European Journal of Education Studies
ISSN: 2501 - 1111
ISSN-L: 2501 - 1111
Available online at: www.oapub.org/edu

DOI: 10.46827/ejes.v12i10.6224 Volume 12 | Issue 10 | 2025

REIMAGINING PRIMARY PHYSICS EDUCATION THROUGH ARTIFICIAL INTELLIGENCE: PEDAGOGICAL APPLICATIONS OF CHATGPT

Konstantinos T. Kotsis[i]
Department of Primary Education,
University of Ioannina,
Greece

Abstract:
This study examines the pedagogical potential of Artificial Intelligence (AI), particularly big language models like ChatGPT, in elementary science education, emphasizing physics instruction. The article, which is grounded in modern constructivist and inquiry-based learning theories, explores how AI tools might assist young learners in cultivating scientific comprehension through dialogic engagement, scaffolded inquiry, and contextually enriched explanations. The analysis synthesizes previous worldwide research, demonstrating ChatGPT's ability to generate narrative-driven learning experiences, develop age-appropriate experimental activities, and rectify prevalent errors in fundamental physics concepts, including force, motion, and energy. From an educational standpoint, AI serves as both a teaching resource and a cognitive instrument, facilitating varied learning and advancing student-centered methodologies. ChatGPT's versatility enables educators to incorporate it into many educational settings, providing tailored explanations, exemplifying scientific reasoning, and fostering inquiry-based debates. The study highlights its significance in assisting non-specialist educators by offering immediate help in lesson preparation, experimental design, and formative evaluation, thus improving teacher confidence and instructional quality. Effective integration relies on providing educators with AI pedagogical literacy—competencies to critically assess AI outputs, connect them with curriculum objectives, and cultivate epistemically rich learning environments. The article warns against excessive dependence on AI, emphasizing the necessity of maintaining the primacy of teacher mediation and inquiry-based pedagogy. This paper presents AI to enhance, rather than supplant, human instruction, positioning ChatGPT as a driver of pedagogical innovation in primary scientific education. It asserts that strategically deployed AI can enhance early science education by promoting curiosity, profound conceptual comprehension, and active engagement in scientific inquiry processes.

[i] Correspondence: email kkotsis@uoi.gr

Keywords: artificial intelligence; pedagogical innovation; primary science education; inquiry-based learning; physics teaching

1. Introduction

The incorporation of Artificial Intelligence (AI) into educational practices signifies a fundamental change in the methods of knowledge delivery, acquisition, and construction. As AI-driven systems rapidly infiltrate curriculum development, instructional design, and student assessment, a novel pedagogical paradigm emerges—especially in scientific education, where inquiry, experimentation, and conceptual reasoning are paramount. In this regard, elementary science education is a vital domain for examining the advantages of AI, due to the fundamental nature of scientific concepts and the significance of early cognitive development. The emergence of big language models, like ChatGPT, has sparked increasing interest in their educational uses, particularly in physics and general science teaching at the basic level.

Recent research highlights the capability of AI to assist educators in developing stimulating learning environments, generating instructional resources, and delivering personalized feedback (Holmes *et al.*, 2022; Roll & Wylie, 2016). These abilities are particularly pertinent in science education, as students frequently encounter difficulties with abstract notions such as force, energy, and magnetism (diSessa, 2018). Conventional instructional approaches, predominantly dependent on textbook content delivery, have faced growing criticism for their inadequacy in fostering students' curiosity and critical thinking (Harlen, 2014). AI has been suggested as an innovative instrument to connect abstract scientific concepts with effective, child-focused teaching methods.

In primary education, the application of AI, particularly through generative tools such as ChatGPT, has shown encouraging outcomes in enhancing experiential learning, creating contextualized instructional resources, and promoting inquiry-based learning methodologies (Kotsis, 2024c; Kotsis, 2025a). These AI-driven tools can replicate real-time conversations with learners, generate age-appropriate explanations, and create inquiry projects that conform to the national curriculum. Additionally, they can assist educators who may possess insufficient content expertise in science by offering direction on structuring experiments, rectifying misconceptions, and fostering student engagement in scientific reasoning (Luckin *et al.*, 2016; Holmes *et al.*, 2022).

AI's influence on educational policy and pedagogical innovation has gained prominence beyond the classroom. The promotion of digital transformation and technological integration in education by national and international frameworks necessitates a critical examination of the ethical implications, equity concerns, teacher professional development, and epistemological shifts associated with the implementation of AI in educational systems (Zawacki-Richter *et al.*, 2019; Knox, 2020). The issue of primary science education is particularly significant, as it merges the difficulties of conceptual learning with the potential to cultivate scientific literacy from a

young age—a goal increasingly highlighted by international educational initiatives such as the OECD's Future of Education and Skills 2030.

This article seeks to deliver a thorough synthesis of scientific contributions regarding the incorporation of AI in primary science education, specifically emphasizing physics. This article analyzes the pedagogical potential and challenges of employing AI tools like ChatGPT to improve experiential learning, narrative-driven instruction, and conceptual comprehension in young learners, based on a collection of studies of contemporary international literature. The paper examines how AI can assist educators in curriculum development, professional growth, and classroom execution, while critically evaluating issues pertaining to academic integrity, data privacy, and the future of human-AI partnership in education.

This work enhances the expanding literature aimed at comprehending both the deployment of AI tools in educational settings and their transformative impact on the concepts of teaching, learning, and knowledge in the digital age. The results are pertinent to educators, researchers, politicians, and curriculum creators seeking to create more inclusive, engaging, and forward-thinking science education systems.

