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# Evaluating ChatGPT and DeepSeek as AI-Powered Supports for Physics Teachers

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**Abstract**
The rapid emergence of generative artificial intelligence (AI) is transforming educational practice, offering new opportunities for dialogic interaction, structured explanation, and adaptive feedback. This paper examines the pedagogical potential of two natural language processing systems, ChatGPT and DeepSeek, in the context of physics education, with a particular focus on conceptual understanding and instructional design. Drawing on constructivist, behaviorist, and sociocognitive perspectives, as well as the emerging framework of AI literacy, we analyze how these tools align with different phases of the instructional cycle. ChatGPT supports inquiry and conceptual change through adaptive, dialogic interactions that surface and address students' intuitive models. DeepSeek emphasizes semantic precision and structured explanations, supporting formal reasoning and curricular alignment. Empirical studies indicate that these affordances are complementary: when integrated strategically, they can foster both exploratory engagement and disciplinary rigor. However, their effective use depends on teacher mediation, critical engagement, and thoughtful sequencing within instructional frameworks such as the 5E model. The paper concludes by identifying key limitations in the current research, including the scarcity of longitudinal studies, issues related to epistemic agency, and the need for teacher professional development. Together, these insights contribute to a nuanced understanding of how AI can be integrated meaningfully into physics education.

**Keywords:** ChatGPT, DeepSeek, Physics Education, Artificial Intelligence, Science Pedagogy

## 1. Introduction

The fast rise of generative artificial intelligence (AI) and large language models has triggered a transformation in education that rivals earlier technological revolutions like the printing press and the internet. In physics education, this change carries particular weight. Physics requires the coordination of abstract concepts, mathematical reasoning, and scientific inquiry, skills that traditional instruction often struggles to nurture. Tools such as ChatGPT and DeepSeek introduce new possibilities by enabling real-time dialogue, structured explanations, and adaptive feedback that respond to students' needs.

Recent research has underscored both the promise and the complexity of integrating AI into classroom practice. On the one hand, these systems can promote conceptual change, self-reflection, and problem solving through interactive conversation and immediate feedback [1, 2]. On the other, their use raises significant questions about epistemic authority, accuracy, and the evolving role of the teacher (20; 7). Such tensions are particularly pronounced in physics classrooms, where educators must balance open-ended inquiry with conceptual precision and critical engagement.

This paper explores ChatGPT and DeepSeek as educational tools that can enrich physics teaching and learning. By examining their affordances, theoretical foundations, and pedagogical implications, especially in primary and lower-secondary physics instruction, it seeks to clarify how these platforms might support different phases of the learning process. In doing so, the study bridges constructivist, behaviorist, and sociocognitive theories with emerging ideas about AI literacy, providing a framework for using generative AI in science education responsibly and effectively.

## 2. Theoretical and Empirical Foundations

The educational use of NLP tools in physics can be understood through the lens of major learning theories, constructivism, behaviorism, and sociocognitive theory, alongside the developing framework of AI literacy. Together, these perspectives help explain how ChatGPT and DeepSeek can promote conceptual understanding and disciplinary reasoning.

Constructivist theory, grounded in the ideas of Piaget and Vygotsky, views learning as an active process in which students build knowledge through interaction and reflection. ChatGPT's conversational design resonates strongly with this approach: its dialogic nature allows students to express their reasoning, confront misconceptions, and receive immediate feedback. Such engagement is vital in physics, where intuitive misconceptions, such as the belief that heavier objects fall faster than lighter ones, often persist [3]. Through Socratic questioning, analogies, and counterexamples, ChatGPT can challenge these misconceptions and support conceptual restructuring within Vygotsky's zone of proximal development [4, 5].

DeepSeek, by contrast, reflects behaviorist and cognitive information-processing traditions. Its focus on structured presentation, semantic precision, and reinforcement of accurate reasoning aligns with models of explicit instruction and schema automation. This approach is particularly valuable for topics like electromagnetism or quantum mechanics, where stepwise derivations and formulaic reasoning are crucial [2, 6]. ChatGPT and DeepSeek therefore serve complementary functions within the learning cycle: one fosters exploration and dialogue; the other consolidates and formalizes understanding.

