


Concept Article

Artificial Intelligence in Physics Classrooms: Comparative Perspectives on ChatGPT and DeepSeek as Learning Supports

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Abstract: This study presents a conceptual comparative analysis of two advanced AI-driven platforms, ChatGPT and DeepSeek, within the context of physics education. It explores how these systems can serve as complementary learning supports that enhance conceptual understanding, inquiry, and problem-solving in classroom settings. ChatGPT's dialogic and adaptive interaction style fosters exploratory learning, metacognitive reflection, and conceptual clarification, aligning well with constructivist and inquiry-based pedagogies. In contrast, DeepSeek's precision-oriented architecture and iterative refinement processes lend themselves to structured problem-solving and cognitive efficiency, supporting students in procedural and computational tasks. Together, these affordances illustrate how distinct AI designs can address different dimensions of physics learning. The analysis also examines emerging ethical and pedagogical challenges, including issues of academic integrity, cognitive dependency, and algorithmic bias, underscoring the importance of teacher mediation and institutional regulation. The study concludes that, when thoughtfully integrated, AI tools like ChatGPT and DeepSeek can enrich physics education by balancing conceptual exploration with procedural rigor, while emphasizing the need for ethical literacy and transparent frameworks in their classroom use.

Keywords: ChatGPT; DeepSeek; physics education; artificial intelligence; pedagogy

1. Introduction

The swift incorporation of artificial intelligence (AI) into educational settings has generated increasing interest in comprehending both its theoretical foundations and its practical implementations within particular disciplinary frameworks. Although recent academic research has explored the conceptual frameworks, pedagogical opportunities, and ethical implications of AI in education (Holmes et al., 2022; Luckin, 2025), there is a pressing necessity for empirical studies that assess the actual efficacy and classroom influence of particular AI platforms. This study conducts a comparative analysis of two leading AI-driven conversational agents, ChatGPT and DeepSeek, within the field of physics education, building on the theoretical and pedagogical foundations laid in a prior companion paper and extending recent comparative perspectives in the field (Kotsis, 2025b). This emphasis facilitates the examination of their unique affordances, constraints, and prospective functions in enhancing physics education and learning.

Physics education serves as a distinctive platform for the integration of AI, owing to the field's dual focus on conceptual comprehension and problem-solving abilities. Educators frequently encounter the difficulty of rendering abstract concepts comprehensible while simultaneously promoting analytical thought and empirical reasoning (Valle-Muñoz et al., 2025). AI tools like ChatGPT and DeepSeek can aid in these tasks by offering context-specific explanations, enabling dialogue-driven inquiries, and producing examples or problem sets customized to various levels of student proficiency. Nonetheless, variations in their training data, interaction methods, and pedagogical alignment may affect their efficacy in the classroom.

This study intends to investigate these differences via a classroom-focused comparative analysis. This research aims to assess the performance of ChatGPT and DeepSeek across diverse instructional contexts to discern patterns in accuracy, conceptual clarity, adaptability to student requirements, and their ability to facilitate inquiry-based and problem-solving

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methodologies in physics.

The study emphasizes insights derived from classroom-oriented and discipline-specific literature rather than generic descriptions of AI capabilities, aiming to provide actionable theoretical guidance for educators and policymakers (Garzón et al., 2025). This approach extends the conceptual foundations established in the previous paper by integrating established research findings and pedagogical interpretations, thereby offering a deeper understanding of the role of AI in contemporary physics education (Kotsis, 2025c).

Accordingly, this study is situated at the intersection of physics education and the integration of AI, focusing on how emerging AI systems can transform learning processes. The study develops a theoretical and comparative framework for understanding the pedagogical, cognitive, and ethical dimensions of ChatGPT and DeepSeek in physics classrooms. The analysis draws on established theories of science learning, such as constructivism, cognitive apprenticeship, and formative assessment, to interpret how these systems can support both conceptual exploration and procedural reasoning. In this sense, the article constitutes a theoretical research study that synthesizes existing empirical evidence and educational theory to generate new insights for practice and policy in AI-enhanced physics education.

2. Key Features and Affordances of ChatGPT and DeepSeek in Physics Education

The emergence of large language models (LLMs) like ChatGPT and DeepSeek in education has created new opportunities for improving instructional design, personalizing learning, and broadening the range of formative feedback. Although both platforms possess the core ability to produce human-like text in response to user prompts, their architecture, design philosophy, and training methodologies result in unique advantages that warrant further analysis within the field of physics education.

