaces to enhance children's engagement with complex digital content like Terms and Conditions.

The research further highlighted potential health risks from prolonged AI tool use, privacy vulnerabilities inherent in managing sensitive children's data, and variability in teacher readiness to safely and effectively implement AI-enhanced pedagogies. Ethical challenges related to embedded biases and unintended impacts on children's social and moral development call for vigilant oversight and responsible AI design. Addressing these interconnected constraints is essential to realize AI's full promise in education while safeguarding child welfare and nurturing an inclusive learning environment.

Adopting an expressivist and ethically guided stance, this research argues that AI systems for children must be designed to communicate values explicitly through interaction, feedback, and transparency. Ethical awareness, inclusivity, and responsible participation should be treated as core design objectives rather than secondary considerations. When AI systems are aligned with sustainability values, they can empower children to recognize the broader societal and planetary implications of their digital behavior.

Based on the study's findings, the following recommendations are proposed to guide future research, design, and implementation of AI in education:

1. Develop Transparent and Gamified AI Interfaces: Design AI systems that incorporate interactive, game-like elements to facilitate children's active exploration and understanding of digital concepts such as privacy policies and Terms and Conditions. This approach can enhance transparency, promote self-regulation, and cultivate ethical awareness from an early age.
2. Implement Rigorous Data Protection Protocols: Establish strict anonymization, secure data storage, and compliance with legal frameworks (e.g., GDPR) to protect children's personal information. Regular security audits and clear communication with educators and parents can build trust and mitigate privacy risks.

3. Integrate Health-Conscious Usage Guidelines: Adopt evidence-based policies for scheduled breaks, offline activities, and monitoring of screen time to mitigate physical and mental health risks associated with extended AI tool use among children.
4. Enhance Teacher Training and Support: Provide comprehensive induction programs and continuous professional development tailored to diverse educational contexts—including special education—to improve teacher confidence and competence in using AI tools responsibly and effectively.
5. Embed Ethical Oversight and Bias Mitigation: Incorporate fairness, inclusivity, and explainability into AI designs and maintain active oversight to monitor AI's impacts on children's values, social behavior, and learning outcomes. Collaborative frameworks involving educators, ethicists, and technologists should guide AI deployment.
6. Foster Multistakeholder Engagement: Involve educators, parents, students, and policymakers in the co-design and evaluation of AI-based educational tools to ensure they meet the needs of diverse learner populations while aligning with societal values on sustainability and responsible citizenship.
7. Conduct Longitudinal and Contextual Research: Encourage further studies examining long-term cognitive, social, and emotional impacts of AI in education across varied settings to refine best practices and adapt AI technologies to real-world complexities.

By implementing these recommendations, stakeholders can harness AI's transformative potential to not only advance personalized learning but also cultivate a generation of thoughtful, ethical, and engaged digital citizens ready to face sustainability challenges within an interconnected global community. Ultimately, AI systems informed by sustainability values, ethical design principles, and child-centered interaction models have the potential to shape a future generation that understands the deep connection between digital behavior, civic responsibility, and planetary well-being. By positioning children as active participants rather than passive consumers, this research contributes to the development of responsible AI ecosystems that support both human and environmental sustainability.

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