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COMPARATIVE ANALYSIS OF APPROACHES TO THE STUDY OF ARTIFICIAL INTELLIGENCE IN THE HIGHER EDUCATION SYSTEMS OF THE USA AND CHINA

ANÁLISIS COMPARATIVO DE LOS ENFOQUES DEL ESTUDIO DE LA INTELIGENCIA ARTIFICIAL EN LOS SISTEMAS DE ENSEÑANZA SUPERIOR DE EE.UU. Y CHINA

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ABSTRACT

The USA and China are now rivals in a wide range of areas. One of the most relevant now is artificial intelligence (AI), where the potential of the two leading states is also quite comparable. AI is an extremely knowledge-intensive industry and requires a large number of highly qualified specialists capable of developing and implementing such systems. Thus, the future of AI directly depends on the quality of education, especially higher education, and on the approach to its organization. This paper describes how China and the United States integrate AI training at the higher level of education. The authors conclude that now AI education in China and the United States is at a comparable level. However, in China they observe a centralized approach, while in the USA the approach is more flexible and freer. Further, the authors provide an analysis of the advantages and disadvantages of each country's approach and how they can influence the future of science, technology, and education there. Chinese centralized system allows the necessary scientific and technical personnel to be trained in a streaming mode, the US system cannot achieve this, but it has more potential in the development of innovation and academic freedom. In conclusion, the authors provide a forecast of measures that should be taken by each of the parties to effectively use the advantages of their approach to education and overcome its shortcomings.

Keywords:

Artificial Intelligence, Higher Education, Computer Science, Postgraduate Studies, Curriculum.

RESUMEN

Estados Unidos y China son ahora rivales en una amplia gama de ámbitos. Uno de los más relevantes ahora es la inteligencia artificial (IA), donde el potencial de los dos Estados líderes es también bastante comparable. La IA es una industria extremadamente intensiva en conocimientos y requiere un gran número de especialistas altamente cualificados capaces de desarrollar e implantar este tipo de sistemas. Así pues, el futuro de la IA depende directamente de la calidad de la educación, especialmente de la enseñanza superior, y del planteamiento

de su organización. Este artículo describe cómo China y Estados Unidos integran la formación en IA en la enseñanza superior. Los autores concluyen que actualmente la formación en IA en China y Estados Unidos se encuentra a un nivel comparable. Sin embargo, en China observan un enfoque centralizado, mientras que en Estados Unidos el enfoque es más flexible y libre. Además, los autores ofrecen un análisis de las ventajas e inconvenientes del enfoque de cada país y de cómo pueden influir en el futuro de la ciencia, la tecnología y la educación en ellos. El sistema centralizado chino permite formar en streaming al personal científico y técnico necesario, el estadounidense no puede conseguirlo, pero tiene más potencial en el desarrollo de la innovación y la libertad académica. Para concluir, los autores ofrecen una previsión de las medidas que debería tomar cada una de las partes para aprovechar eficazmente las ventajas de su enfoque de la educación y superar sus deficiencias.

Palabras clave:

Inteligencia Artificial, Enseñanza Superior, Informática, Estudios de Postgrado, Plan de Estudios.

INTRODUCTION

Nowadays, it is difficult to imagine life without information technologies since they have already become an integral part of it. The field of education, which aim to form a full-fledged understanding of the surrounding world and the necessary skills for orientation and living in it, naturally cannot ignore the existence and application of innovative technologies both as a phenomenon and as a tool. In the educational systems of different countries changes are taking place at all levels of education: from primary to postgraduate education (Astratova, 2021). This is due to the fact that the field of education adapts to the inevitable changes in the life of modern society, the increasing importance of information and information technology, the constantly updated demands of the labor market. Now the most promising direction is the development and implementation of artificial intelligence (AI), which allows us to enhance human capabilities, and at the same time there is an aspiration in the education system to use AI to realize their own goals and objectives, as well as to provide society with knowledge about AI.

