The innovation and development of mathematics curricula in China in the context of artificial intelligence

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Abstract

This article examines the pros and cons of artificial intelligence (AI) in education and science. It analyzes how AI can change the traditional education system and proves that these changes are surmountable. The results of studying the theoretical foundations and practical experience of using AI in the development of mathematics curricula and their implementation are presented. It is noted that the novelty of using AI increases students' interest in mathematics, motivates them to study new types of tasks, and stimulates independent study of the subject. It is concluded that AI can provide an individual and adaptive approach to learning, an interactive and immersive environment, instant feedback and access to a wide range of resources that contribute to improving knowledge of mathematics, including in the field of engineering calculations, programming and economics. This article also explores the use of artificial intelligence in China's education system to improve access to education. As a result of the study, the role of AI in China's education system was determined.

Keywords

artificial intelligence, curricula, mathematics programs, China's education, digitalization, innovation, high technologies.

Introduction

Recent technological advancements, such as artificial intelligence (AI), have become an integral part of the processes shaping the 21st century. The implementation of AI received a significant boost in recent years, spreading across the globe and impacting numerous industries. Today, governments are prioritizing the development of national AI strategies, as well as education planning concepts aimed at effective human-machine interaction in everyday life, learning, and professional activities, which is key to sustainable development.

In this paper, artificial intelligence (AI) refers to a combination of hardware and software endowed with a wide range of capabilities and algorithms that mimic the human mind (McCarthy, 1990).

The relevance of the study is due to the rapid development of AI and its increasingly deep penetration into various spheres of activity, including education. The field of education, being one of the most traditional in society, is actively transforming under the influence of innovative digital solutions, based, among other things, on artificial intelligence technologies. The demand for such solutions is constantly growing, which is expressed in the expansion of the range of online courses, the introduction of visual practices, the holding of interactive

webinars and the transition to distance forms of control with an automated assessment system. The integration of artificial intelligence (AI) into the modern education system presents both new opportunities and challenges. To effectively evaluate these, it is beneficial to analyze the experience of AI implementation in the education systems of China, a country demonstrating rapid technological advancements. China also faces the challenge of ensuring equal access to education, making its experience particularly valuable.

Examining China's achievements in AI-powered education and government initiatives in this domain will enable us to understand how these technologies can:

1. Expand learning opportunities: AI can personalize learning experiences, catering to individual student needs and learning styles, making education more effective and engaging.
2. Ensure equitable access to education: AI-based tools can bridge geographical and socioeconomic barriers, providing equal access to quality education for all students, regardless of their background or location.
3. Promote unbiased and inclusive education: AI can mitigate biases in traditional assessment methods, ensuring fairer evaluation of student performance and fostering a more inclusive learning environment.
4. Enhance teacher effectiveness: AI can assist teachers in lesson planning, grading, and providing personalized feedback, allowing them to focus on building meaningful interactions with students.

By understanding the Chinese experience in AI-powered education, we can gain valuable insights into how to harness these technologies to transform our own education systems, making them more effective, equitable, and inclusive.

The purpose of the article is to consider the impact of artificial intelligence on higher education using the example of China. This article examines the positive impact of artificial intelligence (AI) on the higher education system using the example of China. To achieve this goal, the following tasks were set:

1. Analyze the scientific literature on the threats that artificial intelligence poses to classical education;
2. Analyze the prospects and challenges that AI poses to traditional forms of education;
3. To identify the advantages and disadvantages of AI for education, in particular for teaching theoretical and applied mathematics;
4. Assess the potential threats that AI may pose to the existing education system;
5. To propose solutions to these problems and ways to adapt the modern education system to new realities.

The use of AI in education can lead to a number of positive changes:

– improved learning quality through the personalization of educational programs and their adaptation to the individual needs of each student;
– make the learning process more interactive and engaging by using various AI tools, such as chatbots, virtual assistants, and educational games;
– automate routine tasks, allowing teachers to devote more time to working with students;
– make education more accessible to people with disabilities.

The scientific novelty of the article lies in the analytical research analysis conducted by the author. Having systematized and classified the theoretical foundations and practical aspects of using artificial intelligence technologies in the process of teaching theoretical and applied mathematics, the author for the first time presented a generalized overview in this area, specifying the positive experience of the Chinese education system.