Sociocognitive theory further extends this framework. Bandura's social learning principles highlight modeling and guided practice, both of which NLP tools can emulate through examples of expert reasoning [7, 8]. The emerging concept of AI literacy, encompassing digital epistemology, media awareness, and critical engagement, adds another layer, emphasizing that learners and teachers alike must understand how AI systems produce answers and evaluate them critically [9, 1]. In physics, where accuracy and reasoning are paramount, AI literacy becomes a metacognitive tool that strengthens conceptual learning.

Empirical studies reinforce these theoretical claims. Earlier intelligent tutoring systems, such as AutoTutor, demonstrated that guided dialogue can significantly improve students' understanding of physics concepts [10]. More recent findings show that ChatGPT encourages metacognitive reflection and conceptual change through adaptive questioning and explanation, especially in Newtonian mechanics [2, 1, 11]. DeepSeek, on the other hand, excels at promoting procedural fluency and symbolic reasoning by offering structured, semantically precise explanations [12], minimizing cognitive overload and supporting analytical rigor [6].

Current literature increasingly suggests that combining dialogic and structured AI tools produces the most effective results. ChatGPT can stimulate curiosity and initial engagement, while DeepSeek reinforces formal understanding and curricular alignment [7, 13]. This dual approach parallels the 5E instructional model [14], where exploration precedes explanation and is followed by consolidation. However, these tools are most effective when teachers actively mediate their use; without such guidance, students risk uncritically accepting AI-generated information [15].

Despite encouraging outcomes, the research base remains thin. Longitudinal evidence is limited [16, 17], and questions persist about how extended AI use shapes students' epistemological beliefs, science identity, and transfer of learning [18, 19]. Ethical and cultural considerations, such as algorithmic bias and unequal access, also require attention [20, 7].

Overall, the literature positions ChatGPT and DeepSeek as complementary agents in physics education. ChatGPT's dialogic adaptability promotes exploration and conceptual growth, while DeepSeek's precision supports the structured reasoning necessary for scientific mastery. When integrated thoughtfully within research-based frameworks, these systems can together cultivate both inquiry and rigor, two pillars essential to meaningful learning in physics.

## 3. Methodology

This study employs a qualitative comparative document analysis approach to investigate how NLP tools can enhance physics instruction. This method is widely used in educational research to explore the pedagogical, epistemological, and functional dimensions of emerging technologies, particularly when classroom-based empirical data are still limited or developing [7, 13]. The purpose here is to examine how ChatGPT (developed by OpenAI) and DeepSeek can support conceptual understanding, student engagement, and the correction of misconceptions in physics, and to evaluate how their design features align with established frameworks in science education.

Two main textual sources form the basis of the analysis:

(1) a detailed evaluative essay that assesses both platforms' performance in educational contexts, and

(2) a literature-based pedagogical review integrating recent empirical studies.

Together, these documents offer complementary perspectives, one focusing on the platforms' operational characteristics, the other on theoretical and research-based insights into their classroom application.

The analysis followed a mixed deductive–inductive strategy. Six theoretically grounded categories from science education literature guided the deductive phase: pedagogical alignment, conceptual scaffolding, feedback and adaptivity, accessibility and usability, curricular integration, and responsiveness to misconceptions [17, 1]. During the inductive phase, new themes and contrasts between the two platforms were identified, allowing for the emergence of unanticipated insights relevant to physics teaching.

Document analysis is increasingly recognized as a rigorous and systematic method for studying educational innovations in digital environments [21, 22]. It allows researchers to examine the design principles, pedagogical assumptions, and learning goals that underpin technological tools, an approach particularly useful for rapidly evolving systems such as AI tutors. Within the AI domain, this methodology also reveals how theoretical learning principles are operationalized in tools like ChatGPT and DeepSeek.

