



Leveraging smart education for sustainable development in the digital era: insights from China's four key pillars

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Resumo

Este estudo teve como objetivo identificar os principais pilares da prática política para promover o desenvolvimento da educação inteligente através da análise de questões políticas relacionadas à educação inteligente na China de 2013 a 2023. Quatro pontos de alavancagem foram apresentados: governança prospectiva e iniciativas políticas, ambientes inteligentes de aprendizagem, ensino e aprendizagem transformadores habilitados através da tecnologia e considerações abrangentes para educação inteligente. As conclusões enfatizaram a importância da governança proativa e da formulação de políticas, do estabelecimento de ambientes de aprendizagem adaptativos, da integração da tecnologia para promover práticas transformadoras de ensino e de aprendizagem, e de considerações abrangentes para a implementação sustentável da educação inteligente.

Palavras-chave: Educação inteligente; Estrutura; Política educacional; Ambiente de aprendizagem

Abstract

This study aimed to identify the key pillars of policy practice to promote the development of smart education by analyzing policy issues related to smart education in China from 2013 to 2023. Four leverage points were presented: forward-thinking governance and policy initiatives, smart learning environments, transformative teaching and learning enabled through technology, and overarching considerations for smart education. The findings emphasized the importance of proactive governance and policy formulation, the establishment of adaptive learning environments, the integration of technology to foster transformative teaching and learning practices, and comprehensive considerations for the sustainable implementation of smart education.

Keywords: Smart education; Framework; Education policy; Learning environment

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1. Introduction

The rapid advancement of big data and artificial intelligence has significantly impacted society and business. In the field of education, there is a pressing policy concern regarding the utilization of intelligent technology to transform the education ecosystem and reshape the teaching process. Smart education can be defined as the educational behaviors (system) provided by schools, regions, or governments with the characteristics of high learning experience, learning content adaptation, and teaching efficiency (Huang, 2014). Smart education received widespread attention all over the world (Chen et al., 2021). For example, UNESCO IITE (2022) initiated the development and implementation of rewarding strategies for smart education, aiming to expand access to quality education and lifelong learning opportunities in order to achieve Sustainable Development Goal 4.

The education system in China is distinctively characterized by centralized governance (Wei; Johnstone, 2020). Since 2010, China has introduced a series of policies to support the establishment of information and communications technology (ICT) in education and smart education, including the Notice of the Second Period Special Education Improvement Plan (2017-2020), National Plan for ICT in Education (2011-2020), Action Plan of ICT in Education (2.0 version), Notice on the Recommendation and Selection of the Smart Education Pilot Zone Construction Project, Guidance on Promoting the Construction of a High-Quality Education Support System for New Infrastructure Construction in Education. With national leadership from the top-down, local governments and education bureaus have actively responded to the call for participation in smart education development. The Ministry of Education (MOE) of People's Republic of China has annually selected and established "Smart Education Pilot Zone". In 2019 and 2020, 20 national smart education pilot zones were designated. These pilot zones prioritize the promotion of ICT innovation in education, the reform and innovation of educational theories and models, the enhancement of regional education, and the creation of advanced experiences and exemplary cases that can be replicated.

Thus, this study aims to analyze the policies and practices of smart education in China, identify the characteristics of integrating smart technologies into education for the purpose of smart education, and better understand the key leverage points for promoting sustainable development in the digital era. Sections 4 to 7 will present the four leverage points for smart education policy and practice in China, followed by a concluding section 6.

2. International policy context

The development of technology is changing the way people live and work. In the field of education, technology is not only a helpful resource provider, but also a powerful learning tool. It enriches the presentation of teaching content in three-dimensional forms such as images, animations, audio, and video, creates a supportive learning environment, and then realizes human-computer interaction. Such application of technology in education breaks the constraints of time and space, with that the learning quality is improved, and the educational equity is promoted. Especially since the outbreak of Covid-19, the demand for online teaching has accelerated the digital transformation of education around the world. As a high-end form of digital education development, smart education has attracted more attention worldwide.

United Nations Educational, Scientific and Cultural Organization (UNESCO) proposed the Sustainable Development Goals by improving the quality of education around the world. Among them, one vital goal, sustainable Development Goal (SDG) 4 is "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (UNESCO, 2021).

As the Framework for Action for the implementation of SDG 4, *2030 Agenda on Sustainable Development* is committed to the *Education for All Agenda* and the "unfinished business" of the education-related *Millennium Development Goals*, setting a new road map for the education development. *2030 Agenda* emphasizes the importance of national smart education development. Firstly, guided by the concept of "lifelong learning", it was stated that to complement formal schooling, broad and flexible, lifelong learning opportunities should be provided by encouraging non-formal learning, including through the application of information and communication technologies (ICT). Additionally, to provide equal education, access to distance learning, ICT training, appropriate technology and the necessary infrastructure should be provided to create learning environments in the country and in conflict and remote areas. Moreover, to increase the number of qualified teachers, teachers should be equipped with appropriate technical skills to manage ICT and social networks, as well as media literacy and source criticism skills (UNESCO, 2016).

The UNESCO Institute for Information Technologies in Education (UNESCO IITE) supports Member States in developing its smart education strategies, making it more resilient and inclusive through the use of digital services and platforms. UNESCO IITE released the *Medium-Term Strategy 2022–2025* (UNESCO IITE, 2022), where it is mentioned that smart education is an important trend for education worldwide. One of the strategic objectives is to promote smart education in post-pandemic world and future education. To this end, IITE

strengthens the role of digital innovation in teaching and learning, develops smart education strategies and solutions, design teaching/learning methodologies and tools.