Theoretical significance of this study lies in the systematic organization of the advantages and promising directions of AI development, contrasting them with potential disadvantages. The implementation of AI can provide a personalized and adaptive approach to learning, creating an interactive and immersive learning environment. Prompt feedback and access to a wide range of resources will contribute to the improvement of students' subject mathematical knowledge, including computer science and economics. The practical significance of this work lies in the application of AI tools to solve specific tasks in mathematics lessons within the framework of curricula and to assess their impact on improving student knowledge and automating independent work.

By analyzing various points of view on the problems of the modern world of technology and its digital future, it can be assumed that we are on the verge of a new scientific and technological paradigm. This new system of knowledge, based on revolutionary discoveries that will become possible thanks to the widespread introduction of information technologies and artificial intelligence, can fully take shape in the coming years. The impact of this paradigm can affect not only practical, informational, educational, economic, or engineering activities, but also the very principles of mathematical thinking (Kuhn, 1970).

Current challenges of mathematics in modern engineering, information (mainly digital) and educational activities are:

– optimization of a set of mathematical operations related to the transmission and processing of signals represented as «words» of error-correcting code;

– solving mathematical problems of algorithmic coding and decoding of dimension 24 thousand (in connection with the transition to more modern 5G data transmission standards);

– development of new solutions in the field of big data processing.

Materials and methods of research

In the near future, mathematics will become a powerful catalyst for progress in quantum physics and related technologies. This applies to quantum computing, quantum computers, quantum machine learning, and other areas that can radically accelerate scientific and technological progress and lay the foundation for a new engineering mindset.

Bioengineering also holds tremendous potential. It can become the starting point for the creation of biomathematics – a new interdisciplinary field that will merge biology, genetics, combinatorics, analysis, geometry and computer science. This will allow researchers to build a model of the human brain and study its cognitive functions in detail.

Breakthrough in mathematical modeling methods for complex systems can be a catalyst for the rapid development of a number of promising technologies with great significance for the future. These include space exploration, development of unmanned control systems (like self-driving cars), forecasting and managing weather events and climate, and even improving social spheres such as politics, art, economics, and sociology. According to experts, the key element on this path will be the creation of a high-quality conceptual theory of the formation of dynamic configurations in chaotically complex systems.

University educators around the world held a positive outlook on artificial intelligence prior to the emergence of chatbots. They envisioned several advantages, including personalized learning through AI-selected educational materials (audio, video, e-textbooks) to significantly enhance educational quality, streamlined content creation through AI's assistance in finding materials and crafting lectures, and improved assessment and understanding of student progress due to AI's ability to reduce errors.

In addition to the listed advantages, teachers also noted some potential disadvantages of using AI in education:

– potential increase in teacher workload: AI may require additional teacher training and time to integrate it into the educational process;

– dependence on technology: Excessive reliance on AI can lead to a decrease in the creativity and critical thinking skills of students;

– ethical concerns: The use of AI raises concerns about data privacy, student anonymity, and potential bias in AI algorithms (Bucea-Manea-Ţoniş, 2022).

The utilization of specialized educational chatbots, also known as AI tutors, has become prevalent in enhancing students' mathematical knowledge. These systems simplify the comprehension of complex economic concepts by providing clear and concise explanations. Examples of such systems include EconoGuide, EconomicsGPT, El Economista, Deep Dive: Economics, and Intermediate Microeconomics GPT. The primary goal of these interactive assistants is to make economics education more accessible and engaging.

The learning process underlying these GPTs is based on a comprehensive and analytical approach to mastering economic theories and models. They employ engaging and real-world examples from practice to

illustrate microeconomic applications. This allows users to observe the application of theory in the context of real-world problems.

Results and discussion

Over the past decade, China has witnessed remarkable progress in Industry 4.0 technologies, emerging as a frontrunner in several cutting-edge fields, including artificial intelligence (AI). One exemplary illustration of AI implementation in China is the Squirrel AI project. This company specializes in personalized education powered by AI, investing heavily in AI talent and fostering further research in the domain. Squirrel AI's algorithm enables students to receive 70% of their learning content from the AI system, while the remaining 30% is delivered by traditional teachers. This approach strikes a balance between individualized instruction and human oversight, ensuring personalized learning experiences while maintaining human control over the educational process.

The integration of artificial intelligence (AI) into China's education system is driven by a transformative vision: to transition from a mass-produced education model to one that prioritizes high-quality learning for all. AI-powered programs are designed to cater to the unique needs and abilities of each individual student.

In 2017, the State Council unveiled the New Generation Artificial Intelligence Development Plan, outlining China's ambition to become a global leader in AI innovation by 2030. A key pillar of this plan is to enhance public awareness and adoption of AI.

