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Alternating Environmental Teaching through AI: Potential Benefits and Limitations

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ABSTRACT

Environmental education is essential for developing awareness, critical thinking, and problem-solving skills needed to address pressing global challenges such as climate change, biodiversity loss, and resource depletion. Artificial intelligence (AI) can expand access to environmental learning by providing scalable, personalized educational tools that overcome geographical and logistical barriers. This paper explored the perceptions of science teaching about the potential application of AI in environmental teaching. A purposive sampling method was employed to select 25 science teachers, who were selected through an online screening process and subsequently interviewed individually. Findings indicated that AI enabled personalized learning pathways, allowing students to engage with designed content and tasks suited to their individual levels, which enhanced academic growth and interest. AI-powered simulations allowed students to experiment with

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environmental changes in immersive, risk-free environments, while teachers used AI to simplify complex concepts and create diverse materials, enhancing instructional strategies like flipped classrooms. Individualistic nature of AI-based learning could reduce collaboration, limiting students' understanding of environmental science and social dimensions. Overreliance on AI also hindered hands-on fieldwork, essential for practical skills and adaptability, while causing strong trust in AI-generated results, weakening critical evaluation and data collection abilities. These findings highlight the need for an optimized integration of AI with collaborative activities, field experiences, and critical thinking to ensure a comprehensive environmental science education.

Keywords: Artificial Intelligence; Environmental Education; Science Education; Student-Centered Learning

1. Introduction

The incorporation of AI into education has brought about significant advancements, particularly in teaching environmental science [1]. Among these advancements is the growing reliance on AI chat models, which students find appealing due to their accessibility and practicality. Such tools have provided new avenues for academic assistance, enabling learners to complete tasks more efficiently [2].

Through innovative technologies, educators can now present intricate topics more effectively, bridging the gap between theory and practice [3]. However, this shift introduces challenges, particularly in balancing modern AI-based methods with traditional teaching approaches [4]. While AI promises improved learning outcomes, it also presents limitations, particularly in addressing ethical considerations and sensory engagement.

Artificial intelligence has reshaped how instructional methods are delivered, allowing personalized learning experiences tailored to individual student needs [5]. A notable advantage of AI in education is its ability to enhance ***systems thinking***. This method, crucial for driving meaningful change, is often emphasized yet lacks sufficient actionable advice for decision-makers on incorporating such insights to promote responsible AI use [6]. Utilizing AI-powered simulations, students gain a clearer understanding of interconnected ecosystems, such as the intricate dynamics between climate, biodiversity, and human actions [7]. These simulations equip learners to analyze environmental challenges from a comprehensive perspective. However, these tools may oversimplify the complexities of natural systems, potentially hindering students' understanding of real-world uncertainties.

The role of ethical reasoning in environmental science education cannot be overstated. Addressing sustainability and environmental decision-making requires more than data analysis; it necessitates cultivating moral responsibility and cultural sensitivity. Such education emphasizes proactive engagement and real-world simulations that instill a sense of responsibility toward future generations and the environment [8]. Developing critical thinking skills is also essential, as they enable learners to navigate intricate ethical dilemmas in sustainability and environmental conservation [9]. While AI excels at processing and presenting data, it lacks the depth to facilitate nuanced ethical discussions. This gap highlights the importance of integrating AI as a supplementary tool rather than a standalone solution, ensuring it enhances rather than replaces collaborative and ethical learning experiences.

The ability of AI to revolutionize learning through sensory immersion has also transformed environmental education. This approach introduces a dynamic and engaging dimension to the learning process [10]. Virtual and augmented reality technologies provide students with immersive opportunities, such as exploring endangered ecosystems or visualizing the effects of climate change. Among the many applications of these technologies, their use in science education is among the most prominent, furthering their utility across diverse fields, including architecture, engineering, and medicine [11–13]. These immersive tools encourage curiosity and foster a strong sense of environmental advocacy. However, they cannot replicate the hands-on experiences and emotional depth gained through real-world fieldwork, which is crucial for building a tangible connection to nature.

Through this exploration of AI's advantages and limitations in environmental education, the study seeks to understand its broader implications. Analyzing these issues through the frameworks of systems thinking, ethical reasoning, and sensory immersion, it highlights the need for balance. The research underscores that while AI has the potential to enhance learning, it must be integrated thoughtfully, preserving the irreplaceable value of human engagement and real-world interactions. This balanced approach aims to create an impactful educational experience in environmental science.

