Digitalisation and the Future of Education

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i. More blended and hybrid approaches

Blended learning has become the new norm in Chinese higher education. Since 2019, the Ministry of Education has been actively promoting the "Implementation Opinions on the Construction of First-class Undergraduate Courses" [1], with over 31% of the first-class courses being hybrid (online and offline), making it the main direction for first-class course construction. In 2020, the sudden outbreak of the pandemic accelerated the development of digital education. Universities responded positively to the national guidelines of "suspending classes without stopping learning and teaching," conducting large-scale hybrid education. They also co-published the "Handbook on Flexible Learning – China's Experience in 'Suspending Classes Without Stopping Learning'" [2] with UNESCO, sharing China's blended teaching experiences globally. In 2022, the Ministry of Education proposed the "Implementation of the Digital Education Strategy Action" [3], promoting diverse explorations in blended learning. Beijing issued the "Beijing Higher Education Undergraduate Talent Training Quality Improvement Action Plan (2022-2024)" to build a new online and offline integrated teaching system [4]. Jiangsu Province launched the "Jiangsu Higher Education Smart Education Platform" [5]. Shandong University constructed the "Holographic Interactive Classroom" [6]. Nankai University built the "TEAL Classroom" [7]. Zhejiang University created the "Learn at Zhejiang University" platform [8]. Beijing Normal University launched the "Changke Interactive Teaching Platform" [9]. The Ministry of Education, relying on the World MOOCs and Online Education Alliance, offered 341 global blended courses and launched 10 global blended certificate programs, attracting nearly 25.4 million learners [10]. In China, the central and local governments, along with universities, have established a number of new educational spaces, utilizing high-speed 5G networks to conduct large-scale online and offline, same-screen cross-regional, remote simultaneous, and virtual-real integrated multimodal blended teaching. This meets the demands of modern learners for more flexible, convenient, and efficient learning experiences.

ii. Online learning provision – who is the target?

In 2011, with the rise of online open courses represented by the Khan Academy in the United States, the Ministry of Education of China successively issued a series of documents, including the "Opinions of the Ministry of Education and the Ministry of Finance on Implementing the 'Higher Education Undergraduate Teaching Quality and Teaching Reform Project' during the

12th Five-Year Plan Period," the "Implementation Opinions on the Construction of National Premium Open Courses," and the "Implementation Measures for the Construction of Premium Resource Sharing Courses." These documents supported the construction of 1,000 high-quality video open courses and 5,000 national premium resource-sharing courses. In 2018, the Ministry of Education released the "Guidelines for the Construction and Application of Online Learning Spaces" [11] and the "Education Informatization 2.0 Action Plan" [12], and partnered with universities and enterprises to continue promoting the application of online learning spaces [13]. They aimed to create national premium online courses covering all academic fields and implemented the "MOOCs Going Global" initiative to promote the construction of international online learning platforms. This effort involved collaboration with more than 30 renowned universities and online education institutions worldwide to establish a bidirectional communication channel for course import and export [14]. During this period, Shanghai established the "Shanghai Digital Education Resource Center" [15], Tsinghua University created "XuetangX" [16], Sichuan University built "Dachuan Academy" [17], and the Superstar Group developed the "Learning Pass" [18]. In 2022, the "National Smart Education Public Service Platform" was officially launched, aggregating over 27,000 high-quality MOOCs in higher education, making it the world's largest educational and teaching resource repository [19]. As of May 2024, the platform has reached a total of 40.54 billion page views. Today, online learning has become a daily habit for Chinese citizens, with China having established a global, open, diverse, and inclusive online learning service system.

iii. LLL – also through non-degree education (certificates, microcredentials)

China is advancing towards the goal of "promoting education digitalization and building a lifelong learning society and a learning-oriented nation." The Ministry of Education issued the "Key Tasks for the Construction of a Learning Society" [20], leveraging institutions such as open universities to advance the development of learning cities in China. They launched platforms like the "Lifelong Education Platform" [21], "National Lifelong Learning Public Service Platform"[x] and the "National Open University Credit Bank" [22], issuing learning certificates, establishing lifelong learning archives for all citizens, promoting the certification of learning outcomes, and achieving horizontal integration between certificate-based education and non-certificate-based education, as well as vertical integration among various levels of certificate-based education. As of January 2024, the lifelong education platform has accumulated nearly 2 million online resources, serving over 93 million learners. Local governments are actively building online learning platforms with local characteristics, providing abundant digital education resources, and encouraging the public to engage in learning anytime and anywhere to improve their qualifications. For example, Jiangxi Province launched the "Jiangxi Lifelong Learning Network" [23], Zhejiang Province released "Learn at Zhejiang" [24] and the "Zhejiang Lifelong Learning Public Service Platform" [25], and Shaanxi introduced the "Xi'an Lifelong Learning Network" [26]. Meanwhile, enterprises and institutions are supporting the national work plan by actively collaborating with universities to continuously optimize learning platforms and course resources, providing knowledge and skills certification based on certificates to meet the