ChatGPT, created by OpenAI, utilizes the Generative Pre-trained Transformer architecture, refined through reinforcement learning from human feedback to enhance contextual relevance, coherence, and alignment with user intent (OpenAI, 2023). This combination allows ChatGPT to respond in a way that frequently corresponds with conversational teaching methods, rendering it especially effective for scaffolding student comprehension through incremental explanations. In physics classrooms, ChatGPT can facilitate Socratic questioning, create analogies for intricate phenomena, and tailor explanations to diverse levels of prior knowledge. The ability to generate various representations, such as verbal descriptions, symbolic equations, and conceptual diagrams, enhances multimodal learning, which has been demonstrated to promote deeper conceptual understanding in science education (Ainsworth, 2006; Treagust & Tsui, 2013).

DeepSeek, although an advanced LLM, has adopted a distinct design approach, prioritizing computational efficiency, enhanced access to multilingual training datasets, and an emphasis on precision in problem-solving (Madupati et al., 2025). This orientation is well-suited for computational physics tasks and structured problem-solving exercises, where precision and succinct reasoning are essential (Manik, 2025). Moreover, DeepSeek's architecture incorporates mechanisms for iterative refinement, allowing it to revisit and modify prior responses based on user feedback with greater flexibility than certain other LLMs (Madaan et al., 2023; Jiang et al., 2025). This feature corresponds with inquiry-based learning methodologies in physics, wherein hypothesis modification and iterative experimentation are essential to the educational process.

The capabilities of these tools are influenced by their interactional style. ChatGPT excels in fostering a collaborative learning environment, emulating a tutor-like presence that engages students in prolonged exploration dialogue. This dialogic nature may prompt students to express their reasoning, a practice linked to enhanced conceptual understanding and metacognitive growth (Chi & Wylie, 2014). Conversely, DeepSeek exhibits the capacity to provide concise, targeted responses, which can be especially beneficial in exam preparation contexts or when students need swift elucidation of procedural steps.

Moreover, both platforms can facilitate differentiated instruction in physics by modifying language complexity, depth of explanation, and utilization of technical terminology based on learner requirements. This adaptability corresponds with inclusive pedagogical principles and facilitates the creation of learning experiences that accommodate diverse student populations, including those with differing levels of science capital (Archer et al., 2015). The synergistic potential of ChatGPT and DeepSeek indicates that, when strategically

integrated, they may enhance each other, ChatGPT facilitating conceptual exploration and narrative-driven elucidation. At the same time, DeepSeek guarantees accuracy and efficiency in structured problem-solving scenarios.

3. Comparative Pedagogical Analysis

A direct pedagogical comparison of ChatGPT and DeepSeek in physics education highlights significant differences in their instructional capabilities, the depth and style of their responses, and their potential compatibility with various teaching methodologies. Although both systems utilize extensive corpora and sophisticated transformer-based architectures, their differing optimization objectives and interactional characteristics place them uniquely within the educational framework.

ChatGPT's ability for dialogic interaction renders it especially appropriate for constructivist and socio-cultural methodologies in science education. In a constructivist classroom, students actively construct new knowledge through engagement with peers, educators, and instructional resources, frequently by integrating prior understandings with new information (Driver et al., 1994). ChatGPT's adaptive and context-sensitive responses enable it to function as a "conversational partner," facilitating learners' conceptual refinement and enhancing metacognitive awareness. The model facilitates student reasoning by posing clarifying questions, suggesting analogies, or presenting counterexamples, thereby creating cognitive conflict that can stimulate conceptual change (Kotsis, 2025b).

Conversely, DeepSeek exhibits pedagogical advantages in contexts where accuracy, procedural transparency, and temporal efficiency are paramount. In the context of physics problem-solving, particularly within cognitive apprenticeship frameworks (Collins et al., 1991), DeepSeek's succinct and precise presentation can replicate the function of an expert demonstrator. The model's iterative refinement mechanism facilitates a feedback loop akin to teacher-guided correction in conventional education, enhanced by immediate response times. This trait is especially beneficial in high-stakes situations like exam preparation, where students frequently emphasize efficiency over exploratory discussion.

From the standpoint of formative assessment, ChatGPT provides a diverse array of formative feedback modalities, encompassing explanatory elaboration, suggestive questioning, and multiple-solution pathways. These attributes correspond with Black and Wiliam's (2009) assertion that formative assessment is most efficacious when it fosters self-regulation and ownership of learning. Conversely, DeepSeek offers concise feedback that is readily actionable, proving effective in situations where learners require specific corrections or swift validation of procedural steps instead of extensive conceptual analysis.