2. Literature Review

The use of AI in education has significantly transformed teaching strategies, providing innovative methods to improve environmental science education [14]. In the Philippines, where environmental issues like deforestation, pollution, and climate change are of critical importance, AI offers valuable opportunities to engage students in addressing these challenges. Students have demonstrated strong awareness and active participation, reflecting a positive reception to these tools. According to Microsoft Philippines [15], 86% of Filipino knowledge workers incorporate AI into their work, which is higher than both the global average of 75% and the regional average of 83%. This active engagement is essential in forming a framework for community-driven environmental management, leading to significant benefits for the environment, society, and nature [16]. Environmental education aims to cultivate awareness in students so they can recognize and address environmental issues [17]. AI facilitates this process by helping students model ecosystems and environmental systems, providing a deeper understanding of the interconnectedness of these issues and enabling them to develop real-world solutions. While the potential advantages of AI in education are considerable, it is also crucial to recognize its limitations to maximize its effectiveness.

Cognitive Psychology's systems thinking approach plays a key role in environmental education, as it allows students to examine the complex relationships within ecosystems. AI-powered tools enable students to simulate environmental situations, such as the consequences of rising sea levels on coastal areas or the effects of deforestation on biodiversity. Systems thinking is crucial for environmental education, helping students understand the intricate interactions within ecosystems. AI tools can simulate scenarios like rising sea levels and deforestation effects, which enhances the learning process. Projects such as SHINE work to incorporate systems thinking into natural science education, equipping students to effectively address climate change issues [18, 19]. In the Philippines, where coastal regions and rainforests are vital to the nation's ecology, systems thinking fosters an understanding of the interconnectedness between human activIties and environmental health. However, despite the effectiveness of AI tools in simplifying complex concepts, they should be complemented with experiential learning to help students fully grasp the complexities of dynamic systems.

The Philippines faces significant challenges, such as finding a balance between economic growth and environmental preservation [20]. AI tools can present scenarios for students to explore these trade-offs, but they cannot offer the moral context necessary to navigate such decisions. Ethical reasoning, a key element of developmental psychology, requires human facilitation to explore cultural, social, and moral perspectives, ensuring that students understand the broader implications of their choices [21, 22]. For instance, debates about preserving marine biodiversity in the Philippines or managing urban development should consider ethical dimensions that AI cannot simulate.

Emerging technologies, such as AI, are reshaping various sectors, including education [23]. AI's impact on education is particularly transformative for inclusivity, especially in the Philippines, where geographic barriers often hinder access to quality education. AI-supported virtual learning environments offer students in remote areas the chance to engage with environmental science topics, ensuring equal learning opportunities with their urban peers [24, 25]. However, this inclusivity must account for disparities in access to technology, as not all students or schools have the resources to utilize advanced AI tools [26]. Ensuring equitable access to AI-powered education remains a challenge that requires policy support and investment.

Considering both the benefits and limitations of AI in teaching environmental science, it is evident that AI serves as a valuable complement to traditional educational methods. As AI continues to play a role in education, ongoing research is needed to assess the viability and effectiveness of existing AI platforms to enhance different teaching methodologies [27]. While AI promotes engagement and understanding, its limitations emphasize the need for human guidance, hands-on learning, and ethical discussions [28]. By thoughtfully integrating AI into environmental education, especially in the Philippine context, educators can offer a comprehensive learning experience that equips students to address the complex environmental challenges of the future.

3. Methods

3.1. Research Design

This paper explored the potential application of AI in environmental teaching in the Philippines based on the perceptions of Filipino science teachers. Exploratory research endeavors are undertaken to investigate specific issues or illuminate emerging phenomena [29]. In social science explorations, this form of inquiry adopts systematic and purposeful methods to identify critical patterns, which enables the organized examination and documentation of social or psychological constructs [30, 31]. Exploratory research frequently serves as a cornerstone for developing hypotheses that may later undergo rigorous empirical validation [32]. Although it has been criticized for deficiency in methodological rigor [33, 34] contemporary academic discourse stands on its significance in advancing the understanding of research problems and in supporting the systematic collection of vital narrative data [35]. This paper answered one critical question in AI-based environmental learning: *how artificial intelligence can contribute to the development of pedagogical practices?* The integration of AI into educational practices could revolutionize how environmental knowledge is imparted, creating opportunities for adaptive and personalized learning experiences for students regarding environmental education.

