



Received: 21-09-2025
Accepted: 01-11-2025

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Ethical, Practical, and Policy Challenges of AI in Teaching Einsteinian Physics

¹ Konstantinos T Kotsis, ² Georgia Vakarou

^{1,2} Lab of Physics Education and Teaching, Department of Primary Education, University of Ioannina, Greece

DOI: <https://doi.org/10.62225/2583049X.2025.5.6.5221>

Corresponding Author: **Konstantinos T Kotsis**

Abstract

The integration of artificial intelligence (AI) into the instruction of Einsteinian physics offers transformational possibilities with significant ethical, pedagogical, and policy concerns. AI-driven tools can improve students' understanding of intricate topics such as spacetime curvature, gravitational time dilation, and relativistic motion by providing adaptive feedback, simulations, and tailored learning environments. Nevertheless, their implementation prompts significant apprehensions over educator autonomy, epistemic legitimacy, algorithmic prejudice, data confidentiality, and disparate access to technology. The assumption of functions historically occupied by professors by AI systems poses a risk of dehumanizing physics education, transitioning from inquiry and dialogue to automated instruction. Moreover, AI-generated explanations

may be scientifically erroneous or epistemically superficial, thus perpetuating errors instead of fostering profound comprehension. The digital divide exacerbates disparities between well-resourced and underprivileged schools, restricting equitable access to AI-enhanced education. Sustainable integration necessitates policies that guarantee transparency, data protection, teacher training, and curriculum reform that properly incorporates Einsteinian physics into scientific education. AI should function not as a substitute for educators but as a cognitive and pedagogical ally that enhances human instruction, fosters reflective thinking, and democratizes access to contemporary physics. This study advocates for a comprehensive paradigm that integrates technological innovation with ethical accountability, epistemological precision, and social equity.

Keywords: Artificial Intelligence, Einsteinian Physics Education, Teacher Agency, Data Ethics, Educational Equity

1. Introduction

The swift progression of artificial intelligence has unveiled novel opportunities for instructing intricate scientific principles, including those fundamental to Einsteinian physics, such as spacetime curvature, time dilation, and gravitational phenomena. AI-driven tutoring systems, sophisticated simulations, and adaptive learning platforms have shown considerable promise in assisting students to visualize complex concepts, address misconceptions, and participate in inquiry-based learning. These findings indicate a transformational potential for AI in the modernization of physics education, yet they concurrently evoke significant ethical, pedagogical, and institutional concerns that require thorough scrutiny. The inquiry now centers not on AI's capacity to enhance conceptual comprehension, but on the feasibility of its integration without undermining teacher autonomy, epistemological integrity, data privacy, equitable access, and the humanistic objectives of science education.

Einsteinian physics, more than any other domain of academic research, necessitates that students critically examine entrenched ideas on the essence of reality. Empirical evidence from Greek primary and secondary pupils indicates that many find it challenging to comprehend fundamental concepts such as spacetime curvature, time dilation, and the nature of gravity, frequently defaulting to Newtonian interpretations^[1]. It necessitates conceptual precision, philosophical contemplation, and deliberate discourse between educator and student. Recent empirical research indicates that well-structured instructional interventions in Einsteinian physics enhance students' conceptual comprehension and markedly elevate their interest in the field of physics^[2]. The introduction of AI without pedagogical and ethical safeguards risks transmitting relativistic principles as decontextualized information instead of as outcomes of scientific research. Furthermore, reliance on AI-generated explanations may diminish students' capacity for independent reasoning, questioning authority, and engaging with the epistemological underpinnings of science. This is especially crucial in relativity, where comprehension developed historically through discourse, contradiction, and conceptual conflict rather than algorithmic refinement.

Concerns also encompass the role of educators. As AI systems increasingly offer explanations, feedback, and assessments,

there is a risk that educators may be relegated to the role of technology facilitators rather than intellectual leaders in the classroom. The possible displacement of teacher competence, along with demands from educational systems prioritizing efficiency and standardization, may undermine the relational, interpretative, and ethical aspects of physics instruction. Moreover, AI systems lack neutrality, they are constructed within certain cultural, economic, and technological frameworks. Their algorithms may exhibit concealed biases, oversimplify scientific theories, or give misleading explanations, particularly in intricate fields like relativity, where language-based AI can generate scientifically erroneous assertions with considerable confidence.