In the context of differentiated instruction, both tools present potential, albeit with distinct strengths. ChatGPT excels at adjusting complexity and establishing interdisciplinary connections, such as correlating kinematics with historical scientific experiments, thereby enhancing the educational experience for students with significant scientific capital or interest. DeepSeek, however, excels at deconstructing intricate procedural issues into a series of manageable steps, rendering it accessible for learners who may find cognitive load challenging in problem-solving tasks (Sweller, 1988).

The incorporation of these tools within the same instructional setting may produce synergistic advantages. A physics instructor may utilize ChatGPT for initial conceptual explorations at the beginning of a unit and subsequently employ DeepSeek to reinforce procedural proficiency. This integrated method corresponds with studies on adaptive expertise, which highlight the capacity to engage in exploratory and efficiency-oriented problem-solving strategies alternately (Hatano & Inagaki, 1986). The tools are not competitive; rather, they function as pedagogically distinct yet complementary resources a conclusion that resonates with recent work on reciprocal AI evaluation in educational contexts (Kotsis, 2025a).

4. Ethical and Institutional Challenges of AI-Assisted Writing

The incorporation of sophisticated AI systems like ChatGPT and DeepSeek into physics education presents a series of ethical dilemmas that transcend the technical functionalities of these tools. These challenges encompass concerns regarding academic integrity, cognitive dependency, data privacy, and algorithmic bias, all of which necessitate meticulous attention from educators, policymakers, and developers.

A primary concern is academic integrity. The ability of these systems to generate highly

coherent, contextually pertinent, and frequently original-seeming text may entice students to circumvent the cognitive processes integral to authentic learning. This phenomenon corresponds with previous concerns regarding plagiarism in the digital era (Park, 2003), yet AI-generated content presents a more intricate situation, as it is neither directly replicated from a singular source nor readily identifiable through traditional plagiarism detection methods (Cotton et al., 2024). The risk is that learners might replace genuine problem-solving with AI-generated responses, consequently compromising the cultivation of conceptual comprehension and scientific reasoning.

A pertinent concern is cognitive dependency, wherein students cultivate an excessive reliance on AI-generated solutions, thereby impairing their capacity for independent reasoning. Studies in cognitive psychology indicate that dependence on external aids may impair memory consolidation and diminish problem-solving resilience (Sparrow et al., 2011). In the field of physics education, this may result in students acquiring procedural proficiency in problem-solving while failing to cultivate a profound comprehension of the fundamental principles, a differentiation essential for nurturing adaptive expertise.

The protection of data privacy and the ethical management of learner interactions constitute a substantial challenge. Both ChatGPT and DeepSeek depend on extensive user-input data to enhance their responses, prompting concerns regarding the storage, anonymization, and potential utilization of this data for model retraining. The collection and storage of personally identifiable information for younger learners present legal and ethical risks, particularly under regulations such as the General Data Protection Regulation in Europe and the Family Educational Rights and Privacy Act in the United States (Regan & Jesse, 2019).

Algorithmic bias, frequently examined in the context of social and cultural content, also possesses pedagogical ramifications in physics education. AI models primarily trained on data from specific languages, curricula, or problem types may unintentionally favor certain methodologies or cultural contexts of science, while sidelining others (Bender et al., 2021). This prompts apprehensions regarding epistemic diversity and the fair representation of global scientific viewpoints. In physics, the variability of problem contexts, measurement systems, and historical references across cultures may result in culturally limited instruction that does not engage all learners.

Moreover, there exists the concern of transparency and elucidation. Although DeepSeek's iterative refinement mechanism and ChatGPT's conversational adaptability may render their reasoning processes seemingly intuitive, neither system genuinely "explains" its internal decision-making in comprehensible human terms. This opacity complicates the educator's responsibility in verifying the accuracy and reliability of AI-generated content, especially in fields such as physics where precision and clarity are essential.

Resolving these ethical issues necessitates a synthesis of institutional policy, pedagogical adjustments, and technological enhancements. Educators should create learning activities that promote AI as a supplementary, rather than primary, problem-solving tool, incorporating reflective tasks that necessitate students to evaluate and validate AI-generated solutions. Institutional policies must delineate explicit parameters for AI utilization in academic settings, harmonizing innovation with protective measures against abuse. Developers must persist in their efforts to mitigate bias, safeguard privacy, and enhance explainability in AI systems to adhere to educational ethics. In the absence of such measures, the prospective advantages of incorporating ChatGPT and DeepSeek into physics education may be eclipsed by unforeseen adverse effects.