3.2. Participants

Exploratory research often utilizes a constrained sample size to conduct a thorough examination of key variables and their interconnections [5]. These investigations typically focus on a distinct and specifically delineated group to ensure reliability in the analysis of a phenomenon [36]. The sample size in such research is inherently adaptable and often small, which is being determined by the participants' capacity to offer substantial contributions toward achieving the research objectives [31, 37]. A usual technique in exploratory research is purposive sampling [38], a non-random sampling method in which participants are intentionally selected based on their specific characteristics or relevance to the research subject. This strategy allowed researchers to pinpoint and engage individuals whose knowledge, attributes, or experiences are particularly pertinent to the study's focus [39–41]. In this study, an online purposive sampling method [42] was conducted, utilizing open-ended questions distributed through Google Forms to gather preliminary qualitative data from the participants. Five major sampling criteria was used: (1) a science-based teacher (>5 years of experience), (2) familiar with or use AI in classrooms, (3) the educator demonstrate a strong understanding of pedagogical approaches, (4) have prior experience in integrating technology into the curriculum, and (5) willingness to participate in one-one-one interview. Out of 75 science teachers who responded, only 25 were selected to be interviewed in this study.

3.3. Instrumentation

In qualitative research, the credibility and rigor of findings are profoundly shaped by the methodologies employed for data collection [43]. Interviews emerge as a versatile and contextually responsive approach in qualitative research, enabling a comprehensive exploration of the phenomena being investigated [44]. The individual interviews were designed to balance structure with flexibility, allowing participants the opportunity to express their views, raise pertinent issues, and steer the discussion in a manner conducive to in-depth exploration [45]. Although initial responses often provided preliminary insights [46], the implementation of probing questions proved essential in discovering participants' underlying values, experiences, and perspectives [47, 48]. To ensure systematic coherence and thorough coverage throughout the interviews [49], a semi-structured interview guide was developed. The process of crafting the interview guide adhered to the structured approach outlined by [50], which involved several critical stages: identifying essential prerequisites, incorporating existing literature, formulating an initial version, conducting a pilot test, and refining the guide based on the feedback received. The pilot testing of the interview questions was a pivotal stage in assessing their clarity, relevance, and efficacy in generating detailed and meaningful responses [45]. Expert feedback was conducted for validity, ensuring its alignment with the research objectives and improving the overall quality of the instrument [51]. The final, validated interview guide is presented in **Table 1**.

Table 1. Final interview guide questions based on established research objectives.

Objectives	Interview Questions
Determine the potential benefits of teaching environmental science with AI.	1. Do you see any value in using AI when teaching environmental science? Explain further. 2. How can AI be a potential help in teaching environmental science? Elaborate further. 3. What are some resources present in AI which can simulate important lessons in environmental science? Enumerate and explain each.
Determine the limitations of AI in teaching environmental science.	1. What do you see as limitations in teaching environmental science through AI? Elaborate more. 2. What particular aspects of AI become limitations in teaching environmental science? Elaborate further. 3. Should we still use AI in spite of its limitations in teaching environmental science? Tell us more.

3.4. Data Gathering

The purpose of conducting the interviews was to gain a understanding of the participants' lived experiences, offering a framework to analyze their behaviors, perspectives, and interactions [52]. In exploration, interviews are essential in uncovering individuals' personal experiences and subjective realities [53]. This study conducted semi-structured interviews, to facilitate both guided inquiry and open-ended discussions, allowing significant insights to emerge naturally [54]. This approach effectively balanced structured themes with the flexibility for participants to share their subjective ideas based on their experiences [55].

