[EPS EDITORIAL]

Beyond automation: the limits of artificial intelligence in physics education

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The rapid development of artificial intelligence (AI) has ignited debate about its role in education, particularly whether it can meaningfully substitute for human teachers. Contemporary AI systems can generate extensive sets of exercises, provide immediate and detailed feedback, and adapt explanations to suit different levels of student understanding. For many learners—especially those who benefit from repetition and incremental reinforcement—such capabilities may rival, or even exceed, the support offered by an average teacher, particularly within the constraints of limited classroom time and large student groups. At first glance, this appears to present a compelling case for adopting AI as a substitute for human instruction.

However, this conclusion warrants careful qualification when one considers the broader aims of education, especially in a discipline such as physics. Education extends beyond the transmission of information and the correction of errors; it also involves the cultivation of intellectual dispositions. Human teachers play a crucial role in fostering motivation, stimulating scientific curiosity, and developing students' capacity for judgment and analytical reasoning. Effective teaching entails not only explaining what is to be understood but shaping how students come to understand. This includes encouraging conceptual thinking, confronting misconceptions, and guiding students through the often-non-linear process of scientific inquiry.

Artificial intelligence, despite its sophistication, remains limited in this regard. While it can simulate dialogue, generate probing questions, and scaffold problem-solving processes, it does not possess genuine intentionality or intellectual curiosity. It lacks the capacity to model the lived experience of discovery that is central to scientific learning. Moreover, it may be unable to sustain student motivation and engagement, thereby increasing the risk of passive learning.

These limitations are particularly significant in physics education, where deep understanding often depends on intuition, conceptual restructuring, and the ability to connect abstract principles to physical reality. Such capacities are rarely developed through repetition alone; they require active engagement, and often the influence of a teacher who can inspire confidence and curiosity. The substitution of human interaction with machine-mediated instruction, even when technically efficient, may therefore lead to an impoverished form of learning if not carefully balanced.

It follows that artificial intelligence is more appropriately understood as a powerful complement to, rather than a replacement for, human teachers. AI excels in the personalisation of practice, the reinforcement of procedural knowledge, and the provision of immediate feedback. Human teachers, by contrast, remain uniquely capable of cultivating the intellectual virtues that underpin meaningful learning: curiosity, critical thinking, and disciplined reasoning. The principal risk in over-reliance on AI is not merely a decline in instructional quality, but an increase in passivity, whereby students become recipients of solutions rather than active participants in the construction of knowledge.

This concern echoes a much older philosophical insight. More than three hundred years ago, in his "Discours de la méthode, pour bien conduire sa raison et chercher la vérité dans les sciences" René Descartes emphasised the importance of intellectual autonomy, urging that one should "never accept anything as true" without clear and distinct understanding, and to avoid both haste and prejudice in judgment. Such a principle underscores the necessity of active reasoning in the pursuit of knowledge—an ideal that cannot be fully realised through passive interaction with even the most advanced technological systems.

In conclusion, while artificial intelligence may rival or exceed average teachers in narrowly defined instructional tasks, it cannot fully replicate the broader pedagogical role of the teacher, particularly in physics education. The enduring value of human educators lies not only in their ability to convey knowledge, but in their capacity to shape the intellectual character of their students. As AI continues to assume responsibility for routine aspects of instruction, the distinctly human elements of teaching—enthusiasm, curiosity, and the ability to inspire—will become not less important, but more so. ■

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