Similarly, the Organization for Economic Cooperation and Development (OECD) releases *Trends Shaping Education 2022*, pointing out that with the development of artificial intelligence, smart learning is the development trend of future education. OECD published a joint work *How Learning Continued during the COVID-19 Pandemic*, which emphasized OECD member countries' various coping methods toward COVID-19 (OECD, 2022a). The global smart education agenda summarized five areas that the previous aspects should consider, which are analysis, indicators, standards, capacity development, and development and evaluation. Besides this, its special Project Programme for International Student Assessment (PISA) 2025 turned its focus on learning assessment in a smarter world, that is, measuring students' ability to use computing tools to participate in iterative processes of knowledge construction and problem solving. Smarter education can change the way students learn, offering them new opportunities to explore complex phenomena and create digital expressions of their ideas that students can tinker with and share with others (OECD, 2022b).

Regarding European countries, there are large differences in the education levels, but the European Union (EU) has not stopped the pace of education digitization. Over the past two decades, the European Union has issued a series of important documents to carry out continuous and effective design and exploration for the digital transformation of education. In the *Digital Education Action Plan (2021-2027)* jointly issued by the EU and its member states, two goals are emphasized. The first is fostering the development of a high-performing digital education ecosystem, which requires infrastructure and digital equipment, efficient organization and planning capabilities, qualified teaching staff, learning content and tools that respect privacy and ethics. The second priority is enhancing digital skills and competencies for the digital transformation, which requires early provision of basic digital competencies (digital literacy, computer education, understanding of data-intensive technologies) and advanced digital skills (creating more experts and ensuring women's opportunity) (European Commission, 2020).

At present, under the guidance of the EU, 16 member states including Germany, France, Belgium, Ireland, and Austria have implemented a digital capability strategy, proposed a long-term digital development vision and clarified goals, and incorporated digital education into the national education quality assurance and evaluation system (Zhang; Che, 2022).

Besides, The European Training Foundation (ETF) Network for Excellence, ENE, has just launched in 2022 its Digital initiative, one of eight priorities of the ETF Network for Excellence (ENE) project (ETF.EUROPA.EU). The ENE Digital Sub-initiative demonstrates how smart education can lead to efficient learning and teaching with the necessary buy-in from relevant stakeholders, specifically teachers and students. The first phase of the initiative concentrates on smart teaching and learning, focusing on three macro areas: digital content and tools, digital competencies of teachers, smart learning methods and specific policy measures (ETF Europa EU, 2022).

The increasing demand for quality education will be the natural driving force behind technological development. The mutual empowerment of technology and education will promote cross-domain integration, realize the integration and innovation of data, information, business, applications, and services, and enhance educational intelligence. As a result, learners will experience high satisfaction and enjoyment in receiving smart education services.

3. Method

In this study, textual analysis was utilized to analyze 26 smart education policies from China issued between 2013 and 2023. The systematic procedures followed four stages: database search, identification of search keywords and time period, searching criteria, analysis and categorization (shown in Figure 1).

In the first stage, the author conducted a search for relevant smart education literature and reports using the Web of Science platform to understand the trends in smart education development both domestically and internationally - SDG4, Inclusive Education, Smart Education.

In the second stage, conducted policy searches on the four pillars of the national smart education framework by using the website of the MOE of China⁶, the Chinese government website⁷, as well as educational portal websites of various regions. For example, used keywords such as "smart education demonstration zone," "education infrastructure," and "student-centered" to filter relevant educational policies. The scope of the literature search was limited to relevant policies and conference records published between 2013 and 2023.

⁶ www.moe.gov.cn

⁷ www.gov.cn

In the third stage, the relevant policy content was effectively extracted, and policies that could be included in the comprehensive analysis were listed in a table. For each document, the following inclusion criteria were used:

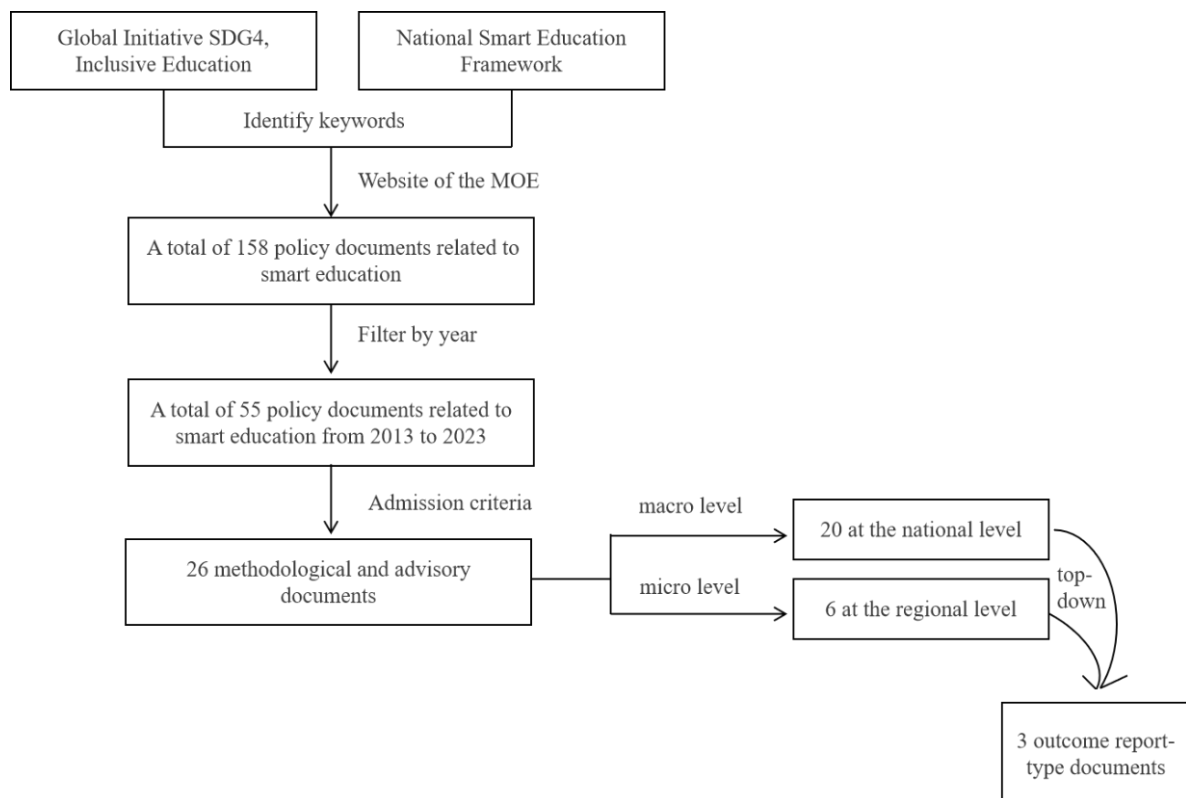
a) The document aligns with the theme and meets the requirements of international education for sustainable development.