5. Considerations in AI-Supported Physics Learning and Research Outlook

This study examined the diverse implications of incorporating AI systems like ChatGPT and DeepSeek into physics education and broader academic settings, yet several limitations must be recognized.

The primary limitation resides in the swiftly advancing characteristics of AI technology. The analysis provided is based on the capabilities and affordances of AI models accessible until mid-2025. Considering the rapid advancements in LLMs, particularly in multimodal processing, real-time reasoning, and adaptive learning capabilities, it is probable that the opportunities and challenges outlined will undergo substantial changes in the near future (von Eschenbach, 2021).

Secondly, a significant portion of the current literature on AI in education, particularly within physics contexts, is predominantly exploratory, with a limited number of extensive,

longitudinal studies evaluating long-term learning outcomes (Zawacki-Richter et al., 2019). Although preliminary research indicates that AI may improve personalized learning and formative feedback (Holmes et al., 2022), the existing evidence remains insufficient to substantiate conclusive assertions regarding its lasting effects on conceptual comprehension, problem-solving abilities, and student motivation in STEM fields.

A pertinent limitation pertains to the methodological diversity of contemporary research. Numerous studies depend on self-reported data, brief interventions, or narrowly defined experimental conditions that may fail to encapsulate the intricacies of authentic classroom environments (Luckin et al., 2016). This methodological fragmentation complicates the establishment of generalizable conclusions, especially across varying educational levels, cultural contexts, and curricular frameworks.

A further limitation is the geographic and linguistic bias present in both research and AI model training datasets. The preponderance of AI education research and the principal datasets used to train LLMs are characterized by English-language material and Western educational frameworks (Bender et al., 2021). This prompts inquiries into the universal relevance of existing findings and the capacity of AI systems to facilitate physics education across linguistically and culturally diverse contexts.

Future research should focus on overcoming these limitations by conducting longitudinal, cross-cultural, and interdisciplinary studies that investigate AI integration in genuine physics classrooms. By addressing existing limitations and strategically guiding future research, the field can advance towards a more evidence-based, equitable, and pedagogically robust integration of AI in physics education.

6. Conclusions

The integration of AI into physics education marks a decisive turning point in the evolution of teaching and learning practices. This study argues that systems such as ChatGPT and DeepSeek have the potential to serve not merely as technological tools but also as cognitive and pedagogical partners that can deepen students' engagement with the conceptual and procedural aspects of physics. ChatGPT's conversational and adaptive features foster inquiry, reflection, and metacognitive awareness, while DeepSeek's analytical precision supports structured reasoning, quantitative modeling, and systematic problem-solving. Together, they provide a complementary framework for developing both the creative and logical aspects of scientific thought.

However, these advantages can only be realized through deliberate and ethically grounded educational design. AI should supplement, not substitute, the teacher's role. Educators remain essential mediators who interpret AI-generated explanations, contextualize information, and guide students' epistemic development. To achieve this balance, institutions must adopt clear policies for the pedagogical use of AI, defining acceptable applications in classroom dialogue, assessment, and inquiry-based learning while ensuring data privacy, equity, and academic integrity.

Policy initiatives at national and institutional levels should prioritize AI literacy as a core component of teacher education and continuous professional development. Teachers need to be trained not only in the technical use of AI but also in understanding its epistemological boundaries and cognitive biases. Such training would enable them to evaluate AI-generated content critically, integrate it into constructivist teaching strategies, and promote reflective, evidence-based learning habits among students. Ministries of Education and curriculum design bodies should encourage the incorporation of AI-supported inquiry activities that align with learning outcomes emphasizing reasoning, modeling, and problem-solving across the STEM spectrum.

Furthermore, educational policy must ensure equitable access to AI tools and infrastructure across schools, preventing a new digital divide between well-resourced and under-resourced educational environments. Institutional governance should also establish transparent procedures for monitoring AI implementation, with advisory boards including educators, technologists, and ethicists to safeguard accountability and fairness. These measures can transform AI integration from an ad hoc innovation into a coherent element of educational reform.

Ultimately, the transformative promise of AI in physics education depends not on technological sophistication but on human pedagogical judgment and ethical foresight. When guided by informed policies, teacher expertise, and reflective practice, systems like ChatGPT and DeepSeek can become catalysts for deeper scientific understanding, inclusive

participation, and renewed curiosity in the physical sciences. The challenge for policymakers and educators alike is to align technological innovation with the enduring goals of education: intellectual autonomy, scientific literacy, and the cultivation of critical, creative minds prepared to navigate the complexity of a world increasingly shaped by intelligent systems.

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