



Exploration of the Path of Artificial Intelligence Enabling Science Education

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Abstract

This paper discusses the application of artificial intelligence technology in science teaching and its far-reaching impact on education model. By analyzing the applications of AI technology in personalized learning, virtual LABS and intelligent assessment, the potential and challenges of AI-enabled science teaching are revealed. Research shows that AI technology can significantly improve the effectiveness and efficiency of science teaching, but it also faces technical, ethical and educational equity challenges. This paper aims to provide a reference for science educators to promote the effective application of AI technology in science teaching.

Subject Areas

Pedagogy

Keywords

Artificial Intelligence, Science Education, Teaching Innovation

1. Introduction

With the gradual application of artificial intelligence (AI), especially large model technology in various industries of society, unprecedented intelligent changes are taking place in modern society. Although artificial intelligence shows very good performance, it cannot be fully adapted to the application scenario of the education industry, and its practical application in the field of education is still in its infancy. As an important way to cultivate students' innovative thinking and problem-solving ability, science education is facing the challenge of how to effectively integrate new technologies to improve teaching effectiveness, which undoubtedly brings more opportunities for the personal and professional development of teachers and students [1].

With the increasingly extensive application of artificial intelligence technology in the field of education, especially in science teaching, it still shows great potential. The ability to provide personalized learning experiences, simulate complex scientific experiments, and enable intelligent assessment and feedback has revolutionized science teaching and is seen as a powerful tool. However, how to make effective use of these tools and formulate reasonable implementation strategies for science education is still a problem that educators need to explore deeply.

2. Core Application Scenarios of Artificial Intelligence in Science Teaching

2.1. Personalized Learning Support

At present, artificial intelligence is mainly used in the field of education for personalized learning and assessment of student progress and has achieved certain results, which are reflected in the following points [2].

First, an AI-driven assessment system can significantly improve the efficiency and accuracy of evaluation of science teaching through real-time data analysis and feedback to students [3]. Through the analysis of students' learning data (such as correct answer rate, learning time, cognitive trajectory, etc.), knowledge mastery, learning habits and interests, personalized learning plans and learning paths are tailored for students. In addition, the artificial intelligence system can also adjust the teaching content and teaching methods in a timely manner according to the real-time learning status and feedback of students, meet the learning needs of different students, and promote the comprehensive development of each student.

2.2. Virtual Experiment and Situational Simulation

Studies have shown that AI can significantly improve the efficiency and student engagement of science teaching through adaptive learning platforms and virtual experiments [4]. With the help of technologies such as virtual reality (VR), augmented reality (AR) and mixed reality (MR), the virtual experiment platform powered by artificial intelligence can provide students with a highly realistic experimental environment and experimental operation experience. For example, the molecular dynamic changes of chemical reactions, the formation process of geological structures, etc., so that students enable students to intuitively observe scientific phenomena and deepen their understanding of scientific phenomena. AI tools can significantly improve student learning in virtual experiments through personalized learning paths and instant feedback while providing data support for teachers to optimize teaching strategies [5] [6].

In addition, the virtual experiment platform not only breaks through the limitations of time and space, but also improves the safety and repeatability of the experiment. For example, for some dangerous experiments or experiments requiring special experimental conditions, students can simulate the operation through the virtual experiment platform, which not only ensures the smooth progress of the experiment, but also avoids safety risks.

2.3. Intelligent Integration of Teaching Resources

The research finds that the teaching resource integration platform of artificial intelligence can achieve accurate matching and efficient utilization of resources through data analysis and knowledge graph technology [4]. The PaperQA2 system, for example, analyzes thousands of academic papers in minutes to generate structured scientific knowledge items, providing efficient support for teachers in lesson preparation and student research. In addition, the intelligent lesson preparation platform can automatically generate multi-modal teaching plans (such as courseware, videos, and games) based on the teaching syllabus, which greatly reduces the repetitive labor of teachers.

Therefore, the integration of AI-driven teaching resources is evolving from an auxiliary tool to an innovation catalyst, and more emphasis will be placed on personalized learning and innovation ability cultivation in the future [7].