2. Theoretical Framework: AI in Science Pedagogy

The incorporation of Artificial Intelligence into education is not just a technology advancement but also a pedagogical transformation with epistemological consequences. This change redefines how students interact with scientific knowledge, cultivate inquiry skills, and construct conceptual understanding in science education. The implementation of AI, especially natural language processing tools such as ChatGPT, facilitates a shift from teacher-centered pedagogy to more dialogic, student-centered learning settings, aligning with constructivist and socio-cultural learning theories.

Constructivism, as defined by Piaget and further elaborated by Vygotsky's sociocultural theory, emphasizes the significance of active engagement, scaffolding, and interaction in the process of knowledge formation (Vygotsky, 1978). AI technologies can function as cognitive instruments inside this paradigm, offering individualized assistance, producing scaffolded explanations, and enabling involvement through simulated dialogues. Instruments such as ChatGPT offer instantaneous feedback, stimulate introspection, anticipate misconceptions, and assist students in articulating their thoughts—attributes that correspond with the fundamental principles of constructivist pedagogy (Luckin *et al.*, 2016).

In science education, these advantages are especially significant. Scientific knowledge is organized, abstract, and frequently paradoxical, posing difficulties for students in aligning it with their daily experiences (Vosniadou, 2013). AI tools can offer contextually enriched and adaptive learning environments in which learners investigate topics through simulations, guided inquiry, and tailored problem-solving exercises. For instance, ChatGPT can formulate Socratic inquiries, devise age-appropriate analogies

based on students' prior knowledge, or suggest experimental designs—attributes that enhance metacognition and epistemic involvement.

Furthermore, the theoretical foundation of AI in education is derived from the notion of intelligent tutoring systems (ITS), which aim to replicate elements of expert human teaching. While early Intelligent Tutoring Systems emphasized rule-based logic and domain-specific feedback (Woolf, 2009), contemporary generative models adopt more adaptable, conversational methodologies. ChatGPT signifies a substantial advancement, offering human-like conversation that can include learners in exploratory dialogue—a type of discourse linked to enhanced learning outcomes in science education (Mercer *et al.*, 2017).

From an educational perspective, AI-enhanced learning environments facilitate formative evaluation via real-time analysis of student responses. These technologies can modify instructional pathways by identifying patterns of comprehension and miscomprehension, facilitating more precise interventions (Holmes *et al.*, 2022). They can aid educators not just in content delivery but also in interpreting student cognition, therefore conforming to contemporary tendencies in formative and responsive pedagogy (Black & Wiliam, 2009).

Notwithstanding these advantages, theoretical apprehensions persist regarding the epistemic framing of science when facilitated by AI. Critics caution that an overdependence on AI may diminish science education to mere algorithmic patterns and factual memorization, so compromising the inquisitive and heuristic essence of the field (Zawacki-Richter *et al.*, 2019). It is imperative that AI tools be integrated into pedagogical frameworks that maintain the exploratory, critical, and socially contextual elements of scientific research. Educators are essential in managing the implementation of AI, guaranteeing that it enhances rather than replaces human guidance and scholarly dialogue.

In conclusion, the theoretical incorporation of AI in science education necessitates a dynamic framework that harmonizes cognitive assistance, dialogic engagement, and conceptual profundity. AI can serve as a catalyst for learner-centered education if implemented within frameworks that acknowledge the intricacies of scientific knowledge and the sociocultural aspects of learning. Kotsis (2024f; 2025a) posits that the educational usefulness of AI is derived not only from its technological sophistication but also from its congruence with robust pedagogical philosophy and its ability to facilitate profound learning in science.

3. Applications for ChatGPT in Primary Science Education

The use of ChatGPT in elementary scientific education signifies a notable advancement in the role of educational technologies in curriculum execution and classroom teaching. ChatGPT, a generative language model designed to emulate human conversation, functions as an adaptive educational agent, facilitating inquiry, conceptual elucidation, and classroom discourse. In contrast to conventional educational software, which is

sometimes inflexibly designed and limited to specific domains, ChatGPT adjusts to diverse teaching environments, customizing replies to meet student requirements and teacher objectives. This versatility has rendered it a formidable instrument in primary science education, especially in physics, where students confront intricate abstract concepts necessitating meticulous scaffolding.

One of the most interesting applications of ChatGPT is its capacity to provide narrative-driven scientific information designed for young learners. Kotsis (2024a) examined the capability of ChatGPT to produce science-themed fairy tales for the instruction of physics principles, including gravity, motion, and sound. This method corresponds with studies indicating that narrative learning improves engagement, emotional connection, and conceptual anchoring, particularly in early learners (Bruner, 1996; Egan, 1988). A narrative featuring a flying squirrel mastering gliding can effectively convey the principles of air resistance and energy transformation in a manner that is both age-appropriate and interesting. Narrative-driven learning captivates students' attention and provides a meaningful framework for the introduction and exploration of scientific language and principles.

Besides storytelling, ChatGPT has been utilized to assist educators in developing organized experimental activities. Kotsis (2024b; 2024c) illustrated the model's capability to generate experimental worksheets, procedural manuals, and safety guidelines for primary-level hands-on science activities. This is especially advantageous for non-specialist elementary educators who may lack confidence in instructing physics or developing inquiry-based laboratory activities. By producing detailed experimental protocols, ChatGPT can reduce the obstacles to executing practical science, hence promoting active participation in the scientific method. The model may generate experimental versions based on accessible materials, allowing educators to tailor education to classroom limitations and student requirements.