The interview process began with a clear articulation of the research objectives, followed by the development of thematic questions that directly aligned with these goals and were informed by a comprehensive review of relevant literature [45, 56]. Establishing a comfortable and confidential setting was crucial to ensure that participants felt relaxed and were able to express themselves openly, with clear and respectful communication [55]. The interview protocol followed a systematic procedure, which included explaining the research's purpose, obtaining informed consent, outlining confidentiality measures, asking both thematic and probing questions, and summarizing key discussion points at the interview's conclusion [56]. To further facilitate open expression, participants were offered the choice of responding in their preferred language, reducing potential language barriers and ensuring data reliability. Each interview was audio-recorded using secure mobile devices to ensure accurate capture of participants' responses for later analysis.

3.5. Data Analysis

The collected data was analyzed using content analysis, a method aimed at organizing and deriving meaningful insights from the data to formulate realistic conclusions [57]. This approach involved identifying recurring themes and patterns in the interview transcripts, particularly focusing on the benefits and limitations of AI in the context of environmental science education. Content analysis provided a systematic and impartial way to examine the data, ensuring that the findings were rooted in the participants' own experiences and viewpoints.

4. Results

Objective 1: Determine the potential benefits of teaching environmental science with AI.

The findings highlight the potential of integrating AI into environmental science education, particularly in developing student-centered learning and enhancing instructional design. The data collected from interviews revealed several transformative benefits that AI offers to both teachers and students in the context of environmental science education.

Participants emphasized the role of AI-powered simulations, such as virtual ecosystems, which allowed students to experiment and observe environmental changes in a controlled, virtual setting. AI facilitated personalized learning pathways, where students received content and tasks that were suited to their individual levels of understanding, further promoting engagement and academic growth. Immersive experiences allowed students to explore environments they might not physically visit, deepening their connection to the subject matter and encouraging a sense of environmental stewardship.

AI was recognized for its capacity to streamline the creation of diverse learning materials, such as worksheets, quizzes, and simulations. Teachers found AI particularly helpful in simplifying complex scientific concepts, transforming abstract topics into visually accessible formats. The adaptability of AI tools enabled instructors to break down intricate subjects into manageable sections, enhancing the clarity and structure of lesson plans.

Theme 1: Student-centered Learning

Educators reported that AI enabled the delivery of personalized instruction, designing resources and feedback to address the individual needs of each student. This personalization facilitated a more effective and engaging learning environment, where students were provided with content and exercises that aligned with their specific progress and understanding.

> "AI has transformed the way I teach environmental science. It enables personalized learning, providing students with tailored resources and feedback based on their unique needs."
> "AI-powered simulations, such as virtual ecosystems, allow students to experiment and observe the consequences of their actions without harming real environments."

For instance, struggling students were offered simpler explanations of complex topics such as climate change, while more advanced learners were presented with challenging tasks, including in-depth data analysis.

> "AI is excellent for preparing students for hands-on activities. For example, AI simulations can model the outcomes of environmental changes before students move into the field."
> "Virtual reality allows students to step into environments that they might never have the chance to experience in real life, like the depths of the ocean or the Amazon rainforest."
> "This immersive experience can spark curiosity and connection to the environment, making them more invested in protecting it."

AI-powered simulations, such as virtual ecosystems, were highlighted as valuable tools that allowed students to experiment with environmental changes and observe their consequences without the risk of damaging real ecosystems. This technology also served as an excellent preparation for hands-on activities by modeling potential outcomes before students ventured into fieldwork, thus enhancing their readiness for practical applications.

> "AI enables personalized learning pathways for students. By assessing a student's progress and understanding, AI can recommend content, exercises, and feedback."

With continuous assessment of student progress, AI could recommend learning materials and feedback, which further supported individual academic development.

> "For example, a struggling student might get simpler explanations of climate change concepts, while advanced learners could be challenged with in-depth data analysis tasks."

Further, AI tools provided students with opportunities to engage with real-world data, such as satellite imagery and biodiversity databases, which were used to analyze environmental trends. The simplification of complex data analysis through AI allowed students to focus more on interpreting results and drawing conclusions, which helped develop their critical thinking and problem-solving abilities.

> "With AI, students can work with real-world data, such as satellite imagery or biodiversity databases, to analyze environmental trends."
> "AI tools simplify complex data analysis, allowing students to focus on interpreting results and drawing conclusions. This approach develops their critical thinking and problem-solving skills, which are essential for addressing environmental challenges."