growing learning needs of the public. For instance, the Higher Education Press launched "Chinese University MOOCs" [27], and Shanghai Excellence R&D Digital Technology released "Wisdom Tree" [28], partnering with Fudan University, Nanjing University, Wuhan University, and other institutions to supply high-quality MOOC resources, offering lifelong learning support services that enable everyone to learn anywhere and anytime.

iv. AI in learning and teaching

The rapid development of artificial intelligence (AI) is profoundly transforming human society and driving educational innovation. China has released documents such as the "New Generation Artificial Intelligence Development Plan" [29] and the "AI Innovation Action Plan for Higher Education" [30] to support the collaboration between universities and technology enterprises in advancing the application of AI achievements in education. These initiatives provide teachers with strategies, tools, and support around the clock to assist in teaching research, data collection, and curriculum design updates. They also offer personalized guidance, intelligent assessment, and feedback for students, helping them engage in deep reflection and reshaping the teaching and learning experience. The Ministry of Education has established the National Education Digital Big Data Center [31], conducting AI application pilot demonstrations and building platforms for data governance, algorithm empowerment, and computational power sharing. This center aims to construct a standard planning system and a network security system, comprehensively empowering student learning, teacher teaching, school governance, educational innovation, and international cooperation. AI is being used to upgrade the national smart education platform, enabling personalized resource recommendations and intelligent search. Universities are actively exploring the application of AI in learning and teaching. For example, East China Normal University developed "EduChat" [32], and Hong Kong University of Science and Technology launched "AI Lecturer" [33], providing personalized and efficient learning experiences for teachers and students. Additionally, the trend of integrating AI deeply into education through university-enterprise collaborations is growing. Beijing Zhipu Huazhang Technology Co., Ltd., and Tsinghua University jointly developed "Zhipu Qingyan" [34], while companies like ByteDance and Wangxin Turing collaborated with Zhejiang University to release the "Zhejiang University Mr. Big Model" application system. China Telecom and Sichuan University have teamed up to explore "Star AI." These large model application systems in universities cover various educational scenarios such as scientific research innovation, classroom Q&A, and academic consulting, creating a new paradigm of AI-powered education that achieves personalized learning and differentiated teaching. Tsinghua University, Zhejiang University, and other institutions have implemented AI for Education curriculum reforms, encouraging instructors to incorporate AI technologies into their teaching practices. These reforms explore practical applications such as real-time question answering, timely assessments, and resource generation. Additionally, personalized learning resources are delivered to learners through the use of knowledge graphs.

b) How to ensure that students are able to learn in digital environments, from the points

i. Technical skills and literacy

In China, enhancing students' digital literacy and skills is essential to meet the demands of the digital age and a strategic task to improve the overall quality of citizens and promote comprehensive human development. China has released documents such as the "Action Plan for Enhancing National Digital Literacy and Skills" [35] and the "Action Plan for Accelerating Digital Talent Cultivation to Support Digital Economy Development (2024-2026)" [36], launched the "National Digital Literacy and Skills Enhancement Platform" [37] , selected 78 units as national training bases for digital literacy and skills, and implemented activities like the National Digital Literacy and Skills Enhancement Month. These initiatives develop digital literacy courses, lectures, and training programs, providing rich media guides and consulting services to cultivate students' learning abilities, scientific spirit, and innovative practice, ensuring learners can thrive in a digital environment. The continuous organization of the National Digital Literacy and Skills Enhancement Month aims to raise the digital literacy and skills levels of the entire population. Hunan Province has recognized 70 units as provincial training bases for digital literacy and skills, enriching the supply of digital resources, strengthening digital education and training, and helping to enhance digital thinking awareness and technical capabilities across the province. Universities such as Zhejiang University, Wuhan University, and Central China Normal University have established blended learning digital literacy training bases [38] to improve students' digital skills and literacy, helping them face the challenges of a digital campus life. The Artificial Intelligence Education Research Center at Zhejiang University has launched the bilingual "Red Book on Artificial Intelligence Literacy of College Students (2024 Edition)", promoted AI general education, and explored a vertical interdisciplinary talent cultivation model of "AI+X."