Pedagogical alignment refers to how each platform supports contemporary instructional practices such as inquiry-based, dialogic, or problem-based learning in physics [23]. The analysis of conceptual scaffolding examined each system's capacity to break down complex ideas, like Newton's laws, conservation principles, or energy transformations, into manageable learning steps suited to different cognitive levels. Feedback and adaptivity were evaluated in terms of each platform's ability to provide timely, context-sensitive responses, a critical function given the wide variation in students' preconceptions of physical phenomena [3, 11].

Accessibility was assessed through the lens of Universal Design for Learning (UDL), considering whether the platforms support features such as multilingual interfaces, screen-reader compatibility, and adjustable display options. Such affordances are essential for equitable access to digital physics instruction [7, 9]. Curricular integration focused on how closely each system's content and language align with official physics curricula, for example, their potential to generate lesson plans, mathematical solutions, or laboratory preparation materials. Finally, responsiveness to misconceptions assessed each platform's ability to recognize and challenge intuitive but incorrect ideas, such as the belief that force is required to maintain motion or that heavier objects fall faster [23].

A comparative-lens perspective was then applied, enabling the study to identify complementarities between ChatGPT and DeepSeek. Prior work suggests that ChatGPT is particularly effective in fostering exploratory dialogue and early conceptual development [1], while DeepSeek excels at structured, evidence-driven exposition suited to advanced or abstract topics [2]. The analysis, therefore, examined whether a sequential or blended use of the two could help learners move from intuitive reasoning toward formal scientific abstraction, a progression central to physics learning [16, 24].

Although this investigation does not include classroom trials, its document-based approach provides a solid, theory-informed foundation for understanding how AI tools can contribute to physics education. By synthesizing theoretical constructions with systematic evaluation of functional features, it offers a framework for educators, curriculum designers, and policymakers to assess the pedagogical value of NLP platforms. Moreover, this methodology is replicable: future studies could extend it to other STEM disciplines or combine document analysis with classroom observations and student interviews, as recommended by Eden [7] and Ortega-Ochoa [13].

## 4. Key Features and Affordances of ChatGPT and DeepSeek in Physics Education

The educational potential of large language models in physics depends on their design principles and modes of interaction. Although both ChatGPT and DeepSeek are built on advanced NLP architectures, they differ in the kinds of learning experiences they enable, making them suitable for distinct instructional functions within the teaching and learning process.

ChatGPT is characterized by an open-ended, conversational interface that supports dynamic dialogue with students. Its context-sensitive responses allow it to engage in Socratic questioning, generate analogies, and provide elaborate explanations that respond to learners' reasoning. This adaptability makes ChatGPT especially effective for conceptual exploration and metacognitive reflection, as students can test their ideas, receive immediate feedback, and refine their understanding through iterative discussion. Its discursive language style also supports early instructional phases, where activating prior knowledge, eliciting intuitive ideas, and addressing misconceptions are crucial. Moreover, ChatGPT's ability to simulate diverse dialogic roles, such as peer, tutor, or skeptic, invites authentic scientific conversations and helps students adopt disciplinary modes of thinking.

DeepSeek, by contrast, adopts a more structured and formal communication style. It generates systematic, step-by-step explanations that align with curricular progression and use precise scientific terminology. This format is particularly valuable for domains that require procedural accuracy and symbolic reasoning, such as electromagnetism, thermodynamics, or quantum phenomena. DeepSeek minimizes ambiguity by offering explicit derivations, definitions, and formal representations, supporting cognitive load management and reinforcing the conventions of scientific language [6]. Its systematic design makes it well-suited to the consolidation and practice phases of learning, when students are expected to internalize concepts and apply them to problem-solving.

These complementary features align naturally with different stages of the instructional cycle. ChatGPT fits best with the inquiry, engagement, and diagnostic phases, where teachers seek to uncover students' reasoning and guide conceptual development. DeepSeek is more appropriate for the explanation, formalization, and application phases, which demand precision and coherence in problem-solving. This complementarity mirrors pedagogical frameworks such as the 5E model [14], in which exploration and dialogue precede structured explanation and elaboration.