To operationalize this policy, in September 2018, the Ministry of Education initiated the Artificial Intelligence Education for Primary and Secondary Schools program. This initiative aims to collaborate with municipal academies of science, schools, and private sector partners to develop high-level AI courses for students.

Schools and municipalities selected for the pilot implementation of AI courses enjoy significant flexibility and autonomy in designing their curriculum and selecting teaching materials. Since 2018, multiple AI textbooks have emerged, primarily co-authored by education experts and AI specialists. These textbooks vary in target audience, thematic focus, and integration with broader information technology (IT) disciplines.

Non-governmental organizations (NGOs) also make a significant contribution to the implementation of China's state policy in the field of AI education. A leader in this area is the Hong Kong company SenseTime, which is engaged in the development of artificial intelligence technologies. In partnership with the East China Normal University's MOOC Center, in 2018 it released the textbook Fundamentals of Artificial Intelligence», which is recognized as the world's first textbook on this topic. Subsequently, the company created a subsidiary SenseTime Edu, aimed at offering comprehensive «educational solutions using AI». These include: providing training platforms, laboratories and training robots based on SenseTime's patented technologies, as well as developing a series of AI textbooks for people of all ages.

To foster both personal and professional development, all School of Engineering students are offered a range of research and project opportunities throughout their studies: exchange programs; mentorship program; internship program; industrial training; competitions; capstone project; undergraduate Research Opportunities Program (UROP) (Rhee, 2024).

The program emphasizes predictive and prescriptive analytical tools, statistical models, machine learning algorithms, simulation, and creative modeling, aligning with the requirements of the modern economy. Building on this foundation, students gain specialized mathematical knowledge in areas of financial engineering or consulting services, including risk management, supply and demand analysis, e-commerce, revenue optimization, healthcare analytics, and even sports analytics (Rhee, 2024).

Morgan Stanley, JP Morgan, Founder Securities, WorldQuant, and others). Internships provide experience in corporate life and introduce students to industry practices (Estrella, 2017).

The Hong Kong University of Science and Technology (HKUST) School of Engineering, a leading engineering school in Hong Kong, offers a wide range of research-intensive engineering programs in aerospace engineering, bioengineering, chemical and environmental engineering, computer science and engineering, sustainable energy, and decision analytics (Tan, 2006).

The program actively invites academic and industry experts to supervise student research projects. Students implement a Capstone project in collaboration with financial firms (including Morgan Stanley, JP Morgan, Founder Securities, WorldQuant, and others). Internships provide experience in corporate life and introduce students to industry practices (Link, 2015).

In today's world, where technology is developing at an ever-increasing pace, artificial intelligence (AI) is playing an increasingly important role in all spheres of life, including education. The enormous potential of AI opens up new opportunities for improving the quality of education, making it more accessible, personalized, and effective.

However, the implementation of AI in the educational process is associated with a number of challenges that require a comprehensive approach and systemic solutions.

A key aspect is ensuring inclusivity and fairness. It is necessary that all learners, regardless of their origin, gender, or socioeconomic status, have equal access to AI opportunities.

To achieve this, it is necessary to develop ethical standards for the use of AI in education, taking into account the rights and interests of all participants in the educational process, ensuring the transparency of the functioning of AI systems, making them understandable and accessible for public control, and strengthening interaction between AI solution developers, teachers, researchers, and representatives of different social groups to develop balanced and effective solutions.

The increasing application of AI technologies in education opens up new opportunities for improving the quality of education, empowering teachers, and strengthening education management systems.

However, it is important that the implementation of AI takes place in compliance with ethical norms and standards, as well as taking into account the following principles:

– AI should serve to improve the quality of education for all learners, empower teachers, and strengthen education management systems;
– the development and use of AI in education should strictly comply with ethical principles;
– preparing for life with AI: The education system should prepare learners and all citizens for safe and effective interaction with AI in everyday life and professional activities.

In addition, AI can help to personalize learning by selecting the optimal methods and materials for each student, freeing up teachers from routine tasks, allowing them to pay more attention to individual work with students, and can be used to create new educational formats, such as online courses, simulations, and virtual laboratories.

It is important to note that the development of AI in education should be accompanied by public discussion and broad participation of all stakeholders. Only if these principles are observed will AI become a powerful tool for improving the quality of education and developing society as a whole.

The implementation of AI in education is a complex and multifaceted process that requires careful planning and a balanced approach. However, with proper use, AI can become a powerful catalyst for the development of education and make it more accessible to everyone.