Higher educational institutions, striving to keep up with the times, are looking for solutions to optimize and update the content of the educational process. The quality and level of modernization of education often correlate with the state of the country's economy (Yershov & Vertakova, 2010). On the one hand, a high level of education provides the labor market with professionals who ensure the achievement of economic success. On the other hand, the advanced economy creates a demand for high-quality education, which will constantly update competitive advantages, create new forms of economic activity, and integrate into the global production system. In addition, the level of economic well-being directly affects how much a country can invest in the development and support of education.

The United States of America (USA) and the People's Republic of China (PRC) are now leaders in the world in terms of the size of the economy, the level of AI development and the quality of university education. Together, they account for 90% of the market capitalization of the 70 largest digital platforms. The race in the field of AI between these two states has been discussed in professional and scientific discussions for several years (Castro & McLaughlin, 2021). It is obvious that the quality of developments and the depth of AI implementation are directly related to the development of the education system, especially higher education, since AI is now an extremely knowledge-intensive industry. In this regard, in this paper we seek to analyze approaches to the role of AI in the higher education systems of the USA and China, to determine their goals, similarities and differences – based on the findings, it will be possible to make a forecast about the prospects for the development of AI in each of the two countries.

MATERIALS AND METHODS

Artificial intelligence in the US higher education system

In US universities there is a belief that the use of information and communication technologies (ICT) in the educational process provides conditions for the formation of methodological views of a graduate, the ability to transform scientific material into a fragment of an academic discipline. At the undergraduate level, AI training is diverse and often depends on the type of educational institution or the availability of partners and sponsors in the industry itself. AI Index Report for 2021 showed that the number of universities offering undergraduate programs in computer science, AI and machine learning has grown significantly. More often, universities offer master's programs and degrees in the field of AI.

In general, US universities are considered the best place among other higher education institutions abroad, where you can get a specialization in IT technologies. According to research company Technavio's forecast, AI-based educational systems will be more actively implemented

in universities in the coming years (Bates et al., 2020). Nowadays, on the threshold of transformation, investments in the new IT industry already amount to hundreds of millions of US dollars. The authors of the study "Artificial Intelligence in Higher Education. Current Uses and Future Applications" (Klutka, 2018) note that AI finds application in the widest range of tasks of the educational process. Researchers identify 4 main groups of tasks:

- selection and admission of students;
- acceleration of learning;
- learning tasks;
- optimization and adaptation of educational programs.

The greatest success, the authors of the report note, is enjoyed by products developed by EdTech startups of universities, or commercial developments, in the creation of which teachers and students actively participated.

According to the report, by 2022, the AI market in the US education sector will grow by 48%. With this growth, AI solution providers will be able to provide integrated educational and training web solutions around the world. The new educational system will be the result of excessive integration of AI that meets the needs and desires of students. Automation will be the most important part of such a system. By the end of 2024, the market volume of e-learning tools based on AI will amount to $6 billion. AI software and applications will remove certain restrictions on students' access to education. Their influence will soon be noticeable from lower-level institutions to higher-level institutions.

With the development of AI technologies, the demand for AI talents is growing, and many students also choose specialties related to artificial intelligence (Göksel & Bozkurt, 2019). Major US universities were first to launch studies of artificial intelligence. The pioneers in the field of AI were scientists from the Massachusetts Institute of Technology (MIT) and Stanford University. Among the top 100 universities in the USA, almost 30 universities have opened majors for computer science graduates.

Purdue University offers an undergraduate program in computer science with a specialization in tracking machine intelligence. At Purdue, computer science specialists can study artificial intelligence, data mining, machine learning, robotics, and a number of similar courses. Although AI courses are not uncommon at American universities, only few schools can offer students as many courses as Purdue. In 2014 Ant Financial has invited Qi Yuan, an associate professor of computer science at Purdue University, to return to China as chief data scientist and form an AI team.

The University of Michigan offers undergraduate programs in artificial intelligence, robotics, and computer vision, as well as master programs in artificial intelligence, computer science and engineering. At the University of Michigan, AI-related degrees are listed not at the School of Engineering, but at the School of Literature, Science and Art. The teaching group realized that computer science students often need to have much other knowledge, so the university provides computer science students with a wide range of professional areas.