The integration of real-world data into projects not only reinforced theoretical knowledge but also allowed students to apply concepts learned in the classroom, such as carbon cycles, water quality parameters, and urban heat islands. This practical application of knowledge helped students make connections between theoretical concepts and real-world environmental issues, such as tracking trends in greenhouse gas emissions and understanding the impact of industrial or policy changes over time.

> "Students can use this real-world data in their projects, linking theoretical knowledge to practical challenges in environmental management."
>
> "…students can directly apply concepts they've learned in class, such as carbon cycles, water quality parameters, or urban heat islands. For instance, they can track trends in greenhouse gas emissions and link them to industrial or policy changes over time."

Theme 2: Instructional Designing

Educators highlighted the usefulness of AI in simplifying the explanation of complex scientific processes, particularly in making abstract concepts more accessible to students. With AI, teachers were able to break down intricate topics into smaller, more digestible components, which provided a structured and approachable learning environment. This breakdown of challenging content allowed students to understand difficult subjects, enhancing their learning retention.

> "As a teacher, I use generative AI in instructional designing. I feel that AI could help in making lessons, especially in explaining complicated science process to students."
>
> "I believe that generative AI can assist in simplifying complex topics, such as abstract scientific concepts, by visualizing them in ways that are easier for students to understand."
>
> "AI aids in breaking down difficult concepts into smaller, more manageable parts, making learning more structured and approachable for my students."

In addition, generative AI facilitated the creation of learning materials, such as worksheets and quizzes, which could be easily adapted to meet the varying progress levels and understanding of individual students. This adaptability enabled instructors to design educational resources to the specific needs of each student, promoting a personalized learning experience. The flexibility of AI tools in generating content allowed educators to streamline lesson planning, saving valuable time that could be redirected toward more interactive and engaging learning experiences within the classroom.

> "Generative AI helps in creating a variety of learning materials, from worksheets to quizzes, that are adaptable to the students' progress and understanding."
>
> "AI-based resources help me save time in lesson planning, enabling me to focus more on interactive learning experiences in the classroom."

Notably, AI supported the adoption of flipped classrooms and blended learning models, which were seen as effective means of enhancing student engagement. These strategies allowed for a more dynamic and participatory approach to learning, where students took greater responsibility for their learning process, both inside and outside the classroom.

> "Generative AI allows me to experiment with innovative teaching strategies, such as flipped classrooms or blended learning, to enhance student engagement."

Objective 2: Determine the limitations of AI in teaching environmental science.

The findings of this study revealed several limitations associated with the use of AI in teaching environmental science. The exploration of these limitations was categorized into three primary themes: declining collaboration, less exposure to field, and reliance on AI.

Firstly, science teachers emphasized that the individualistic nature of AI tools often reduced opportunities for collaborative learning among students. While AI facilitated personalized learning, it was observed to detract from group discussions and brainstorming sessions, which are essential for understanding the social and political dimensions of environmental science.

Teachers also highlighted the essence of hands-on field experiences, such as using physical tools and observing ecosystems firsthand, in developing connection to nature and developing practical skills. AI simulations, while beneficial for certain purposes, were found to be inadequate in replicating the sensory, emotional, and unpredictable elements of real-world environmental research. Fieldwork, with its inherent dynamism and challenges, was deemed irreplaceable for equipping students with the adaptability and observational skills needed in environmental science.

Lastly, teachers expressed apprehension that students might perceive AI-generated outputs as inherently accurate, neglecting to critically evaluate the underlying assumptions or biases. This reliance risked diminishing students' critical skills, such as manual data collection and critical observation of natural phenomena.

Theme 1: Declining Collaboration

Participants observed that individual engagement with AI tools reduced the occurrence of brainstorming sessions where diverse perspectives could enrich the learning process. These discussions were deemed essential understanding social and political dimensions of environmental science, which rely heavily on dialogue and collective analysis.

> "When students work individually with AI tools, they may miss out on collaborative brainstorming sessions where diverse viewpoints enrich the learning process."
>
> "These discussions are vital for understanding the social and political dimensions of environmental science."

It was noted that the focus on AI tools sometimes shifted students' attention away from meaningful discussions and human interaction in the classroom. This trend was identified as misaligned with the inherently collaborative nature of environmental science, which necessitates teamwork and dialogue to have a in-depth understanding of social issues.