ChatGPT's application in conceptual diagnostics and the rectification of misconceptions is another significant area of influence. Kotsis (2024i; 2025c) documents that ChatGPT can be utilized to recognize and address prevalent misconceptions in physics, including the distinction between weight and mass, as well as misunderstandings regarding magnetic poles. The model can provide analogies, counterexamples, and guided explanations that facilitate conceptual shift, which is essential in early scientific education (Vosniadou, 2013). Moreover, recent research comparing ChatGPT with other AI tools, such as DeepSeek, has shown that ChatGPT's conversational interface facilitates more nuanced involvement with learners' cognitive processes, rendering it a useful instrument for formative assessment and dialogic learning (Kotsis, 2025b).

In addition to individual interactions, ChatGPT has been utilized to collaboratively develop inquiry-based classes with educators. Kotsis (2024j) documented the effective incorporation of ChatGPT into inquiry-based science units, wherein the AI assisted in formulating exploratory questions, generating hypotheses, and designing experimental protocols. The AI-assisted co-planning of these units facilitates the

cultivation of scientific skills such as observation, prediction, and data interpretation. Furthermore, ChatGPT's ability to replicate dialogues can be utilized to model scientific argumentation or produce classroom discussion prompts that foster epistemic agency in students (Osborne *et al.*, 2016).

A significant application is to the interdisciplinary utilization of ChatGPT in science education. Kotsis and colleagues have investigated the model's capacity to facilitate thematic units that integrate science with geography (e.g., earthquake education), environmental literacy, and ethical implications regarding technology (Kotsis & Tsiouri, 2024; Kotsis, 2025h). These implementations demonstrate that AI technologies can enhance discipline knowledge and promote transdisciplinary thinking, thereby matching with global educational objectives for sustainability and future-oriented learning (UNESCO, 2020).

The accumulated information indicates that ChatGPT can function as both a teaching assistant and a co-designer in elementary scientific education. It enables planning, scaffolding, differentiation, and engagement, while fostering metacognitive reflection and conceptual clarity. Nonetheless, its efficacy ultimately hinges on the educator's teaching objectives, prompting techniques, and judicious application of the instrument. Instead of supplanting the instructor, ChatGPT enhances the teacher's ability to provide significant, participatory, and inclusive science education.

4. AI in Inquiry-Based and Interdisciplinary Curricula

The incorporation of Artificial Intelligence into inquiry-based and multidisciplinary science courses signifies a crucial development in modern education. Unlike conventional didactic methods that depict scientific information as fixed and segmented, inquiry-based science education prioritizes exploration, experimentation, and the cultivation of scientific reasoning abilities through active student participation. In this context, AI—especially as generative language models such as ChatGPT—arises as a multifaceted instrument that can facilitate the dynamic processes of inquiry, exploration, and knowledge creation. The growing necessity for interdisciplinary methods in education—prompted by the intricacy of real-world issues and the requirements of 21st-century competencies—establishes AI as a facilitator between disciplinary boundaries, fostering the collaborative creation of understanding across fields such as science, technology, ethics, and the arts.

A fundamental principle of inquiry-based science education is the development of testable inquiries and the creation of investigative methodologies by students, frequently with the teacher's support (Harlen, 2014). ChatGPT can facilitate this process by providing prompts that assist students in refining their inquiries, formulating hypotheses, and delineating inquiry plans. Kotsis (2024j) demonstrates that educators can utilize ChatGPT to facilitate inquiry-based discussions with students, exemplify scientific communication, and suggest alternate experimental methodologies. This functionality facilitates equitable access to inquiry by supporting both beginner educators and students

who may lack previous experience with open-ended scientific exploration. Through scaffolding inquiry across various levels—questioning, planning, observing, analyzing, and reflecting—AI enhances cognitive engagement and fosters the development of metacognitive skills.

The interdisciplinary potential of AI is seen in its ability to link scientific material with narrative, social, and ethical dimensions, as demonstrated by ChatGPT. In the research conducted by Kotsis and Tsiouri (2024), ChatGPT was employed to create educational resources on seismic awareness that included physics, geography, and civic readiness. This integration contextualized the scientific information while highlighting practical applications and community awareness, in accordance with multidisciplinary learning objectives. In the study by Samara and Kotsis (2024), ChatGPT was utilized to instruct preschoolers on magnetism via narrative-based learning, integrating scientific concepts with language acquisition and creative cognition. These examples demonstrate how AI may facilitate transdisciplinary activities by producing multimodal learning materials that engage diverse cognitive and emotional dimensions.

ChatGPT has been examined as a tool for promoting discourse on the societal implications of science and technology within the framework of sustainability education and ethical contemplation. Kotsis (2025h) investigated the application of the model in instructing electromagnetic radiation, promoting student reflection on technical hazards, misinformation, and environmental repercussions. This methodology corresponds with global demands for science curricula that integrate ethical reasoning, critical thinking, and global citizenship (UNESCO, 2020). ChatGPT can facilitate multidisciplinary objectives by offering varied viewpoints, creating difficulties, and promoting argumentation—crucial elements of scientific literacy in the digital era—through guided discussions or scenario-based prompts.

Moreover, AI can connect science and the humanities by facilitating digital storytelling, creative writing, and role-playing as educational methods. Kotsis (2024a) suggested utilizing AI-generated fairy tales to impart intricate physics principles to children through narrative form. These narratives not only present fundamental scientific concepts but also enable learners to investigate cause-and-effect linkages, the emotional aspects of discovery, and the ethical ramifications of technological progress. This amalgamation of creativity and empirical reasoning enhances science education and renders it accessible to a wider array of learners with varied learning profiles.