2.4. Teaching Evaluation and Feedback Optimization

In terms of teaching evaluation, in American higher education, with the support of artificial intelligence technology, teaching evaluation has turned to formative and pluralistic evaluation, emphasizing the balance between evaluation subject and technology [8]. A systematic review of empirical research on AI and science education from 2014-2023 shows that the use of AI tools in science education can achieve a variety of pedagogical benefits, including assessing student work and predicting academic performance [9]. For example, students' experimental skills and scientific thinking are evaluated by analyzing their operation steps, reaction time and data records in virtual science experiments. In addition, artificial intelligence is not interfered by subjective factors and can be carried out in accordance with preset rules and standards in scoring and evaluation, avoiding the subjective bias and fatigue errors that may exist in teachers and ensuring the objectivity and fairness of evaluation results.

In terms of teaching feedback, AI can continuously track students' learning progress and dynamically adjust feedback content and strategies. Beyond traditional text-based feedback, artificial intelligence can also present feedback content through images, videos, animations, and other forms, helping students better understand and accept. For example, when explaining the structure of chemical molecules, artificial intelligence can show the correct molecular model through 3D animation, helping students to more intuitively understand their own mistakes in model construction.

3. Implementation Strategy of Artificial Intelligence in Science Teaching

3.1. Professional Development of Teachers

Schools should provide systematic training courses to help teachers familiarize themselves with the functions and use of various AI tools and guide teachers to use AI tools to collect and analyze student learning data for precision teaching and

personalized guidance. Many universities in the United States provide specific training and tutoring for teachers, both online and offline. Stanford University is offering training for teachers to teach using AI through its Teaching Commons ahead of the 2023-2024 academic year. The training consists of six modules: helping teachers get familiar with AI, improving teachers' motivation to accept and use AI tools; Analysis of AI tools' core concepts and functionalities; exploration of AI-driven teaching methodologies and workflows; and discussion on their potential impacts on teaching quality enhancement; For a specific curriculum, analyze the impact of school policies on the use of AI in that curriculum and assess the possibility of applying AI tools; Develop specific provisions for the use of AI tools to be included in the course teaching plan; Discusses how to effectively guide students to use AI tools to complete homework and the corresponding learning outcome evaluation methods.

In addition, training teachers' ability to apply AI tools can provide resources and platforms for teachers to actively learn AI-related knowledge, pay attention to the development of AI, master AI teaching tools, and carry out innovative applications in science teaching, such as developing AI-assisted experimental courses or designing AI-based inquiry learning projects.

3.2. Curriculum Design Integration of Artificial Intelligence

The current state and future direction of AI in education show that technological integration with pedagogy is critical to innovating teaching and learning.

3.2.1. Integration of Teaching Objectives

Before the course design, it is necessary to clarify the use goals of AI tools, such as improving students' learning interest, enhancing concept understanding, and cultivating scientific inquiry ability. For example, students should understand the application scenarios of artificial intelligence in scientific research, such as how artificial intelligence assists astronomy in the analysis of galaxy observation data and cultivate students' cognition of the intersection of science and technology.

3.2.2. Application of Teaching Methods

Make use of AI-driven teaching tools, such as intelligent teaching platforms, virtual LABS, etc. In the teaching of chemical experiments, with the help of virtual laboratory software, students can carry out high-risk or difficult-to-operate experiments in a virtual environment, and through the simulation and feedback of artificial intelligence, students can better understand the experimental principles and steps.

In addition, with the help of artificial intelligence learning analysis technology, personalized learning paths and resource recommendations are provided for students according to their learning progress, knowledge mastery and other data.

3.2.3. Teaching Evaluation Design

The use of artificial intelligence technology for teaching evaluation, such as automated homework grading and exam scoring systems, can not only improve the

efficiency of evaluation, but also provide teachers with detailed student learning reports through data analysis, helping teachers to more accurately understand students' learning problems and advantages, so as to adjust teaching strategies.

In addition, content related to the application of artificial intelligence can also be added to teaching evaluation indicators. For example, it evaluates students' ability of data collection, analysis and interpretation when using artificial intelligence tools for scientific inquiry, as well as their performance when using intelligent software to complete science projects and comprehensively evaluates students' scientific learning outcomes under artificial intelligence environment.

3.2.4. Creation of Learning Environment

Artificial intelligence technology is used to build intelligent learning Spaces, such as classrooms equipped with intelligent interactive devices and learning analysis systems, to provide students with a sense of science and technology and interactive learning environment and promote students' independent learning and cooperative learning. In the new learning environment, NPR_eL can also be integrated into the learning environment to provide personalized learning materials [10]. It can also integrate online artificial intelligence education resources, such as online courses, popular science websites, academic databases, etc., to provide students with rich learning materials. Teachers can guide students to use these resources for extra-curricular extension learning to deepen their understanding of scientific knowledge and artificial intelligence technology.