ii. But also regarding ability to assess information, distinguish reliable from unreliable information sources

In the new era, information literacy requires learners to determine the nature and scope of the information they need, effectively acquire the necessary information, correctly evaluate the information and its sources, and integrate it into their own knowledge systems to reconstruct new knowledge frameworks. China released the "National Cybersecurity Awareness Week Activity Plan" [39], and Beijing issued the "Information Literacy Competency Framework for Higher Education Institutions in Beijing." The Chinese Higher Education Society published the "Research on Information Literacy Evaluation Standards for University Students – A Case Study of Shanghai" [40] to assess students' information capabilities, offering courses, lectures, and training to help them identify and respond to misinformation. Local governments and universities,

such as the Guangxi Zhuang Autonomous Region People's Government, Henan Provincial People's Government, Xi'an Jiaotong University, and Harbin Institute of Technology, actively conduct "National Cybersecurity Awareness Week" series activities [41]. The China Education News Network launched the "National Education Rumor Refutation Platform" [42], and the Cyberspace Administration of China created the "China Internet Joint Rumor Refutation Platform" [43]. These initiatives employ innovative methods and diverse communication channels to help students enhance their information literacy skills, enabling them to promptly verify and prevent unreliable information.

iii. Integrity, and general "code of conduct" in digital environments

In China, universities have established relevant management measures to strengthen students' integrity education, improve the identification and handling of student misconduct, and strictly supervise the learning process and examinations. During exams, technologies such as facial recognition and dual-camera setups are employed to enhance supervision. The state has issued the "Several Opinions on Strengthening the Teaching Management of Online Open Courses in General Higher Education Institutions" [44], guiding universities and enterprises to develop intelligent anti-cheating online exam systems. These measures include formulating disciplinary norms for online teaching, requiring students to sign online learning integrity commitment letters, and adhering to relevant laws and ethical standards to maintain honesty. Nanjing University has developed the "Online Exam Disciplinary Requirements and Student Integrity Commitment Letter" [45]. Universities such as Tsinghua University, Fudan University, and Zhejiang University have collaborated with enterprises like Tencent, Alibaba, ATA Online, and Zoom to deploy their respective "Online Exam Management Systems" [46][47][48], ensuring that students adhere to behavioral guidelines in a digital environment. Universities, such as Communication University of China and Fuzhou University, have begun to strictly regulate AI writing and have successively issued new policies related to AI detection, which have set clear boundaries for the use of AI in graduation theses.

c) How to assess student learning

i. Technical approaches (e-assessment)

China is exploring the use of information technology to improve outcome evaluation, strengthen process evaluation, attempt value-added evaluation, and enhance comprehensive evaluation. This aims to perfect the system and mechanism of holistic education, overcoming the chronic issues of traditional evaluation methods that focus solely on scores, college admissions, diplomas, papers, and titles. The goal is to increase the scientific, professional, and objective nature of educational evaluation. The government has issued documents such as the "Overall Plan for Deepening the

Reform of Education Evaluation in the New Era" [49] and the "Guiding Opinions on Promoting the Construction of New Educational Infrastructure to Build a High-Quality Education Support System" [50], encouraging universities to conduct large-scale online exams and paperless exams, making full use of information technology to enhance comprehensive evaluation. Universities are leveraging AI and big data platforms to automatically collect and analyze data on grades, online behaviors, and course preferences. This provides teachers with personalized teaching suggestions and predictive analyses, and students with personalized learning feedback, moving away from the subjective decision-making of traditional teaching methods and aiding in the implementation of precise teaching. Tianjin University has built a "Student Comprehensive Quality Evaluation System," Zhejiang University operates a "Learning Analysis and Early Warning System," and the Southern University of Science and Technology has launched a "Comprehensive Evaluation Admission Platform," all aiming to improve the scientific, professional, and objective nature of educational evaluation.

ii. In terms of learning outcomes – given the possible use of all kinds of aids, including the internet, AI such as ChatGpt etc.

