



## Artificial Intelligence and the Future of Physics Curriculum in Higher Education: Ethics, and Institutional Challenges

**Konstantinos T Kotsis**

Lab of Physics Education and Teaching, Department of Primary Education, University of Ioannina, Greece

\* Corresponding Author: **Konstantinos T Kotsis**

---

### Article Info

**ISSN (online):** 2583-5289

**Volume:** 04

**Issue:** 05

**Sep-Oct 2025**

**Received:** 07-07-2025

**Accepted:** 08-08-2025

**Published:** 30-08-2025

**Page No:** 12-16

### Abstract

The swift incorporation of artificial intelligence (AI) into higher education is transforming the physics curriculum, presenting substantial opportunities and intricate obstacles. AI applications, including intelligent teaching systems, adaptive evaluations, and simulation-based experimentation, are transforming student engagement with abstract concepts, facilitating virtual experiments, and enhancing problem-solving skills. Simultaneously, these advancements prompt urgent inquiries regarding equity, algorithmic transparency, academic integrity, and the changing responsibilities of educators. This essay, conceived as a conceptual paper, offers an analytical examination of the pedagogical, ethical, and institutional aspects of AI integration in physics education. Utilizing new research and theoretical frameworks, it underscores the twin obligation confronting universities: to leverage the advantages of AI while preserving the epistemic and ethical integrity of scientific education. The discourse underscores that curricular modification should promote reasoning, creativity, and AI literacy, while institutional preparedness necessitates investment in faculty development and cohesive governance structures. Ethical responsibility, encompassing fairness, diversity, and data privacy, is demonstrated to be fundamental rather than ancillary to sustainable adoption. The article positions AI as a revolutionary instrument and a topic of critical examination, so enhancing the discourse on redesigning physics education in a technology-driven age.

**DOI:** <https://doi.org/10.54660/IJMCR.2025.4.5.12-16>

**Keywords:** Artificial Intelligence, Physics Education, Higher Education, Curriculum Development, Institutional Readiness

---

### 1. Introduction

The swift progression of Artificial Intelligence (AI) is revolutionizing various sectors of human endeavor, including higher education, where its incorporation prompts essential inquiries regarding pedagogy, ethics, and institutional readiness (1). In physics education, AI technologies, including intelligent tutoring systems, natural language processing tools, and automated assessment platforms, are transforming both student learning and educator curriculum design and delivery. The advent of generative AI, as demonstrated by tools such as ChatGPT, has heightened both excitement and apprehension, providing opportunities for tailored assistance, increased access to information, and novel methodologies for inquiry-based learning, while concurrently undermining established frameworks of academic integrity, authorship, and evaluation (2,3).

Physics, as a field, holds a distinctive role in this evolution. The dependence on mathematical formalism, conceptual thinking, and experimental methodologies poses unique obstacles and potential for AI integration. AI tools can aid students in resolving intricate problems, simulating physical systems, and interacting with abstract concepts in more dynamic and adaptable manners (4). Conversely, the accessibility of these tools prompts inquiries regarding the equilibrium between cognitive support and intellectual autonomy, particularly in contexts where the acquisition of problem-solving skills is fundamental to the development of professional and scientific identity (5).

The incorporation of AI into physics courses at the institutional level requires a reevaluation of academic policies, encompassing assessment, plagiarism, and the validation of student learning. Universities must simultaneously utilize AI to enhance student

achievements and uphold ethical standards while promoting critical engagement with these technologies (6). This encompasses not just technological aspects but also wider curricular and societal inquiries, such as how to equip students to utilize AI ethically in scientific research and professional environments (7).

This paper aims to critically analyze the influence of AI on the future of physics curricula in higher education, emphasizing the interaction between instructional potential, ethical implications, and institutional preparedness. This conversation emphasizes the necessity for a balanced and proactive strategy that integrates technological innovation with the educational objectives of universities, by contextualizing present practices within the wider framework of problems and debates. This introduction delineates the following sections, which examine contemporary implementations of AI in physics higher education, the challenges and considerations arising from its integration, and the curricular, ethical, and institutional ramifications that shape future trajectories.

This essay employs a conceptual analytical approach instead of an empirical investigation. The objective is to summarize current material and critically assess the pedagogical, ethical, and institutional ramifications of incorporating artificial intelligence into higher education physics. This work, in contrast to systematic reviews that utilize organized processes for literature selection, relies on representative studies and theoretical viewpoints to facilitate a reflective and prospective discourse. Consequently, its value is in offering a theoretical framework for comprehending the benefits and problems of AI inside physics curriculum, rather than introducing novel actual evidence.