3.3. School Technical Support

Schools need to establish a reliable technical infrastructure, including network environments and hardware facilities, to ensure the stable operation of AI tools. At the same time, a special technical support team should be set up to solve technical problems in the process of use in a timely manner. In addition, data security and privacy protection are also important issues to be considered, and schools should develop strict data management policies to ensure the safety of students' and teachers' personal information.

3.4. Establish Evaluation and Feedback Mechanism

Schools should regularly evaluate the use effect of AI tools, establish a scientific evaluation system, and evaluate the use effect of AI tools, including students' learning outcomes, teachers' teaching effects, and curriculum implementation. Simultaneously, it is essential to collect feedback from both teachers and students, promptly identify challenges in AI tool implementation, and adapt strategies to facilitate continuous improvement and optimization.

3.5. Ethics and Educational Equity

Even before ChatGPT appeared, there were scholars who deeply discussed the pros and cons of AI tools. To this end, many countries have begun to actively

develop principles and strategies for responding to and using AI tools. Both the UK and Germany have established normative requirements for the use of AI tools in education. Therefore, in the process of using artificial intelligence education, it is necessary to pay attention to cultivating students' digital literacy and AI ethical awareness so that students can not only master technical skills, but also establish correct values and ethics in the process of using AI tools, and become responsible digital citizens.

In addition, the application of AI technology in the integration of teaching resources can promote educational equity and narrow the technological gap between urban and rural school [11]. With the help of online education platform and artificial intelligence technology, the restrictions of regional and school resource differences are broken so that students in remote areas or areas with poor education resources can also obtain high-quality science education resources. For example, through live courses, virtual LABS, and other ways to share quality education resources, the education gap between urban and rural areas and regions can be narrowed. This is reflected in narrowing the achievement gap between urban and rural areas. For example, Beijing Normal University's "Wisdom Empowerment Project" in Liangshan Prefecture, Sichuan Province, China, shows that AI-assisted teaching has improved the scores of rural students by an average of 20% and narrowed the urban-rural gap by 15%, and Baiyun District, Guangzhou, has reduced the academic level gap between urban and rural students by 12% through the "three classrooms" alliance. The teaching ability of rural teachers has been improved by 30%. It is also reflected in improving equity in education. The survey shows that the "Internet + education" demonstration zone in Ningxia, China, has increased the coverage of quality courses for rural students from 40% to 85% through AI dynamic allocation of resources.

4. Challenges and Prospects of AI Tools in Science Teaching

Although AI shows great potential in science teaching, its application still faces many challenges. The first is technical constraints. Current AI still has limitations in dealing with complex scientific concepts and open-ended questions, making it difficult to completely replace the role of teachers. Then, there is the issue of acceptance by teachers and students. Some teachers may have a conservative attitude towards new technologies, and students may rely too much on AI and neglect the learning of basic knowledge and skills, so AI will also pay more attention to the collaboration with teachers, becoming a good assistant to teachers rather than a substitute [12].

Another important trend is that AI will focus more on cultivating students' creativity and critical thinking rather than just knowledge transfer [7]. Future AI systems may be designed with more open-ended questions and inquiry-based tasks, encouraging students to think and practice creatively.

5. Prospect

The application of artificial intelligence in science teaching offers new possibilities

for educational innovation. Through tools such as intelligent tutoring systems, virtual LABS, and adaptive learning platforms, science teaching can become more personalized, interactive, and effective. However, to fully exploit the benefits of these tools requires educators to deeply understand their principles, develop sound implementation strategies, and actively address various challenges.

The future of science education will be a new era of collaboration between artificial intelligence and human teachers. Educators should maintain an open and innovative attitude and actively explore new applications of AI in teaching while also being alert to the possible negative effects of the technology. Only by finding a balance between technology, education, and ethics can we truly realize the value of AI tools in science teaching. Moving forward, as technological advancements continue to emerge, artificial intelligence will not only improve teaching efficiency but also become the core help to stimulate students' spirit of scientific inquiry and innovation ability.

Conflicts of Interest

The authors declare no conflicts of interest.

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