The development of artificial intelligence (AI) is moving beyond traditional fields of activity, requiring new approaches to its regulation and education. Effective AI regulation is impossible without the active participation and cooperation of all stakeholders representing different disciplines and industries.

In this context, UNESCO plays a key role in facilitating dialogue and knowledge exchange between key players in both the public and private sectors. A number of UNESCO events and adopted resolutions have raised awareness of the wide range of possibilities and enormous potential of AI for education.

In 2019, the Mobile Learning Week – the UN's flagship event on ICT in education – considered the link between AI and sustainable development. This was an important step towards supporting Member States in their responses to the complex challenges posed by AI (Wu, 2020).

In 2019, UNESCO, in cooperation with the People's Republic of China, held an international conference in Beijing entitled «Planning Education in the AI Era». The aim of the conference was to consider the impact of AI on education as a whole. The Beijing Consensus was presented and adopted at this event.

The Beijing Consensus is the first ever document to provide recommendations on the optimal use of AI technologies to achieve Sustainable Development Goal 4 (SDG 4) – Education 2030.

The document, in particular, proposes:

1. For UNESCO to develop guidelines and resources to support policy makers and to integrate AI skills into the ICT competency paradigm.
2. To take a holistic approach to strengthening international cooperation on AI and education with relevant partners.

Thus, «AI Technologies in Education: A Guide for Policy Makers» is a document developed within the framework of the implementation of the Beijing Consensus. It is intended to provide support to those involved in developing educational regulatory measures related to the use of AI (Yan, 2021).

This document serves as a companion to UNESCO's ongoing efforts in AI and education. It targets a broad audience of specialists and practitioners involved in educational strategy and development. The document's objective is to establish a shared understanding of the opportunities AI presents for education, along with the current and future shifts in the knowledge and skill sets needed in the AI age. It assesses the advantages and potential drawbacks of utilizing AI to address challenges in achieving Sustainable Development Goal 4 (SDG 4) for «Quality Education». Additionally, it identifies and outlines methods to mitigate these potential risks. The publication introduces new national regulatory frameworks and cutting-edge practices for leveraging AI to enhance educational quality.

Therefore, this document can serve as a comprehensive guide for developing AI and education regulations, encompassing the full spectrum of considerations, from planning humanistic and strategic objectives to determining the key components for policy formation and implementation strategies. In light of the rapid development of artificial intelligence and its impact on education, this document raises a number of key issues that require close attention from governments and partners. Analysis of accumulated experience and a humanistic approach to policy regulation in this area can be the key to directing the use of AI for the benefit of society.

The relevance of the topic is due to the fact that AI is already being actively implemented in educational processes. This entails both positive changes and new problems. Studying the impact of AI on learning is of strategic importance. It depends on how effectively we can integrate new technologies into educational practices and use their potential to achieve the common good and create a comprehensive and sustainable future.

The integration of artificial intelligence (AI) into the learning process, while offering undeniable advantages, also presents certain drawbacks that demand careful consideration.

Reduced Human Interaction and Communication Skills: overreliance on AI for teaching tasks can lead to a deficit in live communication, hindering the development of crucial communication skills. Education solely mediated by AI systems lacks the richness of interactions and collaborative activities that foster effective communication and teamwork. This, in turn, limits the cultivation of essential soft skills, such as empathy, critical thinking, and adaptability, which are highly valued in both personal and professional spheres.

Emotional Intelligence and Support: neural networks may not always accurately recognize and respond to the emotional state of learners. The absence of interaction with live teachers, who can understand students' emotional needs, deprives them of support during challenging situations. This hinders the development of emotional intelligence, which plays a pivotal role in life and work adaptation.

The implementation of neural networks in higher mathematics education opens up new horizons, making it more effective, personalized, and engaging. This technology offers a paradigm shift by tailoring learning to individual student needs. Neural networks can adapt to each learner's knowledge level and abilities, customizing the curriculum and pace of instruction. This personalized approach fosters rapid progress and a deep understanding of complex mathematical concepts.

Furthermore, neural networks leverage visualization and interactivity to transform abstract concepts into clear, visual representations. Interactive elements empower students to move beyond passive learning, actively exploring the material and establishing connections between different mathematical principles. This fosters a deeper engagement with the subject matter. The learning speed also reaches new heights with neural networks. Powerful algorithms process vast amounts of data and perform complex calculations instantaneously. This enables real-time feedback, allowing students to identify and correct errors quickly, propelling them forward in their learning journey.