b) The policy presents a comprehensive and practice-tested maturity model, describing its different stages.

c) The policy can reflect the new competitive advantages of the country and has profound implications for other countries as a valuable reference.

In the fourth stage, the policy documents can be classified into outcome report-type documents and methodological advisory-type documents. By combining recommendations with achievements, we can reflect China's experience in the field of smart education.

Figure 1. - Methodology adopted for the textual analysis



Source: Prepared by the authors.

4. Forward-Thinking Governance and Policy Initiatives

Establishing a modernized smart education ecosystem necessitates a strategic and long-term commitment from government leaders. They must develop a comprehensive national vision and plan that effectively harnesses educational technology, while also allocating sufficient resources for human capital development (Wilson et al., 2021). This commitment ensures the plan's successful and sustainable implementation, as well as its ongoing refinement. In the context of China, the governance policy practice can be categorized into three key aspects (See Figure 2).

4.1. Develop a National Vision and Plan

“National Vision and Plan” elucidate the national strategic intentions and clarify the focus of government work, serving as a common action guideline for the Chinese people of all ethnic groups. To effectively fulfill the leading role of national development plans, it is essential to reinforce the supportive functions of specialized planning, regional planning, and the foundational functions of spatial planning.

The vision for China's smart education construction is: a) to keep pace with innovative educational concepts and talent development models; b) to promote the innovation of teaching methods; c) to comprehensively enhance the level of intelligence in regional education; d) to build a smart learning environment that supports individualization and adaptation; e) to provide precise education services centered on learners. Based on these visions, the MOE of China (2018a) issued the *Key Points on Work of the MOE for 2018*, which proposed "Promoting the Innovative Pilot of Smart Education" for the first time. In January 2021, the MOE issued the *Notice on the Recommendation and Selection of the Smart Education Pilot Zone Construction Project*. These documents and actions revealed that China upgraded the construction of the smart education pilot zone to the national strategic level, which became an important strategic choice for building a smart society.

As a result, education departments nationwide have been fully mobilized to collect excellent case studies of smart education from various regions, aiming to enhance dissemination and the sharing of experiences. For example, the government of Shanghai Minhang District formulated and implemented the Plan of Creating a National Smart Education Pilot Zone in Minhang District. Measures included: 1) setting up an educational cloud service platform to adapt to the overall promotion of the region; 2) building a smart learning environment; 3) exploring personalized and differentiated teaching and learning (People's Government of Minhang District, 2021).

Thus, government officials should commit to a unified vision that outlines the crucial role technology plays in guaranteeing students' future success as well as the consequences of that role for enhancing social and economic equity in the country. Relevant sectors need to support government leaders in developing national education technology plans and responses.

4.2. Build Infrastructure Capacity

New infrastructure is motivated by the new development philosophy, propelled by technological advancement, based on information networks, and designed to meet the demands of high-quality development. This new infrastructure sought to offer a range of services, such as integrated innovation, intelligent updating, and digital transformation. China's education infrastructure construction has transcended beyond mere networks and hardware equipment. It encompasses the comprehensive development of learning spaces, educational resources, management systems, and more.

In July 2021, the Ministry of Education and five other departments issued *Guiding Opinions on Promoting the Construction of New Educational Infrastructure and Building a High-Quality Education Support System*, which emphasized six key aspects: a) strengthen the trustworthiness & safety of networks and connections; b) upgrade ICT infrastructure for education; c) upgrade the smart campus with cyber and physical spaces; d) harmonize the learning management and administration information system nationally; e) promote innovation in teaching, assessment, and governance through emerging technologies; f) innovate digital resource provision nationwide.

As of February 2021, the Broadband network access rate and wireless network coverage were 100% in primary and secondary schools (10G to school, 1G to class). The proportion of multimedia classrooms surpassed 97%. A total of 2,917 smart classrooms, 60 pilot schools for AI education, and 100 pilot schools for smart campuses were constructed. Through the implementation of the "smart campus" initiative, the capacity to generate and distribute high-quality resources was significantly enhanced.

Government officials should establish and maintain advanced telecommunications and information services, such as fiber-optic and wireless networks, including mobile broadband. This was crucial to ensure that all communities, including remote or rural areas, have access to high-speed internet connectivity. It was imperative to keep these networks up-to-date to meet the evolving technological demands and bridge the digital divide. Schools should improve their smart teaching facilities and enhance the level of multimedia teaching

equipment in general classrooms to support interactive feedback, high-definition live streaming, and recorded lectures as teaching methods.