Beyond content delivery, both systems provide epistemic and metacognitive benefits. ChatGPT encourages reflective thinking and hypothesis testing by responding flexibly to students' reasoning processes, whereas DeepSeek models expert discourse and demonstrates how physicists structure, formalize, and communicate ideas. When integrated deliberately, the two tools enable a hybrid pedagogy that combines dialogic inquiry with structured consolidation, addressing both conceptual change and formal reasoning, a balance that remains one of the enduring challenges in physics education [18, 19].

Realizing this potential, however, requires careful teacher mediation and instructional design. Without guidance, students may either accept ChatGPT's explanations uncritically or fail to use its dialogic affordances effectively. Similarly, DeepSeek's precision can lead to passive learning if it is not embedded within active, inquiry-oriented lessons. Effective implementation therefore involves orchestrating when and how each platform is used and aligning their strengths with specific learning objectives.

In practical terms, these affordances can be translated into instructional routines that sequence the use of both tools. Three illustrative patterns are:

*Diagnose → Probe → Record*

Teachers begin with a short ChatGPT prompt to elicit students' intuitive ideas (e.g., "Why do you think heavier objects fall faster?"). Through follow-up questions and counterexamples, misconceptions are surfaced and documented for later reflection.

*Explain → Formalize → Practice*

The lesson then transitions to DeepSeek for a structured, symbol-rich explanation (e.g., derivation of free-fall acceleration near Earth, discussion of air resistance), followed by a small set of worked examples and practice items that allow students to check understanding.

*Revisit → Compare → Generalize*

Finally, ChatGPT can be used to extend learning through near-transfer scenarios, such as comparing motion in air and in vacuum, and prompting students to predict, justify, and then verify outcomes with DeepSeek's formal model.

These complementary routines distribute cognitive and epistemic responsibilities between the two systems. ChatGPT externalizes reasoning and supports metacognitive monitoring, while DeepSeek anchors precision and formal representation. The sequence aligns with both the 5E model's Explore–Explain–Elaborate flow [14] and the ICAP framework [25], which emphasizes that constructive and interactive engagement produce deeper learning than passive reception.
Teachers play a central role in orchestrating this process. By keeping ChatGPT prompts concise and focused, educators can prevent conversational drift, while constraining DeepSeek's outputs to curriculum-aligned derivations ensures relevance and clarity. The shift, therefore, is not merely from using tools to using routines, repeatable patterns of engagement that integrate exploration with formalization and make conceptual and procedural learning mutually reinforcing.