Nonetheless, although AI demonstrates significant potential in fostering inquiry and interdisciplinarity, its incorporation must be pedagogically directed. In the absence of meticulous design, AI-generated content may become excessively general or misaligned with curriculum requirements and developmental suitability. Educators must rigorously assess AI outputs, contextualize them for their students, and guarantee that interdisciplinary linkages are substantive rather than superficial. Furthermore, ethical considerations—such as authorship, data utilization, and algorithmic bias—must be explicitly addressed when employing AI in interdisciplinary learning contexts (Knox, 2020).

AI systems like ChatGPT have shown the ability to enhance inquiry-based learning and promote interdisciplinary links in science education. Their function as intellectual collaborators in the design and implementation of instruction enhances educators' pedagogical resources and creates new avenues for interdisciplinary knowledge integration. The forthcoming challenge is to develop the essential critical and creative pedagogical literacies required to fully leverage AI for transformative learning.

5. Professional Development and Teacher Empowerment

The effective incorporation of Artificial Intelligence (AI) in elementary science education is fundamentally linked to the professional advancement and empowerment of educators. Although AI systems like ChatGPT provide significant advantages in instructional design, assessment, and content delivery, their effect on learning is ultimately influenced by the pedagogical choices and skills of the educators who utilize them. Thus, the advancement of AI-integrated classrooms requires a corresponding evolution in teacher training, continuous professional development, and the cultivation of AI pedagogical literacy—the capacity to utilize, assess, and critically interact with AI technologies in educational contexts.

Multiple studies underscore the difficulties primary educators encounter in teaching science, especially physics, stemming from deficiencies in content knowledge and a lack of confidence in developing experimental or inquiry-based activities (Appleton, 2008; Kind, 2014). AI-driven solutions such as ChatGPT provide scaffolding and assistance in various domains, allowing educators to create learning exercises, explanations, analogies, and evaluations customized to their students' needs. Kotsis (2024g) illustrates that educators utilizing ChatGPT were capable of designing and implementing physics experiments more efficiently, despite lacking substantial prior experience in laboratory instruction. The AI system offered detailed experimental protocols, safety regulations, and avenues for differentiation, so serving as a virtual co-instructor.

Furthermore, AI has been shown to alleviate the cognitive burden linked to lesson planning. Kotsis (2024k) indicated that educators asserted ChatGPT could aid in formulating lesson outlines, proposing inquiry questions, and modifying curriculum content to accommodate varied learner profiles. This corresponds with findings in extensive educational technology research, wherein AI is regarded as a productivity instrument that alleviates administrative responsibilities and allows educators to engage in more relational and pedagogically enriching encounters with students (Holmes *et al.*, 2022; Luckin *et al.*, 2016). This transition is not just logistical but also epistemological, since it transforms the teacher's role from a singular content transmitter to a facilitator of dialogic learning, augmented by intelligent technologies.

Nonetheless, the advent of AI necessitates the acquisition of new professional competencies that extend beyond mere digital literacy. Educators must cultivate the capacity to critically evaluate AI-generated outputs, discern inappropriate or biased

material, and ensure that the model's recommendations are congruent with curriculum goals and educational principles (Zawacki-Richter *et al.*, 2019). Kotsis (2025g) emphasizes that numerous preservice teachers continue to possess misconceptions regarding AI, frequently perceiving it as either an all-knowing authority or a menace to professional autonomy. It is imperative to rectify these misconceptions in initial teacher education programs, which should include modules on the capabilities, limitations, ethical implications, and pedagogical applications of AI.

Moreover, the application of AI in teacher professional development can transcend mere classroom assistance. AI technologies can facilitate tailored teacher training by providing adaptive learning modules, interactive simulations, and feedback on lesson design. In sophisticated applications, AI may evaluate classroom data—such as student performance or engagement trends—and recommend instructional adjustments, thereby facilitating data-driven pedagogy. This viewpoint corresponds with the notion of "teacher-AI partnerships," wherein human proficiency is enhanced by computer analysis to refine decision-making and reflective practice (Luckin *et al.*, 2016; Holmes *et al.*, 2022).

However, institutional backing is essential for the success of such partnerships. Professional learning communities (PLCs), peer mentoring, and collaborative design teams must be instituted to facilitate environments where educators can investigate, experiment with, and critically evaluate the application of AI in science teaching. Kotsis (2025e) observes that in high school environments, when AI was introduced without adequate support systems, adoption was restricted and frequently shallow. In contrast, when educators collaborated to co-create AI-enhanced lessons and exchanged their experiences in Professional Learning Communities, the pedagogical impact was markedly more profound.

Ultimately, empowerment in the era of AI must encompass the ability to champion ethical and equitable utilization of these technologies. Educators must be prepared to participate in extensive discussions around data privacy, algorithmic bias, and the effects of AI on educational equity (Williamson & Eynon, 2020). As AI becomes increasingly embedded in policy and curriculum frameworks, educators will assume a vital role not merely as implementers but as knowledgeable catalysts of educational transformation.

In conclusion, although AI possesses the capacity to greatly enhance science teaching, its incorporation depends on equipping educators with extensive professional development. This encompasses instruction in AI pedagogical applications, critical digital literacy, ethical consciousness, and engagement in collaborative learning communities. Educational revolution promised by AI can only be fully achieved when instructors are regarded as co-designers and critical users of AI technologies

6. Risks, Ethical Concerns, and Policy Implications

The acknowledged pedagogical potential of Artificial Intelligence (AI) in elementary scientific education prompts several ethical, legal, and policy-related concerns around its

classroom incorporation. These concerns transcend mere technological implementation and delve into profound issues like data governance, learner autonomy, algorithmic transparency, and the evolving role of educators in an AI-mediated context. As educational institutions, governmental bodies, and stakeholders progressively explore AI tools like ChatGPT, it is essential to assess the risks and unexpected repercussions linked to their application, especially for vulnerable groups such as young learners.