4.3. Invest in Human Capacity

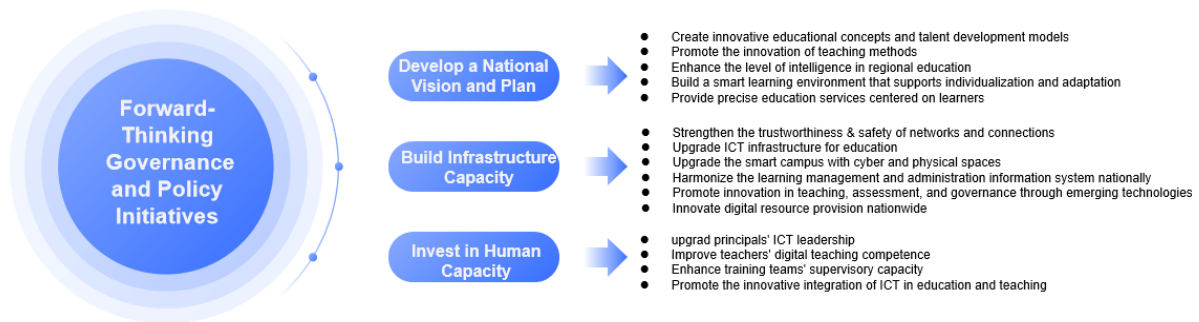
Based on the manpower needs of smart education construction, China is committed to establishing a high-level workforce of technical and managerial talents, as well as a multidisciplinary and cross-domain team of highly qualified education professionals (Chinese Government Network, 2022). "Invest in Human Capacity" involved allocating funds to support teachers in their professional development, teaching reform, and training opportunities.

In 2019, the MOE of China issued the *Opinions on the Implementation of the Digital Teaching Competence Improvement Project 2.0 for Nationwide Primary and Secondary School Teachers*, which further suggested the need for establishing a new mechanism to promote the development of teachers' digital competence. The Opinions outlined the overarching development goal of "Three promotions and One Comprehensiveness": upgrading principals' ICT leadership, improving teachers' digital teaching competence, and enhancing training teams' supervisory capacity. "One Comprehensiveness" meant that comprehensively promote the innovative integration of ICT in education and teaching. The *New Era Basic Education Strong Teacher Plan* proposed to prioritize the establishment of a batch of national teacher education bases, deepened reforms in teacher education, and fully leveraged the role of distinguished teachers and school principals in driving improvement (MOE, 2022).

The MOE (2021a) implemented the second phase of the artificial intelligence (AI) program to advance pilot work for teachers' team construction. A total of 100 units were deployed across 55 universities, 20 municipalities, and 25 districts, with the goal of leveraging AI technology to support and enhance teaching practice. As of September 2022, a dedicated section for "Teacher Training" has been established on the National Smart Education Public Service Platform. In the nationwide "Summer Specialized Teacher Training," over 13 million teachers have registered for learning, with a cumulative total of over 1.3 billion learning visits.

These initiatives reflected the MOE's commitment to fostering digital competence among teachers and utilizing innovative approaches to drive educational development in China. Digital competence was increasingly becoming a professional development skill that teachers, school leaders needed to value and master (Kaminskienė; Järvelä; Lehtinen, 2022). This was not only about enhancing the basic skills for teachers to operate digital devices and access digital content, but also about learning how to integrate the ICT into teaching (Rana et al., 2021).

Figure 2. The policy content corresponds to the smart education framework (Forward-Thinking Governance and Policy Initiatives)



Source: Prepared by the authors.

5. Smart Learning Environments

As information technology continues to advance and teaching practices integrate with it, the establishment of smart learning environments has become the foundation for implementing smart education. The smart learning environment is a learner-centered environment based on the application of the ICT (Jeong, 2022). It was designed to accommodate diverse learning styles and abilities (Jou; Wang, 2019), thus facilitating lifelong learning and the holistic development for learners (Lu et al., 2021). The construction of smart learning environments in China can be summed up by the following three aspects (See Figure 3).

5.1. Seamless Connectivity

"Seamless Connectivity" relies on promoting the upgrade of campus local area networks, ensuring high-speed access to resources and applications within the school. This can be achieved through methods such as 5G and gigabit wireless local area networks, enabling complete wireless network coverage across the campus. China was committed to promoting equitable access network and constructing a campus network to provide high-speed, convenient, and secure network services to users.

In August 2019, the State Council proposed "accelerating the construction of the Nation Network for Education (N2E) to realize all schools' access to fast and stable Internet by 2022". In 2021, the MOE and other departments proposed "constructing the Network for education to facilitate education reform in the context of information technology". Measures include: a) improving the quality of network service; b) reducing the overall cost to users; c) ensuring that teachers and students have Internet access; and d) ensuring that the school network changes from the period of "full coverage" to the period of "improved quality".

As of December 2020, the network access rate for primary and secondary schools in China achieved full coverage, reaching 100%. Furthermore, the majority of schools, accounting for 99.92%, had export bandwidth exceeding 100Mbps.

Through the seamless connectivity of the Internet, all students and teachers can be connected as cross-border participants in smart education, freeing themselves from the constraints of location and time in order to meet the growing demand for seamless learning among students. The integration and interoperability of education data, as well as seamless learning, can provide both teachers and students with efficient and convenient learning services. The government should promote the upgrading of campus local area networks to ensure high-speed access to campus resources and applications.

5.2. Learning Devices and Support

Learning Devices and Support mean that all students and teachers are provided with access to a digital learning device conducive to smart education and capable of connecting to advanced telecommunications and information services (ISTE, 2021). To better meet the educational needs of teachers and students, China has issued an education strategy to support the construction of information infrastructure, emphasizing the establishment of a national-level education service platform.