This work is a conceptual article that adopts a theoretical and analytical approach to the topic rather than presenting empirical findings. Its purpose is to synthesize existing literature, examine contemporary debates, and critically analyze the pedagogical, ethical, and institutional implications of artificial intelligence for the physics curriculum in higher education. By offering a reflective framework instead of reporting on data collection or experimental studies, the article contributes to the scholarly discourse by positioning AI both as a transformative instructional tool and as a subject of critical inquiry.

## 2. Current Applications of AI in Physics Higher Education

The integration of artificial intelligence into higher education in physics has progressed beyond theoretical discourse to tangible applications in teaching, learning, and research. AI is being integrated into adaptive learning platforms that customize the presentation of physics concepts based on students' cognitive profiles and prior knowledge. These systems utilize data-driven models that adaptively modify the speed and intricacy of instructional content, facilitating diverse learning trajectories among extensive groups of physics students (8). Intelligent tutoring systems have been employed to assist learners in problem-solving activities in fields like mechanics or electromagnetism, delivering immediate feedback and scaffolding that is challenging to provide in conventional lecture-based environments (9).

A notable application resides in the incorporation of AI-driven simulations and virtual laboratories. These instruments allow students to interact with intricate physical phenomena that might otherwise be unattainable owing to financial, safety, or logistical limitations. AI-enhanced

virtual laboratories can simulate quantum mechanics experiments, particle collisions, or astrophysical phenomena, hence broadening the educational resources of physics departments (10). Such environments facilitate iterative experimentation, enabling learners to modify parameters in real time and watch the outcomes, so promoting inquiry-based learning and the cultivation of scientific reasoning.

Outside the classroom, AI is utilized for evaluating student learning outcomes. Automated grading systems, driven by machine learning algorithms, can assess textual explanations of physical ideas, laboratory reports, and programming assignments utilized in computational physics courses (11). Although these tools cannot entirely supplant human evaluators, they provide scalability and promptness, enabling educators to concentrate more on delivering qualitative comments. Moreover, natural language processing (NLP) models are progressively utilized to examine student discourse in online forums and collaborative platforms, providing insights into misconceptions and the development of conceptual comprehension (12).

Beyond pedagogy and evaluation, AI has commenced impacting research training inside physics higher education. Students are acquainted with machine learning techniques for the analysis of extensive datasets derived from particle accelerators, astrophysical observatories, and condensed matter simulations. Exposure to these methodologies not only imparts computational abilities pertinent to modern physics research but also connects the disciplines of physics, computer science, and data science (13). By integrating AI technologies into the curriculum, institutions are equipping students to navigate a domain where physics increasingly depends on algorithmic methodologies for knowledge creation.

The present applications of AI in higher education physics exhibit diverse potential: improving instructional delivery, facilitating inventive experimentation, optimizing evaluation, and aligning student training with the dynamic character of scientific research. Nonetheless, these implementations prompt inquiries concerning pedagogical integrity, equity, and the function of educators, which will be analyzed in later sections.

## 3. Challenges and Considerations

The use of artificial intelligence in the instruction and comprehension of physics at the tertiary education level introduces a range of complex issues that surpass simple technological implementation. These issues include pedagogical, ethical, epistemological, and institutional aspects that necessitate thorough analysis prior to the comprehensive and responsible integration of AI into curriculum. The enthusiasm for AI's transformative potential is clear, although the hazards of unthinking application may jeopardize educational equity, academic integrity, and the essence of physics as a field (14,15).

A key difficulty pertains to the epistemological status of knowledge as mediated by AI. Physics education has historically prioritized the acquisition of factual knowledge alongside the development of scientific thinking, problem-solving abilities, and epistemic agency (16). Excessive reliance on AI systems by students for problem-solving, data analysis, or conceptual explanation may lead to a passive learning approach, wherein individuals delegate intellectual effort to machines instead of actively constructing meaning. This prompts apprehensions over whether AI promotes

authentic scientific literacy or diminishes learning to a mere form of "outsourced cognition" (9). The problem is to incorporate AI in manners that support inquiry and critical reflection instead of supplanting these procedures.

A secondary aspect pertains to matters of equity and accessibility. The implementation of sophisticated AI technology in higher education frequently necessitates significant financial expenditures on infrastructure, software, and professional development. Affluent institutions may more rapidly implement AI-enhanced learning environments, thereby disadvantaging under-resourced colleges and students (11). Moreover, students from marginalized backgrounds may encounter further obstacles if AI systems are not developed inclusively, potentially exacerbating existing gaps in physics education. Consequently, ethical implementation must account for both the digital gap and the cultural biases inherent in AI systems (17).