A crucial aspect pertains to equity and social justice. AI tools necessitate digital infrastructure, high-quality gadgets, and dependable internet connectivity, which are not uniformly accessible across all schools or nations. In the absence of legislative actions, AI may exacerbate existing educational disparities by favoring technologically proficient institutions and neglecting underprivileged learners. Moreover, data gathered from students by AI systems, encompassing problem-solving behaviors and emotional reactions, prompts apprehensions regarding monitoring, privacy, and corporate dominance in educational practices.

This paper analyzes these challenges across six interconnected dimensions: teacher agency and epistemological issues, algorithmic bias, accuracy, and data privacy, inequity and the digital divide, ethical and policy mandates for responsible AI integration, and future research trajectories for sustainable human–AI collaboration in science education. The study emphasizes the benefits presented by AI while also addressing the concerns associated with oversimplifying or commodifying scientific comprehension, notably within the context of Einsteinian physics. The objective is to present a framework in which AI serves not as a substitute for human instruction, but as an ethically informed collaborator that fosters critical thinking, equal access, and substantive engagement with contemporary physics.

This article is a conceptual and theoretical research piece that integrates previous material instead of providing empirical facts. The objective is to rigorously examine the ethical, pedagogical, and policy-related difficulties associated with the incorporation of artificial intelligence in the instruction of Einsteinian physics. The paper constructs a structured framework informed by scholarly research in physics education, AI ethics, teacher agency, and educational policy, emphasizing responsible application over the mere reporting of experimental findings. Consequently, it should be seen as a position paper that enhances academic discourse by providing theoretical insights, flagging hazards, and suggesting policy and pedagogical recommendations.

The article is a conceptual and theoretical position paper situated within the field of physics education research. It synthesizes existing scholarly work to critically examine how artificial intelligence can transform the teaching and learning of Einsteinian physics while introducing complex ethical, pedagogical, and policy considerations. The paper proposes a structured analytical framework that addresses issues such as teacher agency, algorithmic bias, data privacy, educational equity, and curriculum reform. By

focusing on the philosophical and institutional implications of AI integration, it emphasizes that technology should serve as a pedagogical partner rather than a substitute for educators, ensuring that scientific understanding, reflective inquiry, and social justice remain central to the modernization of physics education.

2. Theoretical Background

The integration of AI-driven systems in the instruction of Einsteinian physics has raised considerable apprehension regarding the changing function of educators and the safeguarding of the epistemological underpinnings of science education. Instructing on relativity necessitates more than the mere dissemination of scientific information, it entails navigating pupils through conceptual dilemmas, elucidating models of spacetime, and promoting profound contemplation on the essence of physical reality. When AI undertakes tasks such as providing explanations, diagnosing misunderstandings, or evaluating student comprehension, there is a danger that educators may transform into passive facilitators instead of active architects of learning environments. This transition undermines teacher autonomy and diminishes opportunities for professional discretion, creativity, and improvisation, which are vital for effective physics instruction^[3, 4].

Einsteinian physics possesses significant epistemic consequences. Concepts like the relativity of simultaneity, the geometric basis of gravity, and the absence of universal time necessitate a reevaluation of students' preconceptions regarding reality. The comprehension of relativity historically developed through paradoxes, rigorous arguments, and philosophical exploration, rather than through passive information absorption. This becomes increasingly difficult when students enter the classroom with entrenched alternative interpretations of physical phenomena, which are not cognitive errors but rather constructive foundations for conceptual change^[5]. AI-generated explanations that neglect these beliefs are likely to reinforce them instead of altering them. If AI systems provide pre-packaged answers or oversimplified analogies without encouraging critical discourse, there is a risk that students will perceive physics as a collection of definitive assertions rather than an evolving, inquiry-driven field. AI-generated explanations may exhibit linguistic sophistication but lack epistemic profundity, particularly when generated by huge language models that do not possess an understanding of scientific reasoning and instead generate statistically probable text^[6].

There exists a risk of epistemic reliance. When students regularly seek AI for answers, detailed solutions, or argumentative frameworks, they may replace human thinking with algorithmic results. This prompts apprehensions regarding the advancement of scientific reasoning and the capacity to critically assess models and data. The authority of AI may eclipse the teacher's function, causing students to perceive AI as a more "objective" or "reliable" source of truth than humans. Nonetheless, AI systems are neither impartial nor flawless. They are created by people, trained on certain datasets, and susceptible to producing scientifically erroneous or misleading information, especially for abstract concepts of relativity like time dilation or spacetime curvature^[3].