In December 2021, the State issued the "14th Five-Year Plan", a strategic plan for the development of national informatization, which explicitly stated that: a) the government should take actions to improve the level of education informatization infrastructure construction, build a high-quality education support system; b) the various departments should cooperate to improve the national public service system of digital education resources, expand the coverage of high-quality resources; and c) All schools should accelerate digital development and promote high-quality development of education. This guidance provided a crucial blueprint for the work of regional education digitization.

In recent years, the MOE made solid progress in the construction of ICT infrastructure and achieved remarkable results. As of the first quarter of 2021, 98.7 percent of primary and secondary schools in China had constructed multimedia classrooms; 84.44% of schools had full coverage of multimedia teaching devices; and the total number of multimedia classrooms had reached 4.3 million. In March 2022, the National Public Service Platform for Smart Education was officially launched online, providing plentiful resources and educational services for all teachers and students. As of February 2023, the platform had made available over 44,000 educational resources to consumers from over 200 countries and regions. The National Smart Education Platform basically formed the world's biggest digital center and

service platform for education resources (Cyberspace Administration of China, 2020; Chinese Government Network, 2023)

Hence, there was a need to reinforce the construction of network platforms, establish a digital service ecosystem, and promote the seamless connectivity of educational resources. This ensured that all teachers and students can access digital support services, connect to advanced educational information and resources, break down information silos, and facilitate differentiated teaching approaches, personalized learning, and intelligent services. By providing digital and intelligent support, it paved the way for the comprehensive development of high-quality talents in the digital age.

5.3. Ethical Use of Technology

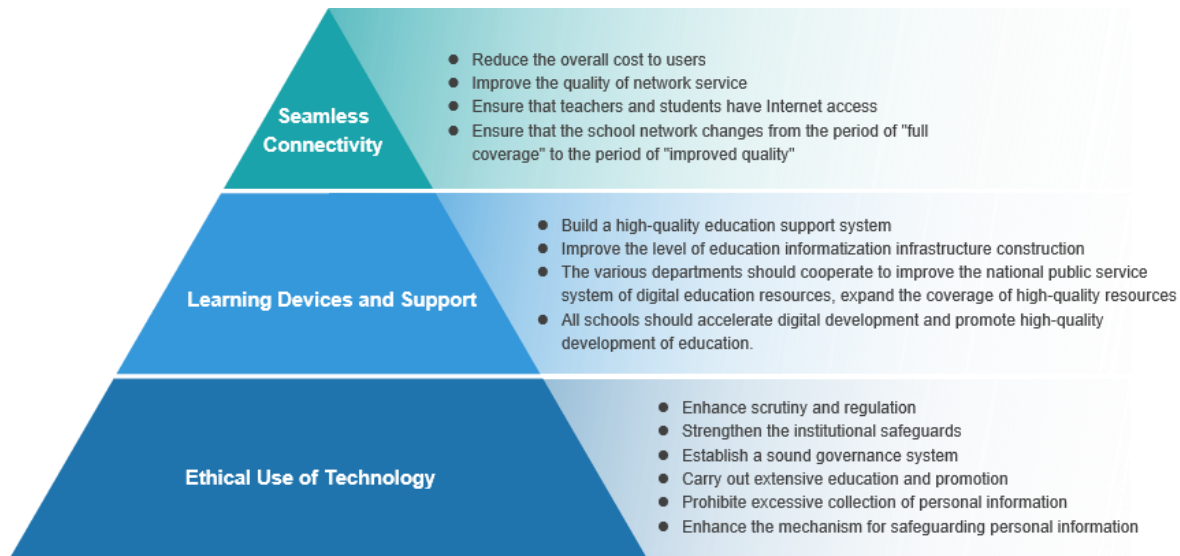
Technology ethics are the value concepts and behavioral norms that need to be followed in conducting scientific research, technological development, and other scientific activities. They serve as an important guarantee for promoting the healthy development of the science and technology industry (Chinese Government Network, 2022). It is essential for to ensure the availability, integrity, confidentiality, and security of data in cyberspace, as well as to effectively address the ethical issues of digital technology.

In 2021, the *Personal Information Protection Law of the People's Republic of China* provided a legal guarantee for cracking the topical and hard issues in the protection of personal information. The law clearly stipulated that excessive collection of personal information was prohibited and enhanced the mechanism for safeguarding complaints and reporting personal information. And In 2022, *Opinions on Strengthening the Governance of Science and Technology Ethics* provided guidance for preventing and controlling risks in technology ethics: a) establish a sound governance system; b) strengthen the institutional safeguards; c) enhance scrutiny and regulation; d) carry out extensive education and promotion. This opinion aims to establish and improve a technology ethics system that is in line with China's national conditions, emphasizing the unity of promoting innovation and preventing risks, the combination of institutional norms and self-discipline, and strengthening bottom-line thinking and risk awareness.

China has recently established the National Science and Technology Advisory Committee and established the National Science and Technology Ethics Committee., which could address the problems of fragmented allocation of scientific and technological resources and make the governance mechanism more responsive to the needs of scientific and technological development.

Thus, it is essential to strengthen the ethical training of technicians, faculty, and students so that digital technologies are subject to ethical guidelines during the design and development stages. More attention should be paid to cybersecurity and digital ethics. Specifically, including technical security, algorithm security, data security, etc., we should ensure the availability, dependability, and controllability of the digital network platform for education and perpetually improve the level of digital management in education.

Figure 3. The policy content corresponds to the smart education framework (Smart Learning Environments)



Source: Prepared by the authors.