The California Institute of Technology (CIT) is a world–renowned private research university. It is listed as an academic center on the West coast of the United States along with Stanford University and the University of Berkeley. Although the school is small in scale, it houses more than 50 advanced research centers. Its research areas cover AI, chemistry, seismology, etc., which makes it one of the best research centers.

The Department of Computer Science of the University of California Los Angeles (UCLA) is impressive – a joint research base was created here in cooperation with Stanford University. Interventional radiology researchers have discovered the advanced technology of "unmanned driving" here (Holmes et al., 2019). This AI technology was used to invent an intelligent physician assistant for interventional radiology. In addition, Zhu Long, the founder of the Chinese computer vision company Yitu Technology, received a PhD in statistics from the UCLA.

San Jose State University (SJSU) is one of the leading public universities in the western part United States, and its Computer Science Department holds high positions in relevant university rankings. Most graduates of the university can get a job in Silicon Valley, inside which the city of San Jose is located. Many Silicon Valley companies offer internships for students of relevant faculties. According to LinkedIn statistics, San Jose State University is among the top 20 universities whose alumni work in the staff of IT-giants, such as Google (Loudenback & Baer, 2015).

Arizona State University (ASU) is a well–known public research university in the USA. For many years, it has been among the leading research universities in the United States. In 2016 and 2017, US News & World Report named the university the most innovative ine in the USA (Stanford University and the MIT took second and third place, respectively). ASU's professor Subbarao Kambhampati was elected Chairman of the American Association for the Advancement of Artificial Intelligence. In the latest study, a group of 22 computer scientists from the ASU proposed a set of algorithms that can predict the smell of various molecules based on their chemical structure

(Sanchez-Lengeling et al., 2019), making not only sight and hearing, but also sense of smell available to AI.

Thus, US universities not only introduce AI into the educational activities of students, but also actively trains specialists in the field of ICT.

Artificial intelligence in the higher education system of China

In China, where the management of various spheres, including education, is more centralized, the goals and development trends are usually indicated in official state documents: plans, resolutions, strategies, etc. (Wang, 2023). Since 2017, several strategic plans have been released in China regarding the role of AI in the education system. "Next Generation AI Development Plan" (新一代人工智能发展规划) was provided by the need for training of AI at every stage of the education system. In parallel with the Plan, the initiative "The World First Class University and First Class Academic Discipline Construction" (世界一流大学和一流学科建设) was adopted, which aims to optimize universities in China to such a level that education in them is of the highest quality, advanced and meets the needs of global society. In 2018, the "AI Innovation Plan for Colleges and Universities" (高等学校人工智能创新行动计划) was launched, which proclaimed the transformation of universities and colleges in the world centers of personnel production for the development and implementation of AI by 2030. This should provide China with the necessary human resources for technological development.

The most active work with the introduction of AI and AI science in education takes place at the higher school level. AI is now the most widely studied discipline in China (Liu et al., 2018). Even before the problem of AI education in universities became public, various universities opened their own centers or schools of AI research. However, after the publication of the "AI Innovation Plan for Colleges and Universities" and the release by the Ministry of Education of a standardized curriculum for a standardized major program "Artificial Intelligence", the number of such centers began to grow actively. However, in order to open such a course of study, the university must receive approval from the Ministry of Education. In 2018, such centers were opened in 3 universities from the list of the Seven Sons of National Defense (国防七) (Fedasiuk, Weinstein, 2020). These universities are under the direct control of the Ministry of Industry and Information Technology (MIIT). They are in close cooperation with the People's Liberation Army (PLA) and are engaged in engineering research in course of national interests of the PRC. In 2019, the Ministry of Education approved the introduction of the Artificial Intelligence program in 35 universities, including Beihang University, Shanghai Jiao Tong University

and Zhejiang University (Jain, 2020). At this point, almost 500 universities (40% of the total number of universities in China (Jain, 2020)) already offered training in specialties related to big data.

In total, in 2019-2021, the Ministry of Education officially approved the conduct of undergraduate training in the "Artificial Intelligence" and the awarding of a degree in engineering sciences in 345 universities, including the remaining 4 from the list of Seven Sons (Peterson et al., 2021). The approval of the new unified separate AI curriculum was a marked change from previous curricula when AI was available within computer science.