In this situation, teacher agency is increasingly vital. Only educators can contextualize AI-generated knowledge inside

significant instructional frameworks, encourage pupils to engage in deeper analysis, and guarantee that AI serves to enhance rather than supplant critical inquiry. Recent research in Greek primary teacher education indicates that numerous pre-service teachers exhibit moderate to low levels of scientific literacy, potentially hindering their capacity to instruct on complex subjects like Einsteinian physics or to critically assess AI-generated explanations [7]. Educators serve as ethical and epistemological gatekeepers, determining the appropriateness of AI explanations, identifying when misconceptions require clarification, and emphasizing the philosophical dimensions of physics. Instead than being supplanted, educators ought to be encouraged to collaborate with AI as reflective practitioners who facilitate learning, offer challenging inquiries, and preserve the humanistic essence of science education [8].

The incorporation of AI into Einsteinian physics education raises not only practical inquiries but also significant epistemological dilemmas: Who or what is the source of scientific authority? What is the process of knowledge validation? What does it signify to "comprehend" relativity in an age of advanced technologies? Maintaining instructors' agency and interpretive authority is crucial to avert AI from diminishing physics education to just information transmission. AI should foster a learning culture that encourages the questioning, construction, and comprehension of knowledge within both scientific and human frameworks.

3. Algorithmic Bias, Data Privacy and Transparency

The incorporation of artificial intelligence into Einsteinian physics education presents intricate ethical issues including algorithmic bias, data privacy, and the transparency of AI decision-making processes. AI systems are frequently seen as impartial or objective, nonetheless, they are intrinsically influenced by the data utilized for training and the assumptions inherent in their design. This poses significant challenges in physics teaching, where precision, epistemic reliability, and conceptual clarity are paramount. Extensive language models and adaptive learning systems are developed using datasets that may include mistakes, cultural biases, or oversimplified interpretations of physical ideas. In discussions of relativity, they may produce scientifically inaccurate or misleading interpretations, such as characterizing gravity as a force instead of spacetime curvature or distorting the twin paradox, without indicating any doubt [6]. These inaccuracies threaten to perpetuate myths instead of fostering scientific comprehension.

Algorithmic bias extends beyond mere scientific mistakes. AI systems may inadvertently reinforce socioeconomic and cultural disparities by propagating biased depictions of physics, language usage, or presumed previous knowledge. If AI models are predominantly trained on Western, English-language content, their examples, metaphors, and issue situations may marginalize pupils from diverse linguistic or cultural backgrounds. This implicitly favors specific cognitive frameworks while marginalizing others, thereby perpetuating epistemic injustice in science education [4]. Moreover, predictive learning algorithms that classify pupils according to performance metrics may inadvertently perpetuate preconceptions related to gender, race, or socioeconomic status, especially if historical data embody systemic inequities [9].

Data privacy constitutes a significant concern. AI-driven tutoring systems frequently gather extensive student data, encompassing performance history, emotional reactions, time allocated to tasks, and, in more sophisticated platforms, voice or facial recognition data. Although this data facilitates individualized learning and the identification of misconceptions, it also prompts issues of ownership, consent, surveillance, and potential misuse. Data are frequently held on corporate servers, outside the jurisdiction of educational institutions or educators, and may be exploited for commercial purposes or disseminated to third parties. This raises ethical concerns about whether students and their guardians comprehensively comprehend the utilization of their data and whether genuine permission is feasible in mandatory educational settings [4].

Transparency is intricately associated with these issues. Numerous AI systems function as "black boxes," delivering outputs without revealing the mechanisms or rationale for specific explanations, feedback, or student categorization. In the realm of Einsteinian physics, where reasoning, logic, and empirical validation are paramount, opaque AI systems compromise the essence of scientific comprehension. If a student or teacher cannot ascertain the methodology by which an AI system generated a particular explanation of time dilation or gravitational redshift, the educational use of the system is diminished, and critical thinking is undermined. Transparent AI design, often known as explainable AI (XAI), is so necessary. Explainable AI allows educators and learners to assess the credibility of AI-generated content, scrutinize erroneous reasoning, and uphold human supervision in scientific interpretation [10].