## 5. Comparative Pedagogical Analysis

The educational value of large language models in physics instruction lies not only in their technical capacities but also in how they interact with established teaching philosophies and learning objectives. This section examines the pedagogical contributions of ChatGPT and DeepSeek within contemporary science education, focusing on their respective roles in fostering conceptual understanding, addressing misconceptions, and supporting scientific reasoning. Their contrasting yet complementary designs reflect long-standing debates in physics pedagogy, between inquiry-based and exposition-based approaches, conceptual change and procedural fluency, and dialogic learning versus information delivery.
At the heart of constructivist physics education is the notion that learners must build their own understanding by confronting phenomena, testing ideas, and revising mental models through guided reasoning. ChatGPT aligns closely with this approach. Its conversational format enables real-time, scaffolded interaction that mirrors the dialogic processes described in Vygotsky's sociocultural theory and later developed into the idea of productive disciplinary engagement [11, 7]. When students pose questions or express partial explanations, ChatGPT responds with hypotheses, counterexamples, and rephrasing that match the learner's language and cognitive level. This interactive exchange is particularly effective in dispelling persistent misconceptions in mechanics and energy, for example, the idea that heavier objects fall faster or that continuous force is required to sustain motion [4]. In such contexts, ChatGPT acts as a cognitive scaffold, prompting students to evaluate their reasoning and reconstruct understanding, a process central to decades of research on conceptual change [5, 26].
DeepSeek, in contrast, reinforces epistemic precision and the coherence of scientific knowledge. Its structured, semantically consistent responses follow curricular standards and use formal scientific language, making it especially effective for subjects requiring rigorous definitions and symbolic reasoning, such as thermodynamics or electromagnetic induction [23]. From a pedagogical standpoint, DeepSeek aligns with expository teaching models, where conceptual frameworks are presented clearly and systematically to promote procedural fluency and disciplinary accuracy. This approach is valuable in settings emphasizing exam preparation, advanced placement (AP) physics, or university-level instruction. DeepSeek's ability to generate textbook-like explanations, formula derivations, and applied examples makes it an efficient complement to structured learning environments [16].
The contrast between ChatGPT and DeepSeek maps neatly onto different stages of the instructional process. ChatGPT excels during exploration and conceptual conflict, when curiosity, dialogue, and reasoning dominate. DeepSeek, on the other hand, becomes more effective during explanation, application, and evaluation, when learners need formal consolidation and practice. This sequencing aligns with the 5E instructional model, Engage, Explore, Explain, Elaborate, Evaluate, widely adopted in science education [14]. For example, a teacher might begin a lesson on gravitational acceleration by using ChatGPT to guide inquiry and uncover students' intuitive ideas, and later employ DeepSeek to formalize the concept through quantitative problem sets and Newtonian derivations [1].
This complementary pattern reflects dual-process theories of cognition, which distinguish between intuitive (Type 1) and analytical (Type 2) thinking [27]. ChatGPT naturally engages intuitive reasoning through dialogue and analogy, whereas DeepSeek nurtures analytical precision through formal exposition. Together, they can promote the coordination of intuitive and scientific reasoning, a key objective in physics education [18].
Both systems also exhibit distinct strengths in accommodating diverse learners. ChatGPT's generative flexibility allows it to adjust explanations to different reading levels, provide culturally relevant examples, and employ accessible metaphors, supporting inclusive and differentiated instruction [7, 9]. Its conversational mode can foster student agency and belonging by validating learners' voices within scientific discourse. DeepSeek, while less adaptive in tone, offers reliability and structure, qualities that benefit students who thrive on clear, sequential information and those preparing for standardized assessments. For teachers, this complementarity offers a spectrum of instructional strategies: ChatGPT can reveal students' conceptual hurdles, while DeepSeek helps in crafting precise content summaries, quizzes, or conceptual maps aligned with curricular goals.
From a teacher professional development perspective, both systems can serve as reflective partners. Teachers using ChatGPT gain insights into common student misconceptions and alternative ways of explaining complex ideas, enriching their pedagogical content knowledge. DeepSeek, in turn, offers scientifically consistent reference material that reinforces subject expertise and curriculum alignment [23]. Research on AI-supported professional learning environments confirms that such tools can enhance teacher autonomy and reduce the cognitive load of content planning [27, 28].
Nevertheless, integrating large language models into teaching demands a critical and intentional pedagogy. Overreliance on ChatGPT may encourage superficial engagement if students accept its answers uncritically or fail to develop metacognitive strategies for evaluating information. Similarly, DeepSeek's precision may foster passive learning if students treat it as an authoritative source rather than a tool for exploration. As Ortega-Ochoa [13] emphasizes, the success of AI in education depends as much on pedagogical orchestration, the careful design and facilitation of learning experiences, as on the technology

itself. Teachers must guide students in using AI interactively, questioning, comparing, and validating results against empirical or theoretical evidence.

In summary, ChatGPT and DeepSeek represent two complementary pedagogical paradigms in physics: one rooted in dialogic inquiry, the other in structured exposition. When integrated thoughtfully, they offer educators a powerful toolkit for promoting conceptual understanding, engagement, and epistemic rigor. Their combined use allows classrooms to move fluidly between exploration and consolidation, mirroring the way physicists themselves shift between imaginative hypothesis and formal demonstration. Used together, they can help cultivate classrooms that reflect the true nature of scientific reasoning, dynamic, precise, and deeply human.

## 6. Limitations and Future Directions

While the integration of ChatGPT and DeepSeek into physics education presents remarkable pedagogical opportunities, several limitations must be acknowledged. These limitations arise from both technological and educational factors and highlight the need for ongoing empirical investigation and careful pedagogical mediation.