6. Transformative Teaching and Learning Enabled through Technology

Leveraging intelligent technology to enhance teaching and learning within a smart learning environment is a fundamental principle underscored in various educational policies in China. The pedagogy paradigm should transition from being teacher-centered to teacher-guided and student-centered, while the assessment paradigm should shift from primarily summative evaluation to incorporating both formative and summative assessment. Students' core competencies in the digital age should also be reconsidered, which is the foundation for adapting to the uncertain and fast-changing world (See Figure 4).

6.1 Student-Centered Pedagogy

"Student-Centered Pedagogy" views students as designers and shifts the teacher's role from disseminating information to facilitating student learning. China empowers comprehensive educational reforms, providing suitable education for every learner and

emphasizing the significance of student participation in the learning process (China Smart Education Blue Book, 2022).

During the past two decades, the student-centered pedagogy gained widespread recognition, following the full implementation of well-rounded education. The MOE of China (2018b) issued the *Opinions on Accelerating the Construction of High-Level Undergraduate Education to Comprehensively Improve Talent Cultivation*, highlighting the need for teaching reforms that focused on stimulating students' learning interests and unlocking their full potential. The goal was to initiate a learning revolution centered around students' development, guiding them towards self-management and active learning. This approach aimed to foster a genuine thirst for knowledge, enhance learning efficiency, and cultivate independent learning abilities. As education and technology continue to advance, it became imperative for teachers to harness these technologies to revolutionize instructional methods. This included abandoning conventional spoon-feeding teaching in favour of engaging, interactive, and inquiry-based teaching. Furthermore, cooperative, project-based, and research-based learning should be used.

The Dongcheng District in Beijing actively explores future school and future education models, gradually establishing digitalized, intelligent, and learner-centric schools. Through personalized curriculum content and teaching methods, it aimed to achieve students' personalized development. During the pandemic, the "Open Online Q&A Service Platform for Secondary School Teachers" had over 8,900 middle school teachers providing more than 3 million personalized online tutoring sessions for nearly 100,000 junior high school students in the city.

Therefore, teachers should design efficient learning experiences for students by changing teaching methods. This enabled students to embrace the role of digital learners, actively seeking and selecting knowledge in the realm of smart education. Through this approach, students can embark on a path of personalized development, fostering their autonomy in the learning process and facilitating the shift from a teacher-centered pedagogy to a student-centered one.

6.2 Reimagined Assessments

Assessments should comprehensively document students' learning and practical experiences, objectively analyze their abilities, and support both longitudinal evaluations throughout different stages of education and comprehensive cross-domain evaluations encompassing moral, intellectual, physical, artistic, and labor-related aspects. To achieve this

goal, China actively explores the establishment of a comprehensive assessment system and adopts emerging technologies to improve the timeliness and accuracy of assessments.

The MOE of China (2022) issued the *Notice of the General Office of the Ministry of Education on the pilot work of information technology to support the comprehensive quality evaluation of students*, which planned to select approximately 30 regions for pilot programs spanning a five-year period. The primary objective was to establish a comprehensive database encompassing millions of primary and secondary school students, focusing on their all-around developments of moral, intellectual, physical, aesthetics and labor education. To accomplish this, the initiative will employ innovative evaluation tools and emerging intelligence technologies such as artificial intelligence and big data, which aimed to explore the entire process of students' learning and growth. The *Notice on the Recommendation and Selection of the Smart Education Pilot Zone Construction Project* (MOE, 2021b) proposed the precise assessment of the students' Comprehensive Literacy Evaluation (CLE) supported by AI and big data. Here were some of the measures implemented: a) develop uniform data acquisition standards and usage specifications; b) take full advantage of big data acquisition technology; and c) create the CLE index system and assessment model.

Guangzhou City implemented a smart assessment project. Measures included: 1) establishing a CLE management system for students; 2) relying on the CLE Management Platform for secondary school students in Guangdong Province, they promoted the combination of qualitative and quantitative assessment. In 2020, based on the international PISA assessment and national compulsory education quality monitoring, reading and scientific literacy evaluations, as well as mathematics subject monitoring were added. From 2017 to 2022, a total of 283,347 students, 41,846 teachers, and 3,069 principals were assessed, forming the Guangzhou model of intelligent Evaluation for primary and secondary education quality (Guangdong News Network, 2022).

As a result, teachers and students can collaborate to set learning goals and select the most suitable assessment tools for measuring learning outcomes effectively. Digital technology played a pivotal role in reshaping the evaluation landscape by facilitating the development of data collection standards and models. This enabled comprehensive data collection across all facets of student development. Moreover, teachers were encouraged to continuously enhance educational experiences and refine teaching methods based on the data. This iterative process enabled the realization of students' competence improvement through the seamless integration of the evaluation process and the learning process.

6.3 Student's core competencies

Student's core competence refers to the essential qualities and key abilities that students should possess in order to adapt to the needs of lifelong development and social progress. Core competencies focus on the development of quality education, cultivating learners' higher-order thinking skills, comprehensive innovation abilities, and lifelong learning capabilities (China Smart Education Blue Book, 2022). Since 2016, China has comprehensively initiated academic research, practical exploration, and policy formulation in the cultivation of student core literacy.