Academic honesty presents a significant challenge. AI instruments like ChatGPT and specialized physics tutors may produce comprehensive explanations, issue resolutions, and complete essays. Although these skills may serve as frameworks for learning, they can also enable types of academic dishonesty that are challenging to identify using conventional plagiarism detection methods (7). This requires a reassessment of evaluation methods in physics courses, transitioning from mechanical problem-solving activities to assessments that prioritize thinking, creativity, and critical interaction with concepts. The wider educational community is contending with the challenge of reconciling the beneficial application of AI with the preservation of academic integrity. A further area of issue pertains to the transparency and interpretability of AI systems. Physics fundamentally relies on the notion of elucidating natural phenomena via comprehensible and verifiable models. Numerous AI systems, especially those utilizing deep learning, function as "black boxes" with internal mechanisms that remain unclear even to specialists (18). The integration of such systems into physics education prompts philosophical and pedagogical inquiries: Can AI-generated explanations be regarded as reliable scientific materials if they are not subject to complete scrutiny? In what manner should educators contextualize AI outputs about established disciplinary knowledge? These factors underscore the necessity for epistemic vigilance and the cultivation of AI literacy in conjunction with scientific literacy.

Institutional preparedness also presents considerable problems. Faculty members frequently lack the requisite expertise and confidence to effectively integrate AI tools into their pedagogical methods. Professional development programs in higher education have not adequately addressed the pedagogical ramifications of AI integration, resulting in many instructors being either suspicious or reluctant to engage in experimentation (1). Institutional policies regarding intellectual property, data privacy, and ethical usage are still developing and frequently varied among universities, resulting in ambiguity for both academics and students. The absence of comprehensive policies may result in the fragmented adoption of AI, influenced more by market pressures than by educational principles.

Ultimately, ethical considerations must be paramount in the incorporation of AI into physics teaching. Concerns around data privacy, algorithmic bias, and the potential for surveillance in digital learning settings significantly impact student autonomy and confidence (19). Students must be

guaranteed that their data will not be exploited and that AI systems are constructed to honor diversity and maintain the integrity of the educational goal. The ethical aspects of AI are essential to influencing the future of higher education courses.

Collectively, these problems highlight the necessity for intentional, critically informed strategies for incorporating AI into physics teaching. Instead of perceiving AI as a pre-existing remedy for educational challenges, institutions should regard it as a pedagogical instrument that necessitates continuous examination of its advantages and constraints. The factors discussed indicate that the integration of AI in physics education transcends mere technological feasibility, encompassing values, equity, and institutional agendas.

#### 4. Discussion

The incorporation of artificial intelligence into higher education physics necessitates a comprehensive discourse that extends beyond technical viability to include curriculum reform, ethical responsibility, and institutional readiness. The dimensions are intricately linked: curricular choices influence the pedagogical framing of AI; ethical considerations protect the foundational values of academic practice; and institutional frameworks dictate the sustainability, equity, and alignment of implementation with overarching educational objectives. Collectively, they highlight the opportunities and challenges that AI presents within the physics curriculum.

From a curricular standpoint, AI disrupts conventional instructional models by modifying the equilibrium among subject knowledge, procedural skills, and metacognitive practices. Physics curricula have traditionally prioritized the mastery of mathematical tools, conceptual comprehension of natural events, and practical laboratory experience as fundamental components of scientific education (16). The emergence of AI systems capable of automating problem-solving or simulating physical processes requires a reorganization of curricular goals. Educators should prioritize scientific thinking, critical analysis of AI-generated outputs, and the cultivation of "AI literacy" within the field over rote calculations (9). This literacy encompasses both technical proficiency with AI technologies and an understanding of its limitations, biases, and influence on scientific investigation. Incorporating AI in this manner may facilitate a transition from a content-focused curriculum to one that emphasizes inquiry, interpretation, and creativity.

Ethical considerations additionally complicate this curricular transition. The implementation of AI in physics education raises issues of equity, responsibility, and scholarly integrity. Cotton *et al.* (7) contend that AI tools can unintentionally facilitate academic dishonesty, particularly in problem-centric disciplines such as physics, where automated solutions may bypass authentic participation. Curricula must consequently adapt to incorporate assessment systems that value reasoning, creativity, and reflective judgment over simply accuracy of responses. Ethical rules for AI utilization should be integrated into the curriculum, instructing students on both the application of AI and its responsible use. This recontextualization positions ethics as a fundamental element of scientific education, along with overarching trends in higher education aimed at incorporating responsible research and innovation into disciplinary practices (17,8).