> "The use of AI tools can sometimes shift focus away from discussions and human interaction in the classroom."
>
> "Environmental science is a collaborative field, and learning should emphasize teamwork and dialogue, not just individual engagement with AI systems."

Lastly, participants expressed concerns about the static and predictable nature of AI simulations. While these tools provided structured learning opportunities, they were perceived as insufficient for cultivating dynamic problem-solving and social skills, which are critical in addressing the ever-changing challenges of environmental science.

> "AI simulations are static and predictable, limiting the development of problem-solving and social skills."

Theme 2: Less Exposure

The findings revealed that overreliance on AI in environmental science education limited students' exposure to hands-on experiences crucial for developing practical field skills. Participants emphasized the importance of using tools such as thermometers, soil samplers, and water testing kits, which are indispensable for preparing students for real-world environmental research. It was noted that extensive reliance on AI left students inadequately equipped to handle the practical aspects of environmental studies.

> "Students need hands-on experience with tools like thermometers, soil samplers, and water testing kits to develop practical field skills. Relying solely on AI might leave them ill-prepared for real-world environmental research."

In addition, the sensory and emotional experiences from physical engagement with the environment—such as touching soil, observing wildlife, and measuring water quality—were highlighted as irreplaceable. Participants expressed that such experiences encouraged a connection to the environment, which no AI simulation could replicate.

> "…touching soil, observing wildlife, or measuring water quality firsthand provides sensory and emotional experiences that no simulation can replicate."
>
> "AI simulations cannot replicate the real-world experience of collecting data, observing ecosystems, or understanding natural processes in situ."
>
> "I think that fieldwork is still essential to develop connection to the environment."

Participants highlighted that fieldwork provided students with the opportunity to adapt to unforeseen circumstances, such as sudden weather changes or the discovery of a rare species, thereby enhancing their problem-solving abilities. This adaptability was deemed essential for building a comprehensive understanding of environmental processes and developing a sense of environmental stewardship.

> "Natural environments are dynamic and often unpredictable."
> "Fieldwork teaches students how to adapt to unexpected situations, such as sudden weather changes or encountering a rare species."

Theme 3: Reliance

Teachers believed that their students frequently perceived AI-generated results as inherently accurate and beyond question. This inclination, along with insufficient knowledge in environmental science, rendered them less capable of critically analyzing the assumptions, biases, or limitations embedded within the data and algorithms that underpin AI visualizations.

> "Students often view AI-generated results as inherently accurate and unquestionable. Without a strong foundation in environmental science, they might fail to critically evaluate the assumptions, biases, or limitations of the data and algorithms behind the visualizations."

Consequently, the reliance on AI tools tended to cultivate an overdependence on technology, which, in turn, diminished students' proficiency in essential skills such as manual data collection and the critical observation of natural phenomena.

> "AI tools might lead to an overreliance on technology, causing students to lose essential skills like manual data collection or critical observation of natural phenomena."

AI models were often unable to encapsulate the full complexity of interrelated environmental systems. They reduced intricate relationships to static representations that failed to account for the variability and unpredictability characteristic of natural environments. This, in turn, caused the learning process to be less effective when students have strong reliance to AI.

> "AI models often struggle to capture the full scope of these complex relationships, reducing them to static representations that overlook variability and unpredictability in nature."
> "While this makes analysis easier, it fails to capture the complexity and unpredictability of natural systems, leading to an incomplete understanding of environmental processes."

5. Discussion

The integration of AI into environmental science education revealed significant opportunities alongside noteworthy challenges, as demonstrated by the study's findings. This section contextualizes these insights within the framework of the research objectives and grounds the discussion in psychological principles such as cognitive engagement, ethical reasoning, and experiential learning.

The findings underscored AI's transformative potential in creating personalized learning pathways, a concept deeply rooted in cognitive psychology. Respondents highlighted that AI-powered tools, including simulations and real-world data analysis platforms, allowed students to engage with environmental scenarios tailored to their specific learning requirements. For instance, AI algorithms were reported to analyze student data to design individualized learning experiences [58]. Among the educational applications of AI, simulations were widely recognized for facilitating active and adaptive learning [59, 60]. For example, AI provided simplified explanations for struggling learners while engaging advanced students with complex data-driven tasks, fostering critical thinking and problem-solving skills essential for addressing global environmental challenges [61].