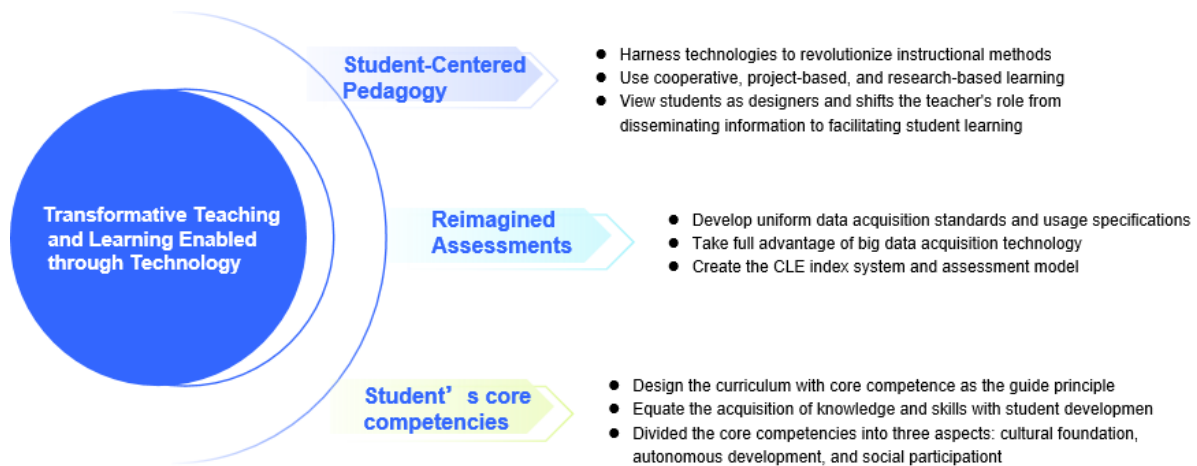
In 2016, the research achievements of core competency development among Chinese students were released, divided the core competencies into three aspects: cultural foundation, autonomous development, and social participation, which were embodied in the six competencies of humanistic cultivation, scientific spirit, learning to learn, healthy living, responsibility, hand-on abilities, and innovation (China Education Network, 2016). In 2019, the MOE proposed a policy of "double reduction", which proposed that the work objectives of schools should be implemented to enhance the development level of students' core competencies. In 2022, the MOE issued the *Compulsory Education Curriculum Programme and Curriculum Standards*, which revised the compulsory education curriculum programme and standards to systematically design the curriculum with core competence as the guide principle, transforming the goal orientation that equated the acquisition of knowledge and skills with student development, and leading teaching activities and teaching evaluation to promote and observe students' overall development from a core competence perspective. Through the learning processes of cooperation, inquiry, and reflection, we promoted students' progressive development of core competence.

In the construction of the smart education demonstration zone, the Dongcheng District in Beijing has established the Youth Information Literacy Education Institute to cultivate students' innovation awareness, innovative thinking, and innovative abilities. It has also created a platform for showcasing students' innovative works, leading young people to explore the field of AI technology. The new teaching scenarios have transformed learning from simple browsing and listening into a process that helps students acquire the learning method of "observe, think, ask questions, solve problems, and form opinions." This approach promotes the development of core competencies (MOE, 2023).

Thus, to develop students' core competence, the state and local communities need to understand the importance of core competencies, create more diverse learning opportunities, clarify students' learning goals, and advocate for students to improve their abilities in

authentic contexts. It was extremely important to focus on student developmental differences and provide timely feedback and assessment.

Figure 4. The policy content corresponds to the smart education framework (Transformative Teaching and Learning Enabled through Technology)



Source: Prepared by the authors.

7. Overarching Considerations for Smart Education

When implementing the three key leverage points mentioned above, Chinese government leaders also prioritize several overarching considerations (see Figure 5) to ensure that the modernized digital learning ecosystem is agile, sustainable, and responsive to the needs of all stakeholders.

7.1 Inclusion and Equity

"Inclusion and Equity" refer to provide lifelong learning opportunities for all students, not least those with disabilities and others who live in rural areas. In the 21st century, China has embraced the principle of "advancing equity as a core tenet of national education policy." Recognizing the value of inclusive education, China has made significant strides in enhancing teaching quality in impoverished regions through insightful recommendations.

"Struggle to give every child an opportunity to be educated" is not only a solemn commitment but also a direction of progress. China had undertaken several steps to ensure inclusion and equity in education. The **State (2017)** issued the *Notice of the Second Period Special Education Improvement Plan (2017-2020)*, which provided guidance for developing inclusive education: a) encourage and guide society to be inclusive towards special education; b) improve the accessibility of compulsory education for children with disabilities; c) establish a sound mechanism for funding special education; d) promote reforms in special education curriculum and teaching. In addition, the MOE of China (2018c) issued the *Action*

Plan of ICT in Education (2.0 version) to improve educational quality in deep poverty-stricken areas by using measures including: a) enhance teacher informative teaching ability training and educational informational leadership training; b) share high-quality digital resources; c) donate ICT teaching equipment.

By 2021, the nationwide consolidation rate of compulsory education reached 95.4%. The enrollment rate for school-age children with disabilities in compulsory education exceeded 95%. The coverage of compulsory education surpassed the average level of high-income countries worldwide. Over 8 million students from impoverished families have received vocational education at the secondary and higher levels.

Therefore, the education sector should play a leading role in promoting inclusion and equity, considering it a guiding principle for all school teachers (Ainscow, 2020). Combining the teaching experience with practise, nations should develop proactive and effective policies to foster the establishment of new school governance models, transform teachers' and students' educational beliefs, and ultimately achieve a more equitable education system. Education leaders should recognize the urgency to modernize the digital learning ecosystem so as to truly provide inclusive and equitable educational opportunities to all students in this new era of learning.

7.2 Continuous Improvement Culture

The foundation of digital culture is built upon collaboration, fostering innovation, embracing data-driven practices, and prioritizing customer-centricity (World Economic Forum, 2021). In China, smart education's value goal is to create a sustainable digital culture, grasp the direction of digital cultural development, and empower cultural innovation through the deep integration of digital technologies (Chinese Government Network, 2022).