Resolving concerns related to bias, privacy, and openness necessitates comprehensive ethical frameworks and regulatory standards. Educational institutions and policymakers must guarantee that AI systems employed in physics education adhere to data protection regulations, such as GDPR, implement transparent permission procedures, and permit students and educators to withdraw without facing disadvantages. Moreover, developers ought to engage with physicists and educational researchers to guarantee the scientific precision of AI models and integrate functionalities that render reasoning processes transparent and debatable. The absence of such protection in the integration of AI into Einsteinian physics jeopardizes epistemic reliability, student trust, and the integrity of science education.

4. Digital Divide and Educational Inequity in Access to AI Tools

Although artificial intelligence can enhance the accessibility and engagement of Einsteinian physics, its application may exacerbate existing educational disparities. AI-driven educational platforms, simulations, and intelligent tutoring systems rely on technological infrastructure, including high-speed internet, modern gadgets, consistent electricity, and educator training. These resources are inequitably allocated among schools, regions, or countries. Students in rural regions, low-income neighborhoods, or inadequately supported public schools are far less likely to access AI-based technologies than their counterparts in affluent metropolitan or private institutions [9]. In many contexts, AI may exacerbate privilege instead of promoting equitable access to contemporary physics education.

Einsteinian physics is a discipline that several pupils do not meet in their educational curriculum. In the majority of educational systems, subjects such as spacetime curvature, black holes, and gravitational waves are either excluded from curriculum or addressed superficially in the latter years of secondary education. Moreover, studies in Greek elementary schools indicate that students frequently exhibit inadequate scientific literacy, which presents an additional obstacle to comprehending more complex ideas such as Einsteinian relativity ^[11]. Implementing AI-enhanced instruction in relativity exclusively in technologically advanced schools may generate a new educational divide: not only between students who study physics and those who do not, but also between those who grasp modern physics conceptually and those confined to classical mechanics. This disproportionate exposure has enduring implications for scientific literacy, access to STEM professions, and engagement in scientific debate ^[12, 13].

The digital gap encompasses both technological and socio-cultural dimensions. Despite the availability of AI tools, students from marginalized backgrounds may not derive similar benefits due to disparities in language, cultural relevance of content, or implicit assumptions regarding prior knowledge. AI platforms frequently depend on English-language datasets, Western scientific metaphors, and cultural references that may not connect with learners in non-Western or indigenous contexts. This engenders what researchers refer to as "cognitive injustice," wherein specific worldviews and epistemologies are favored while others are marginalized in educational narratives ^[4]. If AI-generated explanations of relativity do not resonate with students' lived experiences or existing cultural knowledge, they may exacerbate feelings of alienation instead of fostering empowerment.

The readiness of educators is an additional facet of unfairness. Effectively using AI tools in Einsteinian physics necessitates educators that are proficient in digital technologies and possess robust content knowledge in relativity, with pedagogical skills for critical integration of AI. Numerous educators indicate insufficient training in AI literacy and contemporary physics, which constrains their capacity to use AI-enhanced instruction ^[3]. Recent research in Greece indicates that preservice physics teachers frequently perceive themselves as insufficiently equipped to teach physics in digital or distant education settings, highlighting a wider concern over technological and pedagogical preparedness ^[14]. Consequently, AI systems may be employed carelessly or inaccurately, transforming potent mental instruments into passive digital worksheets. In the absence of continuous professional development, the deployment of AI may exacerbate reliance on automated technologies and diminish teacher autonomy in underprivileged institutions.

To rectify these disparities, AI must be regarded not solely as a technology remedy but as an integral component of a comprehensive educational policy. Governments and organizations must provide equal access to digital infrastructure, superior AI technologies, and educator training prior to extensive use. Failure to meet these prerequisites will result in AI not democratizing Einsteinian physics, hence fragmenting relativity into a domain accessible only to the digitally privileged.

5. Policy Recommendations and Curriculum Reform

The use of artificial intelligence in the instruction of Einsteinian physics necessitates technological preparedness, as well as cohesive policy frameworks and curriculum reforms that adhere to ethical, pedagogical, and equity-focused norms. Although AI can augment conceptual comprehension, inspire learners, and deliver tailored feedback, its deployment must guarantee that it supplements rather than supplants human instruction, safeguards student autonomy, and fosters equity in educational access. In the absence of intentional policy measures, the adoption of AI may exacerbate existing inequities and diminish physics education to mere mechanized information dissemination.