China adopts an inclusive and prudent approach, balancing development and security while promoting innovation and governance by law. The country encourages the evaluation of generative AI-based learning outcomes. Relevant documents such as the "Guiding Opinions on Promoting the Construction of New Educational Infrastructure to Build a High-Quality Education Support System" [51] and the "Interim Measures for the Management of Generative Artificial Intelligence Services" [52] have been issued to advance the national education digitalization strategy. Universities are encouraged to utilize structured data from large models to expand teaching knowledge bases, improve assessment systems, and use natural language processing and machine learning algorithms to analyze students' learning outcomes, predict learning performance, identify students needing additional support, and provide personalized learning paths and assessment tools such as adaptive testing and personalized feedback. For example, the University of Hong Kong and the Hong Kong University of Science and Technology provide students with access to the ChatGPT API, Zhejiang University developed "ZJU ETAIK," and Sichuan University partnered with China Telecom to deploy AI assistants. These initiatives aim to enhance students' learning outcomes and improve the accuracy of outcome evaluations.

d) Quality assurance

China continues to promote higher education institutions to establish quality standards and clarify educational service rules based on the principles of openness, fairness, and justice. The Ministry of Education and four other departments issued the "Guiding Opinions on Promoting the Healthy Development of Online Education" [53] and the "Several Opinions

on Strengthening the Teaching Management of Online Open Courses in General Higher Education Institutions" [54]. These documents emphasize that universities need to take measures to protect data privacy and security, use learning analytics and AI technology reasonably, bridge the digital divide, strengthen professional skills education, support the mental health of teachers and students, and adopt flexible teaching policies. Additionally, universities need to enhance cooperation and collaboration, engage in continuous learning and training, and maintain ethics and transparency to build a fairer, more efficient, and sustainable digital education environment. The Ministry of Education has established the "National Data Platform for Higher Education Quality Monitoring" [55]. Tsinghua University utilizes the "Teaching Portfolio" [56], Zhejiang University employs "Teaching at Zhejiang University" [57], and Sichuan University uses the "Comprehensive Evaluation Data Platform for Teaching Quality" [58] to ensure the quality of education in the digital age.

e) Capacity building: How do institutions support their staff

i. Training

China has issued standards and documents such as the "Teacher Digital Literacy" [59] and the "Opinions on Building a High-Quality and Equitable Basic Public Education Service System" [60]. These documents support local governments and universities in managing training information, conducting needs assessments, and providing comprehensive management. Continuous teacher development, digital application training, and skill competitions are promoted to advance the construction of AI-empowered teaching teams, enhancing teaching design and classroom instruction abilities. The Ministry of Education has established the online "National Academy of Education Administration" [61], and the China Association of Higher Education organizes the "National University Teachers' Teaching Innovation Competition" [62]. In response to the challenges posed by AI, Zhejiang University and other institutions have launched teacher training programs in AI general education, which the goal is to comprehensively enhance instructors' AI education and teaching capabilities, foster innovation in educational methods, aim to explore the evolving role of educators in the teaching process, and ensure that the educational content aligns with the advancements of the times.These initiatives guide teachers in keeping pace with the times, continuously learning new skills, and comprehensively improving their digital literacy. By leveraging transformative digital technologies, these efforts aim to enhance educational capabilities and standards.

ii. Technical support & equipment

China is focusing on the fundamental task of cultivating virtuous and capable individuals, combining business needs, and fully utilizing information technology, especially intelligent technology, to achieve innovative explorations in education

methods under informatization conditions. This includes systematic construction of network security, intelligent connectivity of information resources, digital transformation of campus environments, adaptive development of user information literacy, and digital transformation of core businesses. The country has released documents such as the "Standards for the Construction of Digital Campuses in Higher Education Institutions (Trial)" [63], the "Management Measures for the Ministry of Education's Industry-Education Collaboration and Collaborative Education Projects" [64], and the "Guiding Opinions on Promoting the Construction of New Educational Infrastructure to Build a High-Quality Education Support System" [65]. These documents aim to promote the construction of specialized education networks and the upgrade of campus 5G networks in higher education, develop new resources and tools, improve smart teaching facilities, build intelligent research facilities, and deploy smart public facilities, forming a trustworthy and secure new infrastructure. For example, Wuhan University of Technology has created an education environment centered on student development [66], Shanghai Jiao Tong University focuses on strengthening computational infrastructure [67], and Zhejiang University has developed the "Online Zhejiang University 2.0" new educational space [68]. These efforts ensure that teachers and staff can work efficiently in a digital teaching environment, further enhancing teaching quality and staff skill levels.