A primary issue pertains to data privacy and the administration of personal information. AI systems frequently depend on extensive datasets, encompassing user interactions, to produce adaptive feedback or customized content. The implementation of such technologies in educational environments, particularly those with minors, prompts critical inquiries regarding data gathering, permission, and storage practices. Kotsis (2025f) emphasizes that numerous educators and school officials are oblivious to the degree of student data processing conducted by AI platforms. This absence of transparency may result in breaches of current privacy laws, including the General Data Protection Regulation (GDPR) in Europe and the Family Educational Rights and Privacy Act (FERPA) in the United States. Furthermore, the development of educational AI technologies is frequently driven by third-party commercial interests, which raises issues around the commodification of student data and the deterioration of public trust in educational institutions.

A significant concern pertains to academic integrity and the limits of permissible AI utilization. As systems such as ChatGPT can produce essays, resolve scientific inquiries, and write experimental reports, educators must confront the challenge of differentiating genuine student learning from AI-generated content. Kotsis (2024e) examines this contradiction, questioning whether AI acts as a promoter of learning or a catalyst for academic dishonesty. This topic is especially pertinent in formative assessments, where the employment of AI may hinder the teacher's capacity to effectively assess student comprehension. To resolve this issue, novel evaluation models prioritizing process rather than product, such as performance-based and portfolio assessments, are suggested as more suitable for AI-integrated classrooms (Williamson & Piattoeva, 2023). Bias in AI-generated material poses ethical dilemmas. Language models are developed using extensive datasets that may embody cultural preconceptions, gender biases, or scientific fallacies. In educational settings, this may yield detrimental effects, particularly when AI tools are regarded as authoritative. For instance, if ChatGPT delivers a scientifically erroneous explanation of a physics principle or supports gender stereotypes in a scientific narrative, it may prolong rather than confront misconceptions (Binns *et al.*, 2018). Consequently, essential AI literacy is vital for both students and educators, who must acquire the skills to scrutinize, modify, or dismiss AI outputs to ensure equal and precise instruction.

In addition to classroom-level issues, there are significant policy implications about the manner in which AI transforms the governance of education. Kotsis (2024d) contends that improving scientific literacy among politicians is crucial for ensuring that AI-related educational legislation is based on evidence and grounded in ethics. In the

absence of this, educational policy may be influenced more by commercial fervor or technological determinism than by pedagogical reasoning and public accountability. Concerns of access, infrastructure, and educator autonomy must be prioritized in any national AI-in-education policy, especially to avert the exacerbation of digital gaps. In situations characterized by financial scarcity or poor internet connectivity, AI-enhanced education may intensify inequities rather than alleviate them, unless policies specifically tackle inclusion and accessibility concerns (Holmes *et al.*, 2022).

In response to these hazards, some experts recommend the establishment of ethical frameworks and regulatory norms specifically designed for educational AI (Floridi *et al.*, 2018). These frameworks must encompass essential qualities such openness, accountability, explainability, fairness, and inclusivity. Ethical regulation must not only safeguard against harm but also encourage responsible innovation. This entails assisting educators in the collaborative design of AI tools, facilitating participatory policy procedures, and ensuring that the implementation of AI in education embodies democratic and humanistic principles.

In conclusion, the incorporation of AI in primary science education necessitates a strong ethical and policy framework. Although AI systems like ChatGPT present significant prospects to improve education, they also pose difficulties that require careful management. Data privacy, academic integrity, algorithmic bias, and inclusive policy formulation are fundamental to the sustainable and fair advancement of AI in education. As the discipline progresses, continuous research, professional advancement, and stakeholder engagement will be crucial to guarantee that AI fulfills educational objectives while upholding ethical and democratic values.

7. Discussion

The use of Artificial Intelligence (AI), especially tools such as ChatGPT, into primary scientific instruction signifies a significant transformation in both technology capability and educational philosophy. The preceding sections have examined many applications, including narrative-based physics education, AI-generated experimental tasks, conceptual diagnostics, and transdisciplinary learning assistance. The accumulated evidence indicates the transformative capacity of AI to function as both a pedagogical aide and a collaborative partner in enhancing scientific comprehension among young learners. The implementation of AI in science education exposes significant contradictions, unresolved issues, and emerging prospects that warrant ongoing theoretical and empirical investigation.

A prominent subject arising from this review is the pedagogical adaptability of ChatGPT. It has demonstrated efficacy in facilitating many instructional modes—didactic explanation, exploratory discourse, conceptual scaffolding, and inquiry facilitation. This adaptability stands in stark contrast to previous generations of instructional technology, which were frequently limited to material dissemination or repetitive practice patterns (Holmes *et al.*, 2022). ChatGPT facilitates dialogic interaction and individualized learning

paths, aligning effectively with constructivist scientific education models that prioritize student agency, contextual involvement, and metacognitive growth (Mercer *et al.*, 2017; Vosniadou, 2013). These affordances are particularly pertinent in primary education, when fundamental misconceptions can be more efficiently rectified by customized and dialogic explanations rather than conventional instruction.

The utilization of ChatGPT, and AI in general, prompts significant inquiries regarding the evolving function of the educator. Instead of replacing educators, AI appears to transform their roles into curators, facilitators, and critical assessors of digital materials. Educators are progressively required to facilitate learning environments that incorporate AI-generated information, align it with local curricular objectives, and critically evaluate its educational suitability. This augmented position requires an additional dimension of professional expertise—AI pedagogical literacy—encompassing both technological proficiency and ethical consciousness (Luckin *et al.*, 2016; Zawacki-Richter *et al.*, 2019). Kotsis's studies (2024g; 2024k; 2025g) indicate that empowering educators via specialized training and professional development is crucial for the practical realization of AI-enhanced learning benefits.