A primary policy focus is educator training. Successful AI-integrated physics teaching relies on educators who possess confidence in both AI literacy and the fundamental principles of relativity. Educators must comprehend the operational mechanisms of AI systems, analyze AI-generated feedback, and critically incorporate AI technologies rather than adopt a passive approach ^[8]. Professional development programs ought to integrate training in Einsteinian physics with pedagogical methodologies for AI-enhanced learning. Instead of viewing teachers as mere supervisors of technology, such reforms could redefine them as architects of learning experiences and ethical custodians who navigate the interplay between human cognition and algorithmic direction ^[3].

Curriculum change is equally imperative. Many national science curriculum continue to emphasize Newtonian mechanics, offering merely a cursory introduction to contemporary physics or omitting it entirely. Recent curriculum redesign initiatives in Greece's elementary education have commenced the integration of contemporary scientific aspects, prioritizing inquiry-based learning, conceptual comprehension, and the gradual incorporation of Einsteinian concepts ^[15]. These trends suggest that the integration of AI-supported educational technologies must be synchronized with comprehensive curricular reforms rather than seen as standalone technology enhancements. To effectively integrate AI in the instruction of Einsteinian physics, curricula must recognize that relativity is an essential element of scientific literacy in the 21st century, rather than an ancillary topic. Advanced mathematics is not necessary in the initial phases, instead, qualitative models of curved spacetime, gravitational waves, and relativistic time can be conceptually taught through visualizations, narratives, and experiments enhanced by AI simulations ^[13]. AI ought to be integrated not as an isolated discipline but as a teaching framework that enhances inquiry, visualization, and conceptual discourse inside current science curricula.

The ethical governance of AI in education must be institutionalized. Policies must mandate transparency in AI decision-making processes, guarantee the secure storage of student data, and prevent the commercial exploitation of learning analytics. Students and families must possess the right to be informed about the data collected, its utilization, and the option to opt out without incurring penalties. Regulatory frameworks like the European Union's AI Act and UNESCO's guidelines on AI in education offer foundational principles that require adaptation into national legislation and institutional norms ^[4].

Ultimately, policy must encompass digital infrastructure and equity. AI can democratize Einsteinian physics only if access is ensured in urban and rural regions, public and private educational institutions, and diverse socioeconomic environments. This necessitates public investment in internet infrastructure, educational technology, and open-access artificial intelligence platforms. The incorporation of AI into physics education necessitates institutional strategies that focus on ethical governance, curricular reform, and academic accountability. Recent scholarships contend that higher education institutions must reevaluate physics curricula due to AI's impact on scientific inquiry, assessment methodologies, and academic integrity, highlighting the necessity of ethical safeguards and institutional preparedness for enduring reform [16]. AI developed for educational purposes must be bilingual, culturally flexible, and scientifically precise, guaranteeing that relativity is not presented from a limited Western or technologically privileged viewpoint. Collaboration among politicians, physicists, educational researchers, and AI developers is crucial for developing tools that are pedagogically effective, morally reliable, and publicly responsible.

In summary, AI possesses the capacity to transform physics education, contingent upon the simultaneous advancement of policy, curriculum, and teacher development in conjunction with technology. In the absence of such congruence, the incorporation of AI threatens to intensify inequality and undermine the intellectual and humanitarian objectives of science education.

6. Future Directions and Research Agenda

The integration of artificial intelligence into the instruction of Einsteinian physics remains in its nascent phase, and its future advancement relies on cohesive collaboration among educators, researchers, physicists, policymakers, and AI developers. Recent studies indicate that AI can enhance conceptual comprehension. Nevertheless, the long-term impacts on epistemological views, reasoning abilities, and student autonomy are mostly unexamined. There is an urgent necessity for longitudinal research that investigate whether students who acquire relativity in AI-supported environments maintain a stronger conceptual understanding over time, transfer their knowledge to unexpected situations, and cultivate more advanced perspectives on the nature of science.

Subsequent research should focus on optimizing human-AI collaboration in educational settings. Contemporary applications mostly emphasize personalized teaching, nonetheless, Einsteinian physics necessitates social discourse, debate, and collaborative model development. Recent research highlights that AI—especially ChatGPT—can enhance experimental thinking, hypothesis formulation, and scientific reasoning in physics education, but only when utilized as a support tool rather than a source of definitive answers [17]. This indicates that AI ought to be developed not only to elucidate physical concepts but also to actively involve students in the processes of investigation, prediction, reflection, and assessment that define genuine scientific practice. AI technologies ought to be designed not solely for offering feedback to individual learners but also to enhance small-group reasoning, classroom discourse, and teacher-directed research. The inquiry is not centered on how AI may supplant conventional education, but rather on how it may augment activities such as arguing the twin

paradox, reading spacetime diagrams, or contemplating the philosophical ramifications of relativity. Creating artificial intelligence that facilitates dialogic teaching while maintaining teacher autonomy is a significant research challenge [8].