Institutional preparedness is a pivotal element in assessing the feasibility of curricular and ethical reforms. Universities

differ markedly in their ability to invest in AI infrastructure, offer professional development for teachers, and formulate cohesive policies on AI utilization (6). In the absence of robust institutional frameworks, the adoption of AI may become disjointed, experimental, or primarily influenced by commercial interests rather than educational principles (1). Institutions must consider both technical infrastructure and governance frameworks to guarantee that decisions on AI integration are transparent, inclusive, and informed by a variety of stakeholder perspectives, including students, professors, and policymakers (20). Concerns regarding data privacy, intellectual property, and monitoring need the implementation of institutional rules that emphasize student autonomy and trust (21).

The convergence of educational, ethical, and institutional factors underscores the necessity for a comprehensive strategy. For example, incorporating AI-driven virtual laboratories into the physics curriculum can enhance access to experimental methods, especially in areas with limited physical laboratories (22). This breakthrough prompts ethical inquiries regarding the sufficiency of virtual experiences as substitutes for practical experimentation and institutional issues related to equitable access to the technology. Embedding AI tutors into coursework may promote personalized learning; yet, without sufficient institutional support and monitoring, these systems could exacerbate existing disparities in educational results. These examples illustrate that AI cannot be regarded as a neutral or solely technological intervention; its effects are contingent upon the educational settings, values, and institutional frameworks in which it is integrated (14).

Furthermore, the incorporation of AI into physics courses must be contextualized within the wider societal function of physics education. Physics, as a scientific and cultural endeavor, cultivates critical thinkers equipped to tackle intricate global issues, including climate change and energy sustainability. For the responsible integration of AI, curricula must guarantee that students not only acquire discipline knowledge but also cultivate the ability to critically analyze the consequences of AI in science and society. Incorporating ethical AI literacy into the physics curriculum could equip graduates not only as physicists but also as contemplative citizens capable of navigating the convergence of technology and humankind.

In conclusion, the discourse indicates that curricular adaptability, ethical responsibility, and institutional preparation are interconnected components that shape the future of AI in physics education. Curricula must adapt to prioritize reasoning and AI literacy, ethics should be central to scientific education, and organizations must foster environments that facilitate equitable and responsible implementation. This triadic approach guarantees that AI is utilized not alone as a technological instrument but as a catalyst for re-envisioning physics education in accordance with both disciplinary integrity and societal ideals.

## 5. Conclusion

The incorporation of artificial intelligence into the physics curriculum in higher education presents a substantial opportunity as well as a considerable problem. AI possesses the capacity to revolutionize the instruction and comprehension of physics by broadening access to sophisticated simulations, enabling individualized learning, and automating mundane activities. Conversely, these

benefits are accompanied by educational, ethical, and institutional challenges that necessitate meticulous evaluation. The future of AI in physics education transcends mere technology acceptance; it depends on how higher education institutions innovate courses, uphold ethical standards, and ensure long-term viability.

AI necessitates a reevaluation of the fundamental components of physics education. Although conventional curricula have prioritized material mastery and laboratory experience, the growing accessibility of AI-driven tools necessitates a transition towards advanced capabilities, including critical thinking, epistemic awareness, and scientific creativity. In this regard, AI serves not as a substitute for traditional teaching methods but as a catalyst for recalibrating the physics curriculum to align with the demands of a data-driven, technology-oriented society.

The emergence of AI underscores the necessity for responsible integration. Issues of equity, prejudice, scholarly integrity, and the openness of AI systems must be clearly addressed within physics curricula. Students must be educated not just in the utilization of AI technologies but also in the critical assessment of their impact on knowledge production, ensuring that technology does not compromise the integrity of scientific inquiry. Integrating ethical literacy into the physics curriculum provides a means for graduates to become not just proficient physicists but also contemplative practitioners adept at addressing the social and moral ramifications of developing technology.

The effective implementation of AI necessitates strategic preparedness inside institutions. Investment in infrastructure, faculty professional development, and strong governance systems are crucial to avert fragmented or inequitable implementation. Policies concerning data privacy, equitable access, and academic integrity will dictate whether AI functions as a tool for inclusion or exclusion in higher education. Institutions must establish structures for collaboration among educators, policymakers, and students to guarantee that AI integration embodies collective educational principles rather than market-driven motives.