2. Implications for governance and campus development trends of digital education

a) Legal frameworks

The widespread application of cloud computing, big data, and artificial intelligence technologies has brought about issues such as network security problems, data privacy protection, and the rational use of information resources. These issues not only affect the quality and efficiency of education informatization but also pose higher requirements for educational equity and the protection of student rights. To address these challenges and ensure the healthy development of educational digital transformation, the Chinese government has timely issued a series of laws and regulations, building a comprehensive legal framework. While strengthening the digital transformation of higher education, we should pay attention to data security and privacy protection, ensure the promotion of building a safe digital education environment, and protect the personal information of students and teachers from being leaked. China released the "Overall Layout Plan for the Construction of Digital China" [69], which emphasizes optimizing the digital development

environment. The plan proposes measures such as improving the legal and regulatory system, building technical standards, and enhancing governance levels to promote the construction of Digital China. The Ministry of Education issued the "Standards for the Construction of Digital Campuses in Higher Education Institutions (Trial)" [70], providing normative guidance for digital campus construction and reflecting the government's strong commitment to education informatization. Clear goals, principles, content, and requirements for digital campus construction ensure the orderly advancement of education informatization. Supporting laws, such as the "Cybersecurity Law of the People's Republic of China" [71], provide security guarantees for educational activities in the network environment. The "Data Security Law of the People's Republic of China" [72] ensures the security and proper use of educational data, preventing data leaks and misuse. The "Personal Information Protection Law of the People's Republic of China" [73] protects the personal information of students and staff from illegal acquisition and use during the process of education digitalization. The "Interim Measures for the Management of Generative Artificial Intelligence Services" [74] promote the healthy development and regulated application of generative artificial intelligence, safeguarding national security and social public interests. These laws and regulations provide institutional support and a legal framework for China's digital development and education informatization construction, ensuring safety and regulation in the digitalization process.

b) Quality assurance

The rapid development of educational informatization in China faces numerous challenges in areas such as technical standards, resource management, platform construction, and information security. For instance, the lack of unified technical specifications may lead to resource waste and system incompatibility; unregulated platform construction may affect the quality and efficiency of educational services; and information security issues may threaten the personal privacy of students and teachers. To address these issues and ensure the quality of digital education construction, China has formulated a series of important standards and documents to promote and regulate the development of educational informatization. These standards propose general technical requirements for educational informatization, covering infrastructure, resource construction, application services, and management, and outline the universal technical construction standards. They specify the overall requirements, functional requirements, and security requirements for the construction of educational resource public service platforms. Additionally, they define the overall framework for educational management informatization, clarifying the construction principles, structure, and functional modules. These relevant standards have been published in the form of national standards, such as the "GB/T 33172-2016 General Technical Requirements for Educational Informatization" [75], "GB/T 36342-2018 General Technical Requirements for Educational Resource Public Service Platforms for Educational Informatization" [76], "GB/T 36343-2018 Overall Framework

for Educational Management Informatization" [77], "GB/T 35273—2020 Information security technology — Personal information security specification", and "JY/T0641—2022Smart education platform—Basic functional requirements".

c) Credentialing

In China, digital education has not only transformed traditional teaching and learning methods but also raised pressing issues regarding how to ensure educational quality and enhance the relevance and effectiveness of talent cultivation. The certification system for digital education governance in higher education is jointly developed by the Ministry of Education, the Ministry of Human Resources and Social Security (MOHRSS), and the Ministry of Industry and Information Technology (MIIT). This system forms a comprehensive framework covering talent cultivation and certification across various professional fields. The Ministry of Education focuses on the certification of professionals in educational informatization, primarily targeting university teachers and education administrators to enhance their capabilities in informatized teaching and management. The MOHRSS provides vocational skill level certifications, such as Information System Project Manager and Network Engineer, as well as advanced professional skill certifications, such as Digital Management Specialist, to improve the informatization management levels of enterprises and institutions. The MIIT specializes in information technology professional certifications, including Software Engineer and Network Security Engineer, as well as Industrial Internet Engineer and Intelligent Manufacturing Engineer. At the same time, China is actively promoting the market-based application of micro-certificates in the industry, and through cooperation with enterprises, it provides employment and career development opportunities for students who obtain micro-certificates, further enhancing the social recognition and influence of micro-certificates. Under the organization of the Teaching Collaboration Center of Five Universities in East China, the New Generation of Artificial Intelligence Educators Alliance was established by Zhejiang University, Fudan University, University of Science and Technology of China, Shanghai Jiao Tong University, Nanjing University and Tongji University, together with Huawei, Baidu and SenseTime. The body officially released the AI+X micro major. Through learning and practice, students have mastered relevant core skills, successfully obtained micro-certificates recognized by enterprises, and successfully entered relevant industries after graduation.