An additional significant aspect is epistemology and scientific veracity. AI should be constructed to embody the essence of scientific thinking instead of depicting physics as an unchanging collection of facts. This involves incorporating functionalities that enable students to interrogate AI explanations, seek justifications, or contrast alternate views. Investigation is necessary to ascertain how explainable AI might be customized for physics education to enhance transparency and critical thinking while avoiding excessive technological complexity for learners [10]. Moreover, scientists must investigate how AI affects students' comprehension of evidence, theory, and scientific validation, especially for abstract concepts like spacetime curvature or gravitational redshift.

Ethical and cultural aspects necessitate additional consideration. AI systems predominantly educated on Western scientific and language resources may inadvertently favor specific worldviews, so marginalizing alternative perspectives. Future study should investigate how AI tools may integrate multicultural scientific narratives, various metaphors, and contextually pertinent examples to ensure that Einsteinian physics does not remain the exclusive domain of technologically sophisticated countries. Research should also examine student perceptions of AI authority, confidence in AI answers, and the risk of excessive dependence on algorithmic reasoning, particularly when AI-generated responses seem convincing yet contain scientific mistakes [6, 3].

Ultimately, research must guide policy. Inquiries regarding data protection, digital infrastructure, educator training, and equal access should be informed by actual evidence rather than technological optimism. Assessing national projects that include AI into physics curricula, such as pilot studies in Greece, Australia, and Finland, can yield insights toward scalable and morally responsible frameworks. Collaborative frameworks connecting universities, education ministries, and AI developers will be essential to ensure that innovation does not surpass regulation, and that students acquire knowledge about relativity both efficiently and meaningfully.

The future of AI in Einsteinian physics education involves creating systems that honor the epistemological complexity of science, augment the teacher's role, and democratize access to contemporary physics. This necessitates continuous interdisciplinary research, rigorous assessment, and morally guided innovation.

7. Conclusion

Artificial intelligence is transforming science education and has demonstrated significant potential in rendering Einsteinian physics more approachable, visual, and theoretically cohesive for pupils. Its incorporation into classrooms should not be viewed solely as a technological progression, rather, it represents a fundamental shift that impacts the essence of pedagogical practice, the ethics of data utilization, and the epistemology of science itself. Einsteinian physics, by challenging common intuition and necessitating profound conceptual analysis, amplifies both the advantages and dangers of AI in education.

Artificial intelligence can enhance conceptual comprehension by providing adaptive feedback, identifying misconceptions, and modeling intricate relativistic events. Nonetheless, its increasing use in educational settings prompts essential inquiries: Who possesses epistemic authority when AI serves as a source of explanations? How can educators maintain their position as intellectual facilitators instead of becoming mere overseers of technology? How might students be motivated to engage in critical thinking instead of accepting AI-generated responses as infallible truth?

Simultaneously, AI systems rely on student data, and their implementation prompts apprehensions over transparency, surveillance, and corporate dominance in educational practices. If unregulated, AI may exacerbate inequality, especially between technologically advantaged schools and those deficient in infrastructure or teacher preparation. In the absence of inclusive policy frameworks, AI may generate novel forms of educational exclusion and redirect science education towards efficiency and automation, rather than fostering inquiry and reflection.

For AI to really enhance the instruction of Einsteinian physics, it must operate as a collaborator in the learning process, rather than a substitute for human discernment. Educators must remain pivotal in directing thinking, presenting philosophical inquiries, and cultivating ethical consciousness. Policymakers must provide equal access to digital infrastructure, strong data protection, and substantial professional development for educators. AI developers must create systems that are scientifically precise, culturally inclusive, and transparent in their decision-making processes.

The primary problem lies not in the mere integration of AI, but in utilizing it to enhance comprehension, foster intellectual independence, and democratize access to contemporary scientific concepts. If implemented judiciously, AI can assist students in calculating time dilation and describing spacetime curvature, as well as in understanding the construction, questioning, and transformation of scientific knowledge. Misuse may diminish physics to just computational outputs, severed from human curiosity and rigorous examination. The future of AI in Einsteinian physics education will hinge on our preference for technical convenience against pedagogical integrity.