In 2020 and 2021, "Artificial Intelligence" was the most popular curriculum of universities in China (Peterson et al., 2021). In 2021, the next most popular specialties were smart manufacturing and engineering, presented in 84 universities, and data science and big data technology, opened in 62 universities. In addition, 8 universities that opened their own AI institutes in 2016-2018 have also started offering a major AI program. The vast majority of such universities are little-known or focused on the needs of specific enterprises, excluding Tsinghua.

In Tsinghua, studying AI became available early. In 1979, the discipline "Introduction to Artificial Intelligence" was launched here, which was one of the first educational programs on AI in all of China. In the late 1980s, the Laboratory of Intelligent Technologies and Systems was founded at the Department of Computer Science and Artificial Intelligence of Tsinghua University, which is also known as the Institute of Human Intelligence. Now Tsinghua University is on the 9th place in the ranking of the number of published scientific papers on AI (Jain, 2020).

Despite the fact that the major "Artificial Intelligence" was officially approved at Tsinghua University only in 2021. Back in 2018, the university opened its own interdisciplinary Institute of Artificial Intelligence. In 2020, within the framework of the Tsinghua Academy Talent Training Program, a "AI smart class" (智班) was opened, where the integrated study of AI with mathematics, computer science, physics, biology, psychology, sociology, law, and other fields was envisaged (Peterson et al., 2021). In 2019 Tsinghua has opened a major program "Artificial Intelligence Innovations", combining the study of robotic, intelligent hardware technologies, intelligent transport technologies, innovation, and entrepreneurship (Peterson et al., 2021).

Over the past decade, China has significantly increased its potential in the training of scientific and technical personnel (Chen et al., 2022). This progress is remarkable given that the number of students in China is many times multiple than the number of students in the United States.

The number of undergraduate students studying AI in China exceeds one in the United States, the USA gets a slight advantage only at the master's and postgraduate levels. However, even this advantage can be neglected if we take into account that 14% of the total number of graduate students in the USA are foreigners (Peterson et al., 2021). Nevertheless, although the USA leads in the number of applicants to graduate school, China remains the leader in the field of discoveries of graduate students in the field of STEM and over the past 5 years it has become even more pronounced (Jain, 2020). In fact, China's leadership in advanced STEM education has only increased over the past 5 years. In terms of the share of awarded degrees in the field of AI at all levels of higher education, China is ahead of the United States – the gap in PhD degrees is 43% (Peterson et al., 2021).

However, China's progress has its own obstacles to the development of AI education. One of the most serious is the household registration system (hukou, 户口) (Maslov, 2021), which controls the allocation of people by issuing permits for legal residence depending on the place of birth. Despite attempts to reform it, the hukou system still makes it difficult to obtain education above the basic level outside the registration area. This provokes the social inequality between students.

The USA, although it has shown great progress in the development of education in the field of AI, is now experiencing its own problems and changes too. The problem for AI education in the USA is the ability to hire teachers with experience in computer science or AI, because for graduates, prefer working in business rather than at a university because it is a more profitable option. As a result, this creates gaps in knowledge about the practical application of computer science or AI. Now the US National Science Foundation (NSF) actively encourages cooperation between scientific institutions, the government, and the private sector.

Despite the fact that a centralized and standardized approach to education may seem unusual, China has been able to benefit from it. After the publication of the unified major on AI, the Ministry of Education provided support to students and institutes studying AI – they receive funding from commercial companies and foundations, which also become their partners in training interns for industry needs. In combination with the growing numerical advantage over the United States in the number of STEM diplomas awarded, China has managed to create a reliable base for training highly qualified personnel in the field of AI. Now the main risk for the long–term planning is the prospect of an aging population in China since the reproduction of the population there has significantly declined due to

the introduction of the "One Family – One Child" (一胎政策) policy in 1979 (Van, 2018). Even the abolition of these restrictions in 2015 has not helped to ensure the growth of young people for today.