Furthermore, the review indicates a substantial potential for AI to facilitate inclusive and differentiated instruction. ChatGPT's capacity to rephrase lessons, produce alternative examples, and adapt to learners' age and past knowledge creates new opportunities for enhancing educational fairness, particularly for students with learning disabilities or linguistic obstacles. Nonetheless, this promise may be fully realized only if instructors are adept at strategically designing prompts and critically evaluating outputs. The comparison of ChatGPT and DeepSeek, as analyzed by Kotsis (2025b; 2025c), highlights the necessity of matching AI technologies with particular educational goals. Although ChatGPT is proficient in promoting conceptual comprehension via conversation, DeepSeek's accuracy is more suited for retrieval tasks and reinforcement. The combined use of these techniques may provide a more balanced and pedagogically adaptive AI environment in educational settings.

Interdisciplinary education represents a significant advantage of AI integration. ChatGPT fosters a comprehensive approach to scientific education by producing content that integrates science with language arts, ethics, geography, and environmental studies, aligning with the complexities of the real world and the UN's Education for Sustainable Development agenda (UNESCO, 2020). Interdisciplinary success relies on instructors' ability to discern significant links rather than surface integrations. This underscores the significance of teacher agency in AI-enhanced classrooms and the necessity for legislative frameworks that foster teacher creativity and interdisciplinary collaboration.

Nonetheless, significant concerns persist. Concerns regarding data privacy, academic integrity, algorithmic bias, and the corporatization of education must be addressed at both institutional and policy levels (Kotsis, 2024d; 2025f; Floridi *et al.*, 2018). The enthusiasm for AI in education must be moderated by stringent oversight to guarantee that its implementation upholds democratic and inclusive educational principles. Furthermore, the relative novelty of generative AI in educational settings

indicates that much of the existing evidence is exploratory in nature. Longitudinal studies are essential to evaluate the enduring effects of AI utilization on student learning results, pedagogical methods, and institutional cultures.

A further underexamined domain is the creation of AI models that are culturally and linguistically diverse. Presently, prevailing AI techniques are predominantly trained on English-language datasets and may embody Western epistemologies and prejudices. This presents difficulties for science education in non-English-speaking environments or in communities with unique indigenous knowledge systems. Future study ought to investigate the localization of AI, its co-design with educators, and its adaptability to various cultural contexts and pedagogical traditions.

The use of AI in primary scientific education presents transformative educational possibilities, however, necessitates meticulous coordination, critical assessment, and institutional backing. ChatGPT illustrates how generative AI can improve inquiry, rectify misconceptions, and tailor education; yet, its optimal utilization relies on the knowledgeable and ethical involvement of educators. As discipline progresses, educators, researchers, and policymakers must collaborate to guarantee that AI promotes not only efficiency and innovation but also equity, inclusivity, and the fundamental objectives of scientific education

8. Conclusions and Recommendations

The use of Artificial Intelligence, especially generative technologies like ChatGPT, in primary scientific education signifies a pivotal moment in the advancement of teaching methodologies. This article has analyzed a substantial body of research—rooted in the comprehensive work of Kotsis (2024–2025) and bolstered by global scholarship—to delineate the various ways in which AI is transforming teaching and learning in the scientific classroom. AI has demonstrated a significant ability to improve the cognitive, affective, and metacognitive aspects of learning, especially in early physics education, through the creation of narrative-based instructional materials, the design of experimental tasks, the rectification of misconceptions, and the promotion of inquiry.

ChatGPT's most promising addition is its capacity to function as a dynamic educational tool that adapts to diverse learner profiles, facilitates differentiated instruction, and promotes dialogic engagement with scientific concepts. Unlike static resources or pre-programmed instructional software, generative AI facilitates spontaneous, individualized, and contextually relevant interactions that align with modern constructivist and sociocultural learning theories. Furthermore, the incorporation of AI has shown promise in alleviating the challenges encountered by non-specialist science educators, providing timely assistance for class planning, concept elucidation, and experimental design. In this regard, AI can function as both a co-instructor and a catalyst for professional development, facilitating more certain and pedagogically sound science instruction.

The implementation of AI tools in education necessitates a critical understanding of their limits. Concerns around data privacy, ethical utilization, academic integrity, and algorithmic bias are fundamental to the competent and equitable implementation of AI in educational institutions. The implementation of AI must occur inside robust ethical frameworks, institutional protections, and comprehensive educational initiatives. Teacher training programs must encompass not only technical proficiency but also the epistemological, social, and cultural ramifications of AI utilization. In the absence of adequate preparation, the integration of AI may devolve into a mere trend rather than a substantive advancement in scientific education.

The comparative analysis of ChatGPT and DeepSeek indicates that no singular AI tool is universally superior for all educational objectives. ChatGPT excels in promoting inquiry, reflection, and conceptual comprehension, whereas DeepSeek offers more succinct, fact-oriented responses appropriate for targeted retrieval and evaluation activities. Future directions may encompass the creation of hybrid AI systems or modular educational platforms that amalgamate the strengths of diverse models while adhering to curricular objectives and learner requirements.

Consequently, some crucial proposals might be proposed:

Education systems must prioritize substantial and ongoing professional development for educators, concentrating on the pedagogical applications, ethical implications, and technological aspects of AI. AI pedagogical literacy must be an essential element of both preservice and in-service training, especially for educators in STEM and primary environments.