The integration of curricular, ethical, and institutional factors indicates that AI ought not to be regarded only as an adjunct to current physics programs, but rather as a catalyst for rethinking the objectives and methodologies of physics teaching in higher education. By seeing AI as both an instrument and a subject of critical examination, educators and institutions may use its potential while alleviating its hazards. The future of AI in physics curricula will hinge on a dedication to harmonizing innovation with accountability, ensuring that technological progress aligns with the overarching objectives of higher education: to develop knowledge, promote critical citizenship, and equip students to tackle the intricate challenges of the twenty-first century.

## 6. References

1. Zawacki-Richter O, Marín VI, Bond M, Gouverneur F. Systematic review of research on artificial intelligence applications in higher education - where are the educators? *Int J Educ Technol High Educ.* 2019;16(1):39.
2. Kasneci E, Sessler K, Küchemann S, Bannert M, Dementieva D, Fischer F, *et al.* ChatGPT for good? On opportunities and challenges of large language models for education. *Learn Individ Differ.* 2023;103:102274.
3. Kotsis KT. Integration of artificial intelligence in science

- teaching in primary education: applications for teachers. *Eur J Contemp Educ E-learn.* 2024;2(3):27-43.
4. Smith EM, Stein MM, Holmes NG. Direct measurement of the impact of teaching experimentation in physics labs. *Phys Rev X.* 2020;10:011029.
  5. Holmes NG, Wieman CE. Introductory physics labs: we can do better. *Phys Today.* 2018;71(1):38-45.
  6. Wattanakasivich P, Kaewkhong K, Katwibun D. Physics instructors' acceptance and implementation of generative AI. *Phys Rev Phys Educ Res.* 2025;21(1):010155.
  7. Cotton DRE, Cotton PA, Shipway JR. Chatting and cheating: ensuring academic integrity in the era of ChatGPT. *Innov Educ Teach Int.* 2023;60(2):148-59.
  8. Almasri F. Exploring the impact of artificial intelligence in teaching and learning of science: a systematic review of empirical research. *Res Sci Educ.* 2024;54:977-97.
  9. Holmes W, Bialik M, Fadel C. *Artificial intelligence in education: promises and implications for teaching and learning.* Boston: Center for Curriculum Redesign; 2019.
  10. Fischer F, Hmelo-Silver CE, Goldman SR, Reimann P, editors. *International handbook of the learning sciences.* 1st ed. New York: Routledge; 2018.
  11. Luckin R, Holmes W, Griffiths M, Forcier LB. *Intelligence unleashed: an argument for AI in education.* London: Pearson; 2016.
  12. Holmes W, Tuomi I. State of the art and practice in AI in education. *Eur J Educ.* 2022;57(4):542-70.
  13. Radford A, Wu J, Child R, Luan D, Amodei D, Sutskever I. Language models are unsupervised multitask learners. OpenAI blog [Internet]. 2019;1(8):9. Available from: [https://cdn.openai.com/better-language-models/language\\_models\\_are\\_unsupervised\\_multitask\\_learners.pdf](https://cdn.openai.com/better-language-models/language_models_are_unsupervised_multitask_learners.pdf)
  14. Lee G, Yun M, Zhai X, Crippen K. Artificial intelligence in science education research: current states and challenges. *J Sci Educ Technol.* 2025;[Epub ahead of print].
  15. Kotsis KT. Integrating artificial intelligence in science education: benefits and challenges. *Int J Educ Innov.* 2024;6(3):39-49.
  16. Redish EF. Analysing the competency of mathematical modelling in physics. In: Greczyło T, Dębowska E, editors. *Key competences in physics teaching and learning.* Cham: Springer; 2017. p. 25-40.
  17. Floridi L, Cowls J. A unified framework of five principles for AI in society. *Harv Data Sci Rev.* 2019;1(1).
  18. Burrell J. How the machine 'thinks': understanding opacity in machine learning algorithms. *Big Data Soc.* 2016;3(1):1-12.
  19. Kotsis KT. Issues between artificial intelligence and personal data in education. *Int Res Educ.* 2025;13(1):45-65.
  20. Kotsis KT. Integrating artificial intelligence for science teaching in high school. *LatIA.* 2025;3:89.
  21. Selwyn N. *Should robots replace teachers?: AI and the future of education.* Medford: John Wiley & Sons; 2019.
  22. de Jong T, Linn MC, Zacharia ZC. Physical and virtual laboratories in science and engineering education. *Science.* 2013;340(6130):305-8.