8. References

- Vakarou G, Stylos G, Kotsis KT. Probing students' understanding of Einsteinian physics concepts: A study in primary and secondary Greek schools. *Phys Educ*. 2024; 59(2):25004. Doi: 10.1088/1361-6552/ad1768
- Vakarou G, Stylos G, Kotsis KT. Effect of didactic intervention in Einsteinian physics on students' interest in physics. *Eur J Sci Math Educ*. 2024; 12(2):200-210. Doi: 10.30935/scimath/14303
- Regan PM, Jesse J. Ethical challenges of edtech, big data and personalized learning: Twenty-first-century student sorting and tracking. *Ethics Inf Technol*. 2019; 21(3):167-179. Doi: 10.1007/s10676-018-9492-2
- Holmes W, Bialik M, Fadel C. Artificial intelligence in education: Promises and implications for teaching and learning. Boston, MA: Center for Curriculum Redesign, 2019.
- Kotsis KT. Alternative ideas about concepts of physics are a timelessly valuable tool for physics education. *Eurasian J Sci Environ Educ*. 2023; 3(2):83-97. Doi: 10.30935/ejsee/13776
- Polverini G, Gregorcic B. How understanding large language models can inform the use of ChatGPT in physics education. *Eur J Phys*. 2024; 45(2):025701. Doi: 10.1088/1361-6404/ad1420
- Stylos G, Siarka O, Kotsis KT. Assessing Greek pre-service primary teachers' scientific literacy. *Eur J Sci Math Educ*. 2023; 11(2):271-282. Doi: 10.30935/scimath/12637
- Luckin R, Cukurova M. Designing educational technologies in the age of AI: A learning sciences-driven approach. *Br J Educ Technol*. 2019; 50(6):2824-2838. Doi: 10.1111/bjjet.12861
- Williamson B. Datafication of education: A critical approach to emerging analytics technologies and practices. In: Beetham H, Sharpe R, editors. *Rethinking Pedagogy for a Digital Age*. 3rd ed. Routledge, 2019, 212-226. Doi: 10.4324/9781351252805-14
- Khosravi H, Buckingham Shum S, Chen G, Conati C, Tsai Y-S, Kay J, *et al*. Explainable artificial intelligence in education. *Comput Educ Artif Intell*. 2022; 3:100074. Doi: 10.1016/j.caeai.2022.100074
- Tsoumanis KG, Stylos G, Kotsis KT. An investigation of primary school students' scientific literacy. *Eur J Educ Stud*. 2024; 11(2). Doi: 10.46827/ejes.v11i2.5195
- Sadler PM, Sonnert G, Hazari Z, Tai R. Stability and volatility of STEM career interest in high school: A gender study. *Sci Educ*. 2012; 96(3):411-427. Doi: 10.1002/sce.21007
- Kersting M, Henriksen EK, Bøe MV, Angell C. General relativity in upper secondary school: Design and evaluation of an online learning environment using the model of educational reconstruction. *Phys Rev Phys Educ Res*. 2018; 14(1):010130. Doi: 10.1103/PhysRevPhysEducRes.14.010130
- Kotsis KT, Stylos G. The readiness of preservice teachers for the distance education of physics in Greece. *Eur J Educ Pedagogy*. 2023; 4(3):26-30. Doi: 10.24018/ejedu.2023.4.3.668
- Kotsis KT, Gikopoulou O, Patrinoopoulos M, Kapotis E, Kalkanis G. Designing the new science curricula for primary education in Greece. In: Soulis SG, Liakopoulou M, Galani A, editors. *Challenges and concerns in 21st century education*. Cambridge Scholars Publishing, 2023, 101-116.
- Kotsis KT. Artificial intelligence and the future of physics curriculum in higher education: Ethics and Institutional Challenges. *Int J Multidiscip Compr Res*. 2025; 4(5):12-16. Doi: 10.54660/IJMCR.2025.4.5.12-16
- Kotsis KT. Artificial intelligence and the scientific process: A review of ChatGPT's role to foster experimental thinking in physics education. *Eur J Contemp Educ E-Learning*. 2025; 3(3):183-198. Doi: 10.59324/ejceel.2025.3(3).14