Secondly, AI ought to be integrated into inquiry-based and multidisciplinary courses to enhance student agency, creativity, and critical thinking. AI should serve as a facilitator for inquiry, story production, and scientific conversation, rather than only functioning as a content delivery device.

Third, comprehensive policy frameworks are essential to regulate the application of AI in education. These frameworks must encompass data protection, platform responsibility, inclusion, and transparency, while also fostering the collaborative development of AI technologies with educators and learners.

Ultimately, additional study is required to evaluate the long-term effects of AI on student learning results, pedagogical methods, and educational justice. Mixed-methods research, longitudinal studies, and cross-cultural assessments will be crucial for developing a more sophisticated comprehension of AI's educational effectiveness and societal consequences.

In conclusion, Artificial Intelligence is not a cure-all; however, when judiciously incorporated, it presents significant prospects to enhance primary scientific teaching. As educational institutions migrate from traditional chalkboards to chatbots, the primary issue will be to utilize AI tools in a manner that empowers educators, captivates learners, and maintains the principles of equity, inquiry, and scientific literacy that characterize outstanding education in the 21st century.

Conflict of Interest Statement

The author declares no conflicts of interest.

About the Author

Konstantinos T. Kotsis studied Physics at the Aristotle University of Thessaloniki, Greece. In 1985, he was an assistant researcher at Brooklyn University of New York. From September 1987 to September 2000, he served as Lecturer and Assistant Professor specializing in Solid State Physics and X-ray Diffraction at the University of Ioannina Physics Department. Since 2000, he has served as a Faculty Member at the Department of Primary Education at the University of Ioannina. He has been a Full Professor since 2012, specializing in the Didactics of Physics at the Department of Primary Education of the University of Ioannina in Greece. He was the Head of the Department of Primary Education and the Dean of the School of Education at the University of Ioannina. Now he is the Head of the Lab of Physics Education and Teaching at the Department of Primary Education. His research interests are Didactics of Physics, Science Education, Physics Teaching and Learning, Teacher Training, Education Research and AI in Science Education.

References

Appleton, K. (2008). Developing science pedagogical content knowledge through mentoring elementary teachers. *Journal of Science Teacher Education*, 19(6), 523–545. https://doi.org/10.1007/s10972-008-9109-4

Binns, R., Veale, M., Van Kleek, M., & Shadbolt, N. (2018). 'It's reducing a human being to a percentage': Perceptions of justice in algorithmic decisions. *CHI Conference on Human Factors in Computing Systems*, 1–14. https://doi.org/10.1145/3173574.3173951

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability*, 21(1), 5–31. https://doi.org/10.1007/s11092-008-9068-5

Bruner, J. (1996). *The Culture of Education*. Harvard University Press.

diSessa, A. A. (2018). *A history of conceptual change research: Threads and fault lines*. In S. Vosniadou (Ed.), *International Handbook of Research on Conceptual Change* (2nd ed., pp. 1–25). Routledge. https://doi.org/10.4324/9780203154472

Egan, K. (1988). *Teaching as Storytelling: An Alternative Approach to Teaching and Curriculum in the Elementary School*. University of Chicago Press.

Floridi, L., Cowls, J., Beltrametti, M., Chatila, R., Chazerand, P., Dignum, V., ... & Vayena, E. (2018). AI4People—An ethical framework for a good AI society: Opportunities, risks, principles, and recommendations. *Minds and Machines*, 28(4), 689–707. https://doi.org/10.1007/s11023-018-9482-5

Harlen, W. (2014). *Working with Big Ideas of Science Education*. Global Network of Science Academies (IAP) Science Education Programme. https://doi.org/10.13140/RG.2.1.1999.4081

Holmes, W., Bialik, M., & Fadel, C. (2022). *Artificial Intelligence in Education: Promises and Implications for Teaching and Learning*. Center for Curriculum Redesign. https://doi.org/10.1038/s41539-022-00127-1

Kind, V. (2014). A degree is not enough: A quantitative study of aspects of pre-service secondary science teachers' knowledge of physics. *International Journal of Science Education*, 36(8), 1313–1345. https://doi.org/10.1080/09500693.2013.860497

Knox, J. (2020). Artificial intelligence and education in China. *Learning, Media and Technology*, 45(3), 298–311. https://doi.org/10.1080/17439884.2020.1754236

Kotsis, K. (2024a). *Artificial Intelligence Creates Fairy Tales for Physics Teaching in Primary Education*. *European Journal of Open Education and E-learning Studies*, 9(1), 1–16. http://dx.doi.org/10.46827/ejoe.v9i1.5250

Kotsis, K. (2024b). *ChatGPT Develops Physics Experiment Worksheets for Primary Education Teachers*. *European Journal of Education Studies*, 11(5), 1–20. http://dx.doi.org/10.46827/ejes.v11i5.5274

Kotsis, K. (2024c). *ChatGPT in Teaching Physics Hands-On Experiments in Primary School*. *European Journal of Education Studies*, 11(10), 126–143. https://doi.org/10.46827/ejes.v11i10.5549

Kotsis, K. T. (2024d). *The Scientific Literacy Enables Policymakers to Legislate on Artificial Intelligence*. *European Journal of Political Science Studies*, 7(1), 69–83. https://doi.org/10.46827/ejpss.v7i1.1682

Kotsis, K. T. (2024e). *Artificial Intelligence Creates Plagiarism or Academic Research?*. *European Journal of Arts, Humanities and Social Sciences*, 1(6), 169–179. https://doi.org/10.59324/ejahss.2024.1(6).18