In conclusion, neural networks represent a transformative force in higher mathematics education. By offering personalized learning paths, enhanced visualization, and accelerated learning with real-time feedback, they empower educators to create a dynamic and immersive learning environment. This fosters a deeper appreciation and understanding of the fascinating world of mathematics. Automating routine tasks, such as checking assignments, frees up teachers' time. This allows them to focus on individual work with students, mentoring, and creative projects. Personalized learning materials, created by neural networks, cater to the unique characteristics of each student. Unique learning plans, tailored to the individual, boost motivation and improve results.

Accessibility of education is another crucial goal of neural networks. They break down barriers, making knowledge more accessible to people with disabilities. Neural networks are not simply a tool; they are a true catalyst for change in the teaching of higher mathematics. With their help, we can enhance the efficiency of learning, personalize it further, foster a deep understanding of the subject in students, and make mathematics fascinating, understandable, and accessible to everyone.

On the one hand, neural networks can effectively process formulas, operate with numbers, and personalize learning for each student. On the other hand, they lack the flexibility for a full-fledged «understanding» of mathematical concepts, exploring abstract ideas, and generating new theories. The effectiveness of neural networks directly depends on the amount of training data, which can limit their application in conditions of limited resources. The use of neural networks in education also raises ethical issues such as bias, discrimination, and data privacy.

Recurrent neural networks (RNNs) are a powerful tool from the field of artificial intelligence capable of analyzing and predicting time series. Their main advantage is that they take into account long-term dependencies in the data, which leads to more accurate predictions and expands the possibilities for decision-making. RNNs are used in a wide variety of fields, from finance and stock trading to meteorology and demand forecasting.

The implementation of RNNs can bring great benefits, as they:

1. Are able to take into account long-term dependencies, which allows them to make more accurate predictions compared to traditional methods.
2. Can extract hidden patterns in data that are not visible to ordinary analysis methods.
3. Can automate many routine tasks associated with analysis and forecasting, which frees up specialists' time for more creative and strategic tasks (Jiang, 2012).

The integration of artificial intelligence (AI) into education has become an irreversible process, bringing with it both advantages and disadvantages. Researchers are faced with a critical question: which pedagogical functions can be automated using AI, and which require exclusively human involvement? The key to effective AI implementation in education lies in developing hybrid models that combine human and machine capabilities. It is also necessary to establish clear guidelines for AI usage and create algorithms capable of assessing learners' emotional responses. These measures will help minimize the negative aspects of AI while preserving its benefits.

Conclusion

In conclusion of our study, we would like to emphasize that one of the leading trends in the development of modern society is the phenomenon of artificial intelligence, which is increasingly replacing humans in a wider range of areas, including education. At the present stage of development of artificial intelligence, this includes not only teaching, but also grading, writing essays, and making recommendations to students.

AI in education has the potential to revolutionize learning, but it's important to recognize that it also has some limitations. One challenge is that AI may not always be effective in teaching. Unlike human teachers, AI systems don't have emotions or empathy, which can make it difficult for learners to feel connected to them. This can be especially problematic when students need emotional support or have complex questions that require nuanced understanding. Nevertheless, artificial intelligence can be used as a large-scale educational tool that guides students towards their goals by providing personalized feedback. It has the potential to make life easier

for everyone through automation. AI is a major driving force of change in education, as demonstrated by countries like China.

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Инновации и развитие учебных программ по математике в Китае в контексте искусственного интеллекта

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Аннотация

В этой статье рассматриваются плюсы и минусы искусственного интеллекта (ИИ) в образовании и науке. В ней анализируется, как ИИ может изменить традиционную систему образования, и доказывается, что эти изменения преодолимы. Представлены результаты изучения теоретических основ и практического опыта использования ИИ при разработке учебных программ по математике и их реализации. Отмечается, что новизна использования ИИ повышает интерес учащихся к математике, мотивирует их к изучению новых типов задач и стимулирует самостоятельное изучение предмета. Делается вывод, что искусственный интеллект может обеспечить индивидуальный и адаптивный подход к обучению, интерактивную и захватывающую среду, мгновенную обратную связь и доступ к широкому спектру ресурсов, которые способствуют улучшению знаний по математике, в том числе в области инженерных расчетов, программирования и экономики. В этой статье также рассматривается использование искусственного интеллекта в системе образования Китая для улучшения доступа к образованию. В результате исследования была определена роль искусственного интеллекта в системе образования Китая.

Ключевые слова

искусственный интеллект, учебные планы, математические программы, образование Китая, цифровизация, инновации, высокие технологии.

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