d) Infrastructure: shared protocols and tools

Chinese universities still face challenges in the digitization and networked sharing of teaching resources, leading to outdated teaching content and single teaching methods. In campus management, the phenomenon of information silos

is widespread, and there is a lack of data integration and analysis capabilities, affecting the scientific nature of decision-making and the precision of services. Therefore, the country has conducted comprehensive and systematic top-level design and strategic planning in the construction and management of higher education informatization infrastructure. The "Education Informatization 2.0 Action Plan" [78] clarifies the goals and tasks of education informatization construction, promoting the deep integration of information technology with education and teaching to improve educational quality. Six departments, including the Ministry of Education, the Central Cyberspace Administration, the National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Finance, and the People's Bank of China, jointly issued the "Guiding Opinions on Promoting the Construction of New Educational Infrastructure and Building a High-Quality Education Support System" [79], specifying the key directions and implementation strategies for infrastructure construction. Many regions have also followed suit with relevant planning. For example, Zhejiang Province's "13th Five-Year Plan for Education Informatization Development in Zhejiang Province" [80] details the push for education informatization to enhance the informatization level of the province's education system. Additionally, universities such as Zhejiang University, Fudan University, and Tsinghua University are actively developing smart campuses, using technologies such as big data, artificial intelligence, and cloud computing to improve teaching quality and management efficiency. For instance, Zhejiang University has integrated information resources through the construction of a smart campus platform [81] to provide intelligent services.

e) Governmental support

In China, the digital transformation of higher education faces multiple challenges in terms of funding, technology application, policy support, and education governance. Specifically, funding shortages often act as the main bottleneck restricting the informatization of universities; uneven technology application leads to regional disparities in educational quality; and the lack of effective policy support and governance mechanisms makes it difficult to ensure the healthy and rapid development of educational informatization. Therefore, the Chinese government, through a series of policy documents such as the "Education Informatization 2.0 Action Plan," systematically guides and supports digital education governance in higher education, clarifying development directions and implementation paths to promote the deep integration of information technology with education and teaching. National-level funding support, including special funds for the "Double First-Class Initiative" [82] jointly supported by the National Development and Reform Commission and the Ministry of Education, focuses on enhancing the informatization infrastructure and educational quality of universities. Additionally, the Ministry of Education's "Smart Campus" pilot project selects certain universities nationwide to promote the application of information technology in teaching, management, and services. Provincial education

departments, such as in provinces and municipalities such as Zhejiang, Shanghai, and Beijing. support university informatization construction and governance innovation through policy guidance and financial investment [83][84][85]. Financial institutions, such as the Bank of China [86], provide educational loans and special financing to support the construction of informatization infrastructure and technological upgrades in universities. Under the support of national "Double First-Class" construction funds, Tsinghua University, Zhejiang University, Peking University, and other higher education institutions[87][88][89] extensively applies information technology, leveraging big data, cloud computing, and other technologies to improve teaching and research efficiency and educational management levels.

f) Relations with the IT industry

In China, the development of digital education governance in higher education is deepening, and universities are increasingly in need of advanced information technology. Therefore, the development of digital education governance in Chinese higher education is promoted through a multi-layered, multi-role ecosystem. Major universities has formed close collaborative relationships with industry enterprises to promote the integrated development of industry, academia, research, government, and application. This ecosystem includes internet companies, equipment manufacturers, software developers, research institutions, national laboratories, and academic and social organizations. Internet companies like Alibaba, Tencent, and Baidu play key roles in providing infrastructure, cloud computing services, and online education platforms. Research institutions and national laboratories support the development of educational informatization through cutting-edge technology and applied research, while academic and social organizations promote the formulation of industry standards and norms through academic exchanges and cooperation. The China Association of Higher Education, through its Educational Informatization Division, acts as a bridge connecting different ecosystem roles, fostering multi-party communication and cooperation. For example, Universities are building smart education ecosystems through partnerships with enterprises. Shanghai Jiao Tong University and Baidu Group have reached a cooperation intention. Both sides will fully leverage their respective advantages, work together to create a highland for AI talent cultivation, and explore in-depth in fields such as AI for Science to jointly promote technological collaborative innovation[90]. Zhejiang University, in cooperation with companies like Alibaba and Huawei [91], is advancing the construction of an intelligent campus. Tsinghua University has partnered with Baidu to establish an artificial intelligence laboratory [92] focused on AI technology research and its application in education.

