



From Relativity Theory to the Age of AI: Navigating Disruptive Scientific Ideas in University Education

----A Case Study on Physics Education

Yang Li ^{1,*}, Xiangqian Zhang ², Haiyu Zhang ¹, Shirley A. Padua ³

¹ School of Educational Science, Minzu Normal University of Xingyi, Xingyi, 562400, China

² Independent Researcher, No. 111, Erlong New Street, Tongda Town, Lujiang County, Anhui, 231533, China

³ School of Education, Philippine Women's University, 1743 Taft Avenue, Manila, 1004, Philippines

*Corresponding author: 14014772@qq.com

Abstract. This study explores how to address the challenges and opportunities brought by artificial intelligence (AI) in university physics education through the cultivation of students' disruptive scientific thinking. The history of physics, marked by multiple disruptive theories such as relativity and quantum mechanics, provides valuable educational cases. These cases reveal that innovative thinking and a questioning spirit are crucial for scientific progress. With the widespread application of AI in education, students gain a more personalized and intuitive learning experience, but there is also a risk of diminished critical thinking due to reliance on AI. To address this, the paper proposes a series of educational reform strategies aimed at enhancing students' creativity and innovation through curriculum design, interdisciplinary integration, and experimental projects. The findings contribute to understanding how to balance technological application with independent thinking in the AI era, advancing the development of university education.

Keywords: AI, education reform, critical thinking in science

1 Introduction

In recent years, the rapid development of artificial intelligence (AI) has significantly impacted the field of education, particularly in university-level physics education. AI not only provides new tools for knowledge transmission but also supports personalized learning platforms and virtual laboratories, helping students gain a more intuitive understanding of complex physical concepts. For example, using virtual reality technology, students can explore the curvature of spacetime in relativity or simulate particle behavior in quantum mechanics, simplifying the learning of challenging theories ^[1].

However, the widespread use of AI has also brought challenges, especially concerning students' dependence on AI tools, which may weaken their critical thinking skills.

Students may rely on AI-generated answers when facing complex problems, neglecting deeper theoretical reasoning ^[2]. This presents challenges in fostering scientific inquiry and innovation. Moreover, AI has prompted discussions on changes in teaching methods: how to balance traditional knowledge transmission with AI-supported exploratory learning? How to encourage emerging scientific thinking while leveraging AI technology?

Throughout its history, physics has seen many instances of disruptive thinking, such as relativity and quantum mechanics, which have driven major scientific revolutions. This makes physics education an ideal platform for understanding and nurturing such thinking. This study explores how to foster disruptive thinking in students through physics education supported by AI, and proposes related educational reform strategies to advance university education in the new era.

2 Theoretical Foundation of Disruptive Scientific Thinking and Education

Disruptive scientific thinking refers to the mindset that challenges or fundamentally alters existing scientific theories. This kind of thinking requires not only a deep understanding of established knowledge but also the ability to propose alternative hypotheses from new perspectives, often in connection with cutting-edge research. Educational theory emphasizes that fostering such thinking is a critical mission of university education, as it serves as a driving force behind scientific innovation.

The history of physics offers numerous examples of disruptive theories, such as Einstein's special theory of relativity, which transformed the classical understanding of time and space, and quantum mechanics, which, through the uncertainty principle, revolutionized our description of the microscopic world. These theories faced initial skepticism but ultimately became the foundations of modern physics through experimental validation. Such cases illustrate that scientific progress often requires a mindset that breaks away from conventional ideas.

Cultivating students' creativity and critical thinking requires more open educational strategies. For instance, problem-driven teaching encourages students to ask questions like, "What if the speed of light were not constant?" or "Could the speed of light behave as a vector?" Such questions prompt students to explore the limitations of existing theories from fresh perspectives. Additionally, courses in the history of physics help students appreciate the value of skepticism in scientific progress. Interdisciplinary learning, such as quantum computing, which combines physics and information technology, can also inspire students to formulate new hypotheses ^[3].

In summary, disruptive thinking is essential for scientific progress. By using examples from physics, education can unleash students' creative potential, particularly in the context of the increasingly prevalent role of AI technology.

3 Physics Education and Disruptive Thinking

In university education, physics serves not only as a subject for imparting foundational scientific knowledge but also as a crucial platform for cultivating students' scientific thinking and innovative abilities. The unique nature of physics lies in its continuous challenge to and renewal of our understanding of the natural world, which makes it inherently suited for fostering disruptive thinking ^[4]. Through carefully designed courses and experiments, educators can inspire curiosity and creativity in students, encouraging them to consider the world from new perspectives and laying a foundation for scientific innovation.

First, problem-driven teaching is an effective method for cultivating students' innovative thinking. Educators can pose open-ended questions that guide students to examine the limitations and gaps in existing theories from various angles. For example, when discussing relativity, teachers might encourage students to ponder, "Is there a functional relationship between the speed of light and the velocity of the light source?" Such questions not only deepen students' understanding of the core concepts of relativity but also prompt them to propose hypotheses that differ from established theories, thus enhancing their critical thinking skills. Additionally, instructors can introduce "hypothetical challenges," where students work in groups to develop and debate alternative hypotheses in the classroom, stimulating their spirit of inquiry and exploration.

Second, experiments play a vital role in fostering innovative thinking. Physics experiments allow students to validate theories and provide hands-on opportunities to observe phenomena. In designing experiments, educators can promote "open-ended experiments" where students are encouraged to modify or expand standard procedures based on their ideas. For instance, in studies of light refraction and interference, students might be encouraged to explore how the speed of light changes in various media or investigate behaviors at interfaces that traditional theories might not fully explain. Such open-ended approaches allow students to deepen their understanding of physical phenomena while developing new questions that stimulate creative thinking.