Kotsis, K. T. (2024f). *Artificial Intelligence for Writing Academic Papers in Education*. *Journal of Contemporary Philosophical and Anthropological Studies*, 3(1), 10–19. https://doi.org/10.59652/jcpas.v3i1.375

Kotsis, K. T. (2024g). *Artificial Intelligence Helps Primary School Teachers to Plan and Execute Physics Classroom Experiments*. *EIKI Journal of Effective Teaching Methods*, 2(2), 1–9. https://doi.org/10.59652/jetm.v2i2.158

Kotsis, K. T. (2024i). *Correcting Students' Misconceptions in Physics Using Experiments Designed by ChatGPT*. *European Journal of Contemporary Education and E-Learning*, 2(2), 83–100. https://doi.org/10.59324/ejceel.2024.2(2).07

Kotsis, K. T. (2024j). *ChatGPT into the Inquiry-Based Science Curriculum for Primary Education*. *European Journal of Education and Pedagogy*, 5(6), 28–34. https://doi.org/10.24018/ejedu.2024.5.6.891

Kotsis, K. T. (2024k). *Integration of Artificial Intelligence in Science Teaching in Primary Education: Applications for Teachers*. *European Journal of Contemporary Education and E-Learning*, 2(3), 27–43. https://doi.org/10.59324/ejceel.2024.2(3).04

Kotsis, K. T. (2025a). *Artificial Intelligence and the Scientific Process: A Review of ChatGPT's Role to Foster Experimental Thinking in Physics Education*. *European Journal of Contemporary Education and E-Learning*, 3(3), 183–198. https://doi.org/10.59324/ejceel.2025.3(3).14

Kotsis, K. T. (2025b). *ChatGPT and DeepSeek Evaluate One Another for Science Education*. *EIKI Journal of Effective Teaching Methods*, 3(1), 98–102. https://doi.org/10.59652/jetm.v3i1.439

Kotsis, K. T. (2025c). *Comparing ChatGPT and DeepSeek in Addressing Misconceptions about Physics Concepts*. *European Journal of Contemporary Education and E-Learning*, 3(2), 191–206. https://doi.org/10.59324/ejceel.2025.3(2).17

Kotsis, K. T. (2025d). *From Chalkboard to Chatbot: The Future of Physics Education through Artificial Intelligence Integration*. *EIKI Journal of Effective Teaching Methods*, 3(2), 74–79. https://doi.org/10.59652/jetm.v3i2.515

Kotsis, K. T. (2025e). *Integrating Artificial Intelligence for Science Teaching in High School*. *LatIA*, 3, 89. https://doi.org/10.62486/latia202589

Kotsis, K. T. (2025f). *Issues between Artificial Intelligence and Personal Data in Education*. *International Research in Education*, 13(1), 45–65. https://doi.org/10.5296/ire.v13i1.22850

Kotsis, K. T. (2025g). *Misconceptions about Artificial Intelligence from Preservice Teachers: A Literature Review*. *EIKI Journal of Effective Teaching Methods*, 3(2). https://doi.org/10.59652/jetm.v3i2.565

Kotsis, K. T. (2025h). *Transforming Misconceptions into Knowledge: The Use of Artificial Intelligence in Teaching Electromagnetic Radiation*. *European Journal of Open Education and E-learning Studies*, 10(3), 1–16. https://doi.org/10.46827/ejoe.v10i3.6081

Kotsis, K. T., & Tsiouri, E. (2024). *Utilizing ChatGPT for Primary School Earthquake Education*. *European Journal of Contemporary Education and E-Learning*, 2(4), 145–157. https://doi.org/10.59324/ejceel.2024.2(4).12

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence Unleashed: An Argument for AI in Education*. Pearson Education. https://doi.org/10.13140/RG.2.1.2281.1601

Mercer, N., Hennessy, S., & Warwick, P. (2017). Dialogue, thinking together and digital technology in the classroom: Some educational implications of a continuing line of inquiry. *International Journal of Educational Research*, 97, 187–199. https://doi.org/10.1016/j.ijer.2017.08.007

Osborne, J., Simon, S., Christodoulou, A., Howell-Richardson, C., & Richardson, K. (2016). Learning to argue: A study of four schools and their attempt to develop the use of argumentation as a common instructional practice and its impact on students. *Journal of Research in Science Teaching*, 53(6), 893–921. https://doi.org/10.1002/tea.21316

Roll, I., & Wylie, R. (2016). Evolution and Revolution in Artificial Intelligence in Education. *International Journal of Artificial Intelligence in Education*, 26(2), 582–599. https://doi.org/10.1007/s40593-016-0110-3

Samara, V., & Kotsis, K. T. (2024). *Use of the Artificial Intelligence in Teaching the Concept of Magnetism in Preschool Education*. *Journal of Digital Educational Technology*, 4(2), ep2419. https://doi.org/10.30935/jdet/14864

UNESCO. (2020). *Education for Sustainable Development: A Roadmap*. https://unesdoc.unesco.org/ark:/48223/pf0000374802

Vosniadou, S. (2013). *International Handbook of Research on Conceptual Change* (2nd ed.). Routledge. https://doi.org/10.4324/9780203154472

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press.

Williamson, B., & Eynon, R. (2020). Historical threads, missing links, and future directions in AI in education. *Learning, Media and Technology*, 45(3), 223–235. https://doi.org/10.1080/17439884.2020.1798995

Woolf, B. P. (2009). *Building Intelligent Interactive Tutors: Student-Centered Strategies for Revolutionizing E-learning*. Morgan Kaufmann. https://doi.org/10.1016/C2009-0-20922-1

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 1–27. https://doi.org/10.1186/s41239-019-0171-0