The State Council General Office (2022) has issued the *Opinions on Promoting the Implementation of the National Cultural Digitization Strategy*, which makes important deployments for digital cultural development: a) it calls for the comprehensive utilization of achievements from digital projects and databases in the cultural field to form an interconnected Chinese cultural database; b) it emphasizes the consolidation of cultural digital infrastructure to establish a national cultural network; c) it encourages and supports various educational institutions to connect to the national cultural network and utilize cultural data service platforms to explore effective ways for digital transformation and upgrading; d) it coordinates the advancement of the national cultural big data system, the nationwide smart library system, and the construction of the public cultural cloud, aiming to enhance the supply

capacity of digital content for public culture and improve the digitization level of public cultural services.

In the construction of smart education demonstration zones in our country, various regions combine local characteristics and integrate culture with education. For example, in Fuzhou city, they are creating a "smart education" business card to generate a demonstration effect. They rely on the "Mountain and Sea Cooperation" platform to radiate throughout the entire province, the "Fujian-Ningxia Cooperation" platform to radiate nationwide, the "Fujian-Taiwan Cooperation" platform to extend across the Taiwan Strait, and the "Maritime Silk Road platform" to radiate countries along the Belt and Road Initiative. Through Fuzhou's culture, they are building a "united circle" for the coordinated development of smart education. (People's Government of Fuzhou District, 2021).

By creating a data-based education decision-making culture, integrating intelligent technologies such as big data, learning analysis, and the Internet of Things into the transformation process of school education decision-making, and promoting the deep integration of technology and education and teaching, we can change traditional work ideas and business processes, realize the value transformation led by digital thinking, and form a new type of school digital education ecology that is fair and inclusive, personalized and accurate, and context-appropriate.

7.3 Multi-Sector Cooperation and Partnerships

Multi-Sector Cooperation and Partnerships refer to playing their respective advantages and maximizing their interests. Multi-sector cooperation and partnerships appeared as safeguard mechanisms in most policies. Education administrative departments at all levels should take the leading role in establishing a collaborative mechanism involving departments such as cyberspace administration, development and reform, finance, communications, industry and information technology, and finance, in order to build a high-quality education system.

China's governance model was the MOE's leadership and coordination, as well as multi-party cooperation and co-promotion. With the rise of social organizations, more and more non-governmental actors were involved, from policy formulation to implementation (Cai et al., 2022). China's governments also increasingly encouraged the participation of social forces and brought together multiple forces to ensure the supply of resources (Xue et al., 2021). Some regions also took measures to establish government-led primary and secondary schools, universities, and business enterprises multi-participation to build a UGBS (university, government, business enterprise, and school) educational resource supply mechanism (universities, government, business, primary and secondary schools). The MOE

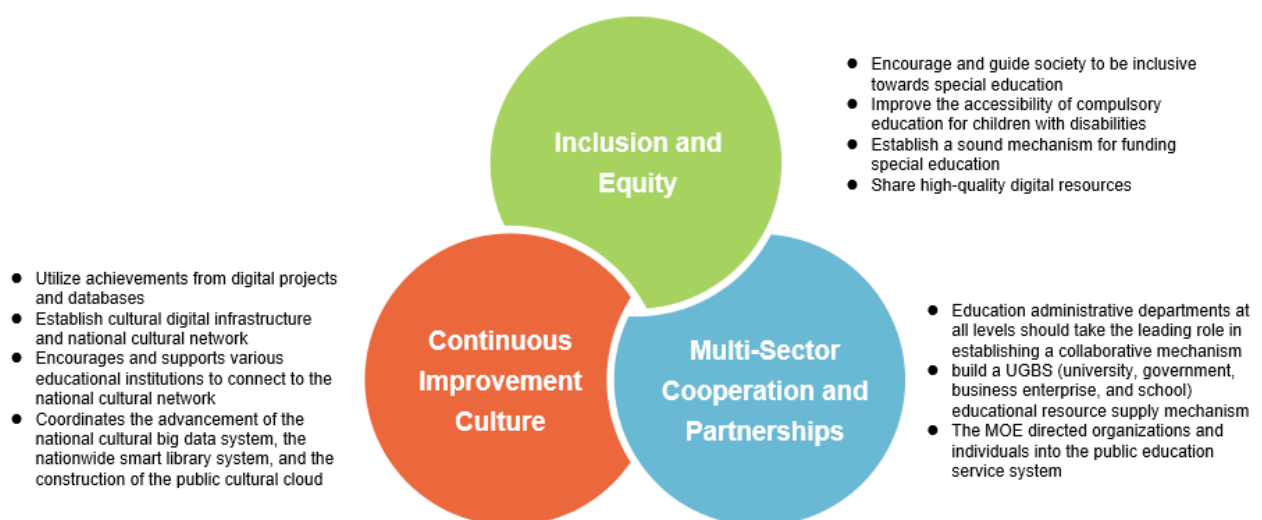
directed organizations and individuals into the public education service system, such as schools, academies, institutions, social organizations, professionals, and so on.

Some well-known Chinese companies, including Tencent, Baidu, iFlytek, etc., have penetrated the field of education. They provided various ICT products and services to different education sectors, positively contributing to the ICT industry ecosystem in education (Li; Wang; Gu, 2019). For example, during the outbreak, Dingding (Alibaba Group) and other social organizations provided simultaneous and asynchronous teaching tools for teachers and students. IFlytek built a business system for three types of customers, including region, school, and parent user groups, and continuously implemented the comprehensive solution of smart education, which was applied in more than 38,000 schools and more than 40 cities and districts. In addition, China also encouraged communication and cooperation with international institutions to strengthen foreign ICT in the education of reference, absorption, and re-innovation.