Third, the history of physics is a valuable tool for teaching disruptive thinking. The development of many groundbreaking theories has involved significant academic debate and experimental validation. For example, the emergence of relativity and quantum mechanics marked not only scientific advances but also the courage of scientists to propose alternative views against mainstream opinions. By presenting these pivotal events, educators help students realize that scientific knowledge is not static; rather, it evolves with new evidence and perspectives. Physics history courses teach students that the essence of science is questioning and innovation, fostering a mindset that remains open to new knowledge.

In physics teaching, discussions about emerging theories can often take place implicitly, addressing relevant concepts and ideas without directly referencing specific theories. For instance, when introducing the wave-particle duality of quantum mechanics, educators could prompt students to consider, "Could the motion of particles in the microscopic world be described using more complex geometric structures?" This approach encourages students to think critically about existing theories without delving into controversial cutting-edge theories. Such implicit discussions can also occur in an

interdisciplinary context, such as comparing quantum computing with classical computing and encouraging students to explore how new physical models might alter information transmission. This not only broadens students' perspectives but also helps them understand the applications and advancements of physics in modern technology.

Moreover, interdisciplinary collaboration and project-based learning are effective ways to nurture innovative thinking. With AI support, the integration of physics with computer science, data science, and other fields has become more seamless. Teachers can organize interdisciplinary research projects that allow students to engage in real-world scientific inquiry. For example, a project might involve students using AI to analyze data from high-energy particle accelerators, investigating potential anomalies that fall outside the Standard Model. Such projects deepen students' understanding of cutting-edge physics and develop their ability to use diverse scientific methods to solve complex problems. This collaborative, interdisciplinary approach helps students transcend disciplinary boundaries, fostering a multidimensional approach to problem-solving and making them more capable of proposing disruptive scientific hypotheses.

In summary, the methods for fostering disruptive thinking in physics education go beyond knowledge transmission; they aim to create an environment that encourages questioning and supports innovation [5]. In this process, educators serve not only as providers of knowledge but also as guides to the frontiers of scientific exploration. Through problem-driven approaches, open-ended experiments, the study of physics history, and interdisciplinary collaboration, university education can unlock students' innovative potential, preparing them to propose transformative ideas in future scientific research. This educational model not only aids students in making breakthroughs in physics but also equips them to maintain an open and innovative mindset when facing future uncertainties.

4 Application and Challenges of AI in Physics Education

The development of artificial intelligence (AI) has brought significant changes to physics education. Through virtual experiments and personalized learning platforms, AI helps students grasp complex physical phenomena more intuitively. For instance, AI-powered virtual labs can simulate phenomena such as light bending around black holes, enabling students to delve deeper into applications of relativity. Additionally, AI can tailor learning paths based on individual student progress, enhancing their understanding of abstract concepts.

However, the widespread use of AI also presents certain challenges. Firstly, students may become overly reliant on AI, neglecting deeper engagement with the fundamental nature of problems, which can impede the development of independent research skills. Secondly, AI models may introduce biases when simulating complex physical systems, necessitating that educators guide students to critically evaluate AI-generated results to ensure scientific accuracy. Moreover, the convenience offered by AI might reduce students' motivation to propose innovative hypotheses, leading them to accept existing answers more readily [6].

To maximize the benefits of AI while avoiding the suppression of students' creative thinking, educators should incorporate open-ended questions into their curriculum, encouraging students to maintain an exploratory mindset even with AI support. By balancing technology with the cultivation of independent thinking, universities can better guide students to become scientifically literate individuals who are adept with modern technology and capable of critical thought.

5 Strategies for Educational Reform and Future Outlook

With the rapid advancement of AI technology and the challenges posed by disruptive scientific thinking in physics, university education must adapt its training models to better foster students' innovation and critical thinking abilities. Firstly, education should focus on guiding students to question and reflect on existing scientific theories. For example, integrating open discussions and inquiry-based experiments into the curriculum can encourage students to explore the limitations of traditional theories and propose new scientific hypotheses. Such teaching methods not only stimulate curiosity but also cultivate independent thinking skills.

Secondly, interdisciplinary integration is a crucial pathway for promoting innovative thinking. Supported by AI and big data technologies, the integration of physics with computer science, information technology, and other fields is becoming more seamless. By involving students in interdisciplinary projects and research, universities can broaden their horizons and help them understand the connections between different disciplines, thus sparking more creative scientific thinking.

Thirdly, adjusting academic evaluation systems is key to supporting the development of disruptive thinking. Current evaluation systems often emphasize outcomes over the process, potentially undervaluing the importance of exploratory research. Future evaluation standards should be more diversified, encouraging students to propose bold hypotheses and novel research ideas. This is especially important in foundational disciplines like physics, where students' contributions to theoretical innovation and methodological exploration should be highly valued.

Looking ahead, AI technology will play an increasingly important role in education, providing support for personalized learning and interactive teaching. However, universities must ensure that students retain their capacity for independent thinking while leveraging the advantages of technology. By balancing AI assistance with students' self-directed exploration, education can better respond to the rapidly evolving landscape of scientific development. Ultimately, the goal of future educational reforms should be to cultivate scientific talent who are not only knowledgeable but also possess a critical and questioning mindset, capable of tackling increasingly complex global challenges.

6 Conclusion

This study explores the impact of AI technology and disruptive scientific thinking on university physics education and proposes educational strategies centered around open-ended teaching, interdisciplinary integration, and evaluation system reform. Through

these strategies, universities can more effectively stimulate students' innovative thinking and prepare them to navigate the challenges of scientific progress. Future research should further investigate the applications of AI in teaching and explore how educational innovation can support the development of scientific theories, providing support for cutting-edge explorations in physics.

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