g) Privacy and security

In China, the leakage of educational data, cyberattacks, and the improper use of personal information can threaten the privacy rights of students and staff and even affect the reputation and operational efficiency of educational institutions. Therefore, the release of strict laws, regulations, and standards at the national level ensures the privacy and security of digital education governance in higher education. The "Cybersecurity Law of the People's Republic of China" stipulates that network operators must take technical measures and other necessary means to ensure network security and data protection. The "Personal Information Protection Law of the People's Republic of China" further clarifies the rules for personal information processing activities to ensure privacy and security in the education sector. Additionally, the "Key Points of the National Education Digitalization Strategy Action in 2024" emphasizes the importance of strengthening network security and data protection. At the provincial level, educational departments such as the Zhejiang Provincial Department of Education, Shanghai Municipal Education Commission, Beijing Municipal Education Commission have formulated policies like the "Zhejiang Province Education Informatization Security Management Regulations"[93], "Technical Requirements for Network Information Security of Shanghai Education System"[94], "Beijing Smart Campus Construction Standards for Higher Education Institutions (Trial)"[95], requiring schools to establish and improve information security management systems to ensure the security and privacy of educational data. Universities such as Tsinghua and Fudan have also taken corresponding measures. Tsinghua University has established a strict information security management system [90], set up a dedicated cybersecurity office, and formulated detailed privacy protection measures and emergency response mechanisms. Fudan University, through its information security management system and regular security audits, has established a comprehensive privacy protection mechanism [96]. Starting from the construction of data security management system, Zhejiang University explores the data security and privacy protection system through the way of data whole life cycle process supervision, regular evaluation and audit.

h) Equitable access, inclusion - digital divide / digital poverty

In China, there are significant differences in accessing and utilizing digital education resources among different regions and social groups. These disparities exist not only between urban and rural areas but also among regions with varying economic levels and different tiers of educational institutions. The government is committed to promoting educational equity and inclusiveness in the digital governance of higher education. Through policy initiatives such as the "Education Informatization 2.0 Action Plan," efforts are being made to use information technology to narrow regional, urban-rural,

and inter-school gaps and promote the sharing of quality educational resources. The Higher Education Department of the Ministry of Education advocates the "MOOC Western Tour Plan 2.0" as a public welfare education action, which promotes the sharing of educational resources through "digital empowerment of shared courses", supports the development of higher education in the central and western regions, achieves the balance of educational resources, and promotes the improvement of teaching quality in higher education in the central and western regions. At the provincial level, provinces like Zhejiang, Shanghai, and Guangdong have established public service platforms for educational resources [97], providing free quality educational resources for teachers and students across the province, thus achieving equitable sharing of educational resources. In terms of universities, institutions like Zhejiang University and Shanghai Jiao Tong University have implemented targeted poverty alleviation projects [98], using information technology to provide educational, industrial resources, and technical support to impoverished areas. The "Internet+Education" project of the National Open University [99] uses internet technology to offer online courses and teaching resources to students in remote and impoverished areas.

3. Prospects of international cooperation in higher education in the digital era

a) Educational cooperation

China is actively implementing the "Digital Education Going Global" initiative to promote internationalization. The country has issued the "Opinions on Deepening the Reform of Talent Development Systems and Mechanisms" [100] and organized activities such as the China International College Students' Innovation Competition [101]. Additionally, China continuously hosts events like the World Digital Education Conference, the International Conference on Artificial Intelligence and Education, and the World MOOCs and Online Education Conference. The ongoing release of the China Smart Education Blue Book, the Digital Education Development Index, and global digital education demonstration cases leverages digital technology to overcome geographical limitations, allowing quality educational resources to be more widely disseminated. This promotes knowledge sharing and academic exchange, optimizes the global flow and allocation of talent, encourages mutual learning of educational concepts, teaching methods, and curriculum systems, explores mutual recognition of credits and degrees, and fosters collisions and integration of different cultural backgrounds, thereby stimulating educational innovation and transformation. The Ministry of Education supports the construction of

international online teaching platforms like "iCourse" and "XuetangX" [102] and has launched an international version of the "National Smart Education Public Service Platform" [103]. Zhejiang University hosts the "Global Summer School for Sustainable Development" [104], while universities such as Peking University, Tsinghua University, the University of Hong Kong, and the Hong Kong University of Science and Technology offer courses on the edX platform, enhancing the fairness and quality of global higher education.