A first and fundamental challenge involves the accuracy and epistemic reliability of AI-generated content. ChatGPT and DeepSeek, despite their linguistic fluency, are not epistemic agents but probabilistic systems trained on vast textual corpora. They generate responses based on statistical associations rather than verified conceptual understanding [20, 7]. This can result in scientifically plausible but factually incorrect statements, especially when addressing advanced or counterintuitive topics, such as quantum indeterminacy or relativistic effects. In physics education, where precision and logical consistency are essential, such “hallucinations” can mislead learners if not identified and corrected by the teacher [1].

Equally significant is the issue of contextual misalignment. While DeepSeek tends to offer formally accurate explanations, it often lacks sensitivity to students’ prior knowledge or the curriculum’s progression. Conversely, ChatGPT’s dialogic adaptability can sometimes oversimplify complex ideas or produce inconsistent reasoning across turns [2]. The dynamic nature of physics learning, where meaning emerges through the interplay of conceptual, mathematical, and experimental reasoning, demands pedagogical supervision to ensure coherence between AI-generated dialogue and curricular goals (5; 19).

A third limitation concerns cultural and linguistic adaptation. Although both systems support multilingual interaction, their underlying training data and linguistic norms are largely Anglocentric, reflecting Western academic discourse. This bias can influence examples, metaphors, and problem contexts, potentially alienating learners in non-English-speaking or culturally diverse classrooms [9]. Research into localized or multilingual AI tutoring systems remains limited, and there is a pressing need to explore how such models can better align with the epistemological and cultural frames of different educational systems [7].

Moreover, the ethical and privacy dimensions of AI use in education remain unsettled. Data collection, consent, and algorithmic transparency are ongoing concerns. When students interact with AI platforms, their inputs —sometimes reflecting misconceptions, emotions, or personal experiences —may be stored and processed without their full awareness [20]. This raises issues of informed consent and accountability. Schools and educational authorities must therefore establish clear policies governing data usage, confidentiality, and digital ethics; while also equipping teachers and students with AI literacy, the skills needed to critically interpret and ethically engage with AI outputs [16, 7].

From a pedagogical standpoint, the most persistent limitation lies in the absence of longitudinal and classroom-based evidence. Most current studies are exploratory or theoretical, focusing on immediate learning outcomes rather than sustained conceptual development [17]. We still know little about how continuous exposure to AI tutors affects students’ epistemological beliefs, problem-solving autonomy, or interest in pursuing physics. Similarly, there is a lack of systematic investigation into teachers’ evolving roles when co-teaching with AI, how authority, dialogue, and classroom dynamics are redistributed as digital partners assume more visible instructional functions [13].

Another open question concerns the transferability of learning. While AI tools can facilitate accurate explanations and conceptual revisions in isolated interactions, it is uncertain whether students can transfer this understanding to novel contexts, such as experimental design, data interpretation, or interdisciplinary problem solving [18]. Future studies should therefore examine not only performance outcomes but also how AI-supported dialogue shapes deeper epistemic habits and scientific thinking.

Looking ahead, several research directions appear particularly promising.

First, hybrid pedagogical orchestration models should be developed, explicitly defining when and how ChatGPT and DeepSeek are used within inquiry-based physics lessons. These models could combine dialogic exploration with structured formalization, reflecting the natural flow of scientific reasoning from intuition to analysis. Second, teacher professional development must accompany AI adoption, equipping educators to critically evaluate AI responses, guide students’ questioning, and integrate AI outputs with hands-on experimentation and collaborative discussion [7]. Third, future systems could incorporate metacognitive and affective feedback, helping learners monitor their confidence, uncertainty, and motivation, factors closely linked to persistence and scientific identity formation [11].

Long-term innovation will also depend on cross-disciplinary collaboration among physicists, computer scientists, linguists, and education researchers. Such partnerships are essential to ensure that NLP models are trained not only for linguistic accuracy but also for epistemological soundness in scientific reasoning. In this sense, AI should not replace human teaching but serve as a cognitive amplifier. This tool extends the teacher’s ability to scaffold reasoning, personalize instruction, and connect abstract theory with experiential understanding.