Additionally, the ability of AI to facilitate collaboration emerged as a pivotal advantage. Platforms enabling student interaction across regions were noted to promote global perspectives and collective action in addressing shared environmental challenges [62]. Respondents emphasized that AI-powered data-sharing systems allowed students to collaboratively analyze and propose solutions to issues such as pollution and the impacts of climate change [63]. Moreover, AI was regarded as a universal discipline with applications across a broad spectrum of intellectual tasks [64].

Immersive technologies, such as virtual reality (VR), were also praised for their capacity to engage students intellectually and emotionally. By creating augmented or virtual environments, these technologies offered immersive experiences that simulated real-world scenarios, such as coral reefs or melting glaciers, inspiring curiosity and encouraging environmental advocacy [65, 66]. However, respondents noted that the impact of these technologies was limited without complementary real-world applications.

Despite its strengths, the study identified several critical limitations of AI in environmental science education. Participants emphasized that AI could not replicate the sensory and emotional experiences provided by fieldwork, such as observing ecosystems, feeling soil textures, or witnessing environmental changes firsthand. These experiences, integral to encourage a profound connection with nature, align with experiential learning theories that emphasize real-world engagement [67].

Another significant limitation involved the oversimplification of complex ecosystems. Although AI models and simulations facilitated easier analysis, they often failed to account for the dynamic and unpredictable nature of real-world systems [68]. This gap underscored the need for integrating interdisciplinary approaches and hands-on experiences to address these shortcomings effectively. In addition, concerns about overreliance on AI were also expressed by participants. Such dependency often occurred when users uncritically accepted AI-generated outputs, which could lead to errors in decision-making [69]. Similar findings were reported by [70], who observed users relying excessively on AI dialogue systems, sometimes accepting outputs without verification, even in cases involving AI hallucinations. These observations underscored the necessity of ensuring AI serves as a complementary tool rather than a substitute for traditional methodologies.

Ethical reasoning, highlighted by several respondents, further illuminated the limitations of AI. While AI provided data-driven insights, it lacked the moral and cultural sensitivity necessary for addressing ethical dilemmas [71]. For instance, debates on economic development versus environmental conservation required empathy and cultural understanding, which AI tools could not offer. This finding reinforced the critical role of educators in developing student-centered learning environments that prioritize moral reasoning and collaborative problem-solving.

The study ultimately emphasized the importance of a balanced approach to integrating AI into environmental science education [72]. While AI's capabilities in data analysis, scenario simulation, and personalized learning were deemed invaluable, its limitations—particularly in sensory immersion and ethical reasoning—necessitated the inclusion of traditional teaching methods, such as fieldwork and classroom discussions. Respondents recommended leveraging AI to model theoretical concepts before engaging students in field-based activities, thereby bridging the gap between abstract knowledge and practical application.

The implications of this study extended beyond the classroom. Thoughtful integration of AI into environmental science education could facilitate holistic learning experiences, preparing students to address complex global challenges. Policymakers and educational institutions were urged to prioritize equitable access to AI tools while fostering pedagogical strategies that harmonize technological advancements with traditional instructional practices [73].

6. Conclusions

The study revealed that AI had the potential to significantly enhance environmental science education in the Philippines, offering valuable tools for personalized learning, data analysis, and immersive experiences. However, its limitations underscored the need for a balanced approach that complemented AI with traditional methods like fieldwork and human interaction. While AI facilitated engaging and innovative learning experiences, it did not replace the critical thinking skills, ethical reasoning, and deep connection to nature fostered through hands-on learning and collaborative discussions. The research emphasized that educators needed to integrate AI thoughtfully, ensuring that it served as a valuable tool for enriching the learning experience, not as a replacement for the essential elements of human engagement and real-world interaction in environmental science education.

The findings of the study emphasize the importance of a comprehensive understanding of AI's role in environmental science education. While AI has the potential to enhance teaching and learning, its limitations in replicating real-world experiences and fostering ethical reasoning must also be acknowledged. Adopting this balanced approach is crucial for creating effective and impactful educational experiences that prepare students to address the complex environmental challenges of the future.

Author Contributions

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data will be made available upon request.

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Conflicts of Interest

The authors declare no conflict of interest.

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