b) Scientific research cooperation

China is continuously strengthening its collaboration with top international universities to establish teaching and research cooperation platforms, jointly promoting high-level basic and high-tech research, and improving the quality of innovation talent cultivation. The country has issued policy documents such as the "International Cooperation Joint Laboratory Program" [105], the "Regulations on the Construction and Management of International Cooperation Joint Laboratories in Universities" [106], and the "Guidelines for the Construction and Management of International Cooperation Joint Laboratories in Universities" [107]. These initiatives aim to create teaching and research cooperation platforms based on interdisciplinary integration, forming clusters of disciplinary innovation while addressing the needs of local universities and regional demands through broad collaboration with relevant foreign institutions.Tianjin University has opened its bioinformatics database to the global community [108], the Chinese Academy of Sciences has implemented the "Global Open Science Cloud" initiative [109], and Tsinghua University has launched the "Open Access Paper Management Service System" [110], all promoting the sharing and openness of global research resources.

4. AI – impacts for institutions and society

a) The dual challenges that AI poses to organizations

The Chinese government has provided comprehensive policy guidance and standard frameworks for the application of AI technology across various industries through policy documents such as the "New Generation Artificial Intelligence Development Plan" [111]. Local governments have actively responded, with Beijing, for example, building intelligent governance systems that have effectively improved the efficiency of public services [112]; Shanghai has utilized AI technology to optimize urban management and public services, such as intelligent transportation systems and public

safety monitoring, but it also faces serious challenges in data security and privacy protection [113]. At the corporate level, Huawei has widely applied AI technology in smart manufacturing, promoting the automation and intelligence of production processes [114]; Haier has used AI technology to optimize supply chains, increasing logistics efficiency, but this also necessitates traditional workers continuously upgrading their skills to adapt to new work environments under the technology [115]. In the field of scientific research, institutions such as the Chinese Academy of Sciences have made breakthroughs in AI technology, advancing the innovation and development of artificial intelligence theory [116]; however, the application of these technologies must be carried out within strict ethical and legal frameworks to ensure the proper use of technology and social welfare [117]. In higher education, universities such as Zhejiang University have not only established AI courses and laboratories but also face challenges in teacher training, allocation of teaching resources, and interdisciplinary integration [118]; Peking University has collaborated with enterprises to build AI research and development centers, strengthening the integration of industry, academia, and research, but how to balance academic research with practical applications remains a significant challenge [119]. Furthermore, with the popularization of AI technology, enterprise employees must continuously update their skills to adapt to the application of new technologies, which poses higher demands for career transformation and retraining, intensifying the pressure of labor market transformation [120].

b) Artificial intelligence has led to the replacement of social occupations and changes in lifestyle

The rapid development and widespread application of artificial intelligence technology are profoundly changing the social occupational structure and people's lifestyles. In the financial sector, financial institutions such as Ping An Bank have introduced AI technology, achieving the automation of intelligent customer service and risk assessment [121]; China Merchants Bank has utilized AI technology to optimize the credit approval process, increasing approval efficiency and accuracy, but also prompting financial practitioners to transform towards data analysis and system optimization [122]. In the medical field, hospitals affiliated with Fudan University have used AI technology to assist in disease diagnosis and treatment [123]; Peking Union Medical College Hospital has built an intelligent medical platform through AI technology, realizing telemedicine and health management, but this also requires medical staff to continuously improve their ability to work collaboratively with AI to ensure the quality and safety of medical services [124]. In the field of education, Peking University has introduced an AI education platform, achieving personalized learning and intelligent tutoring [125]; Tsinghua University has built smart classrooms through AI technology, enhancing teaching effectiveness and learning

experiences, but this also prompts teachers to shift their roles from traditional knowledge transmitters to learning guides and data analysts [126]. In the realm of family life, the proliferation of smart home and intelligent assistants, such as Xiaomi's smart home system and Baidu's intelligent assistant, has made people's lives more convenient and intelligent [127][128]. These technologies not only change the lifestyles of family members but also promote harmony and intimacy within the family, allowing people to invest more time and energy into creative activities and interpersonal interactions.

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