In conclusion, while ChatGPT and DeepSeek represent a significant advancement in the educational use of AI, their successful integration in physics education depends on balanced human–machine collaboration. Their current limitations, conceptual accuracy, contextual sensitivity, ethical governance, and empirical validation call for sustained inquiry and careful design. The path forward lies in cultivating AI-mediated pedagogical ecosystems where digital systems, teachers, and students engage in co-constructed dialogue that preserves the human essence of scientific inquiry: curiosity, reflection, and the pursuit of truth.

## 7. Conclusions

The integration of large language models into physics education represents one of the most consequential developments in contemporary pedagogy. ChatGPT and DeepSeek, as case studies of two distinct yet complementary approaches, reveal how artificial intelligence can extend traditional teaching while reshaping the epistemological foundations of learning science. Rather than replacing human educators, these tools act as mediators, bridging intuition and abstraction, dialogue and demonstration, exploration and consolidation.

ChatGPT exemplifies the potential of conversational AI to nurture inquiry, metacognition, and conceptual change. Its dialogic nature allows learners to articulate reasoning, test hypotheses, and receive adaptive feedback, aligning closely with constructivist and sociocultural perspectives [5]. It transforms learning from passive content reception into an iterative process of meaning-making and reflection. DeepSeek, in contrast, exemplifies structured cognitive scaffolding, providing systematic explanations and formal reasoning that support procedural fluency and conceptual precision. Together, they form a pedagogical continuum, ChatGPT enabling exploration and DeepSeek ensuring formalization, that mirrors how physicists transition from intuitive models to mathematical representations of reality [2, 1].

When integrated within research-based frameworks such as the 5E model [14] or the ICAP model [25], these platforms can support the full cycle of learning: engaging curiosity, eliciting prior knowledge, enabling conceptual reorganization, and reinforcing mastery through deliberate practice. Importantly, they democratize access to individualized tutoring and disciplinary discourse, offering scalable pathways for personalized learning in physics classrooms where one-to-one feedback is often limited.

However, the effectiveness of such systems is contingent upon human mediation. Teachers remain the architects of meaningful learning environments, designing tasks, framing questions, and contextualizing AI-generated responses. As the literature consistently underscores, the pedagogical impact of AI depends less on the technology itself and more on how educators orchestrate its use to align with cognitive, affective, and ethical learning goals [7, 13]. Thus, the role of the teacher evolves: not diminished but redefined as facilitator, guide, and critical evaluator of digital reasoning.

The broader implications of this transformation extend beyond physics. Integrating AI into science education prompts a re-examination of what it means to “know,” “understand,” and “learn” in the age of intelligent machines. As learners collaborate with algorithmic partners, epistemic authority becomes distributed, and new forms of AI literacy, critical evaluation, transparency awareness, and ethical discernment become essential competencies for future scientists and citizens [9, 20]. Educators and policymakers must therefore ensure that AI serves not as a source of ready-made answers, but as a catalyst for deeper inquiry, fostering scientific curiosity and reflective reasoning.

In summary, the findings of this study support three interrelated conclusions:

Complementarity – ChatGPT and DeepSeek are not competing models but mutually reinforcing instruments within the physics learning process, each supporting distinct cognitive functions.

Mediation – Pedagogical effectiveness depends on human guidance that transforms AI outputs into learning opportunities through reflection, experimentation, and dialogue.

Transformation – The long-term impact of AI will not merely be technological but epistemological, redefining the boundaries of teaching, learning, and scientific thinking itself.

Future progress in this field will rely on longitudinal classroom research, the co-design of AI tools with educators, and policies that strike a balance between innovation, equity, and ethics. The ultimate goal is not the automation of teaching, but the augmentation of human understanding, a vision of physics education that remains faithful to its humanistic roots while embracing the cognitive possibilities of artificial intelligence.

In this sense, AI does not diminish the human dimension of learning; it magnifies it. By helping learners see, question, and model the physical world through new forms of dialogue and reasoning, tools like ChatGPT and DeepSeek reaffirm the essence of science education: the shared pursuit of knowledge grounded in curiosity, creativity, and critical thought.

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