The flexibility of the education system may seem to be an undeniable advantage of the United States. Indeed, flexibility provides opportunities for the development of innovative curricula, new approaches in pedagogy, experiments in practical acquaintance with AI, etc. Financing in such systems is also diversified and allows you to acquire more sponsors and partners. Together, this approach encourages and stimulates the development of innovation. However, it may also prove to be a weak side of the education system when it comes to rapid professional development of the workforce, since decentralization, flexibility and fragmentation of funding limit the possibilities of long-term planning. For example, the cooperation of universities with the US private sector is unstable. Unlike the long-term agreements, which are widespread in China, relations in the United States are based on one-time agreements.

Nevertheless, the USA still has an advantage in the scope of ethical and academic freedom of researchers. Since 2018, China has been reforming school education (Van, 2018), in which great importance is paid to the unification of educational materials with officially proclaimed ethical principles. For example, a school textbook on AI prepared by SenseTime, a company that manufactures face recognition systems, ignored the existence of the problem of trolley, fake news, data protection, Internet censorship, etc. As a result, students get a limited understanding of the use of AI and cannot deal with the issue of technology ethics, which in the future affects the quality and objectivity of research and calls into question China's status as a world leader in AI. In contrast, in the USA, on the contrary, researchers pay a lot of attention to the safety and ethics of AI. Experts believe that even with generous funding, in order to create real "world-class universities", China will need to give universities more freedom and autonomy.

In order to remain among the leaders in the AI education industry, the United States, in turn, can use the advantages of its approach, which is fundamentally different from Chinese approach. The future of AI development in each of the two countries directly depends on how they will be able to train the flow of personnel for the development of AI. The lack of centralization of education in the United States, which ensure rapid and stable training, can be perceived as a deliberate defeat of the United States in this race. However, this is not the case. The USA has a number of key advantages of its own education system. The existence of several large competing AI education centers across the country positively influences the process of endless development and modernization of

educational programs, which would be impossible in a more centralized system. The USA still holds the lead in the number of graduate specialists who are occupied in the key stages of training AI systems. In addition, highly qualified AI specialists still prefer to move to the United States – the USA leads in the number of people of foreign origin studying in graduate school. A lot of Chinese researchers uphold their thesis on AI in the United States, not at home. AI specialists from China who have left to study in the USA often prefer not to return – about 90% of them are still in the USA after 5 years after receiving their PhD (Peterson et al., 2021).

However, the US has yet to agree on a major AI curriculum, ensure fair and transparent funding of education, optimize the study of mathematics in schools, expand the use of AI tools in schools, etc., in order to effectively withstand global competition in the field of AI education.

CONCLUSIONS

Over the past 5 years, the United States and China have certainly made significant progress in implementing AI training at different stages of the educational system. Their hard work in this direction is a means of building a global competition in the development and implementation of AI. Each of the two countries strives to identify the best way to organize AI education, identify problems and obstacles, and effectively overcome them.

China's centralized approach has allowed the country to establish streaming training of scientific and technical personnel, who receive more opportunities due to the synergy of educational institutions with business, encouraged by government agencies. However, there is still a risk that access to education in the field of AI will not be equal, which will limit the potential volume of this flow, which may already decrease due to a decline in the proportion of the young population of China.

The USA obviously adheres to a decentralized approach to the organization of AI education. Although practice shows that the US is still more focused on solving the problem of computer science education, rather than AI. However, this does not mean that AI education and training in the United States are doomed. However, the United States will have to recognize the high level of knowledge of AI specialists from China and create conditions for attracting them to American universities.

The US approach gives more freedom to universities and companies for the creative process, experiments with the development and implementation of innovations, the creation of new forms of research and interaction in the field of AI. However, the task is to ensure that the successful results of such experiments are evaluated and extended to the entire education system. The United States will have to make a lot of efforts to ensure stable and coordinated cooperation between entrepreneurs, universities, and governments of all states. This is the only way it will be possible to form a long-term policy in the field of education and training in the field of AI. Otherwise, all the shortcomings of the American AI education system may have negative consequences for the competitiveness of the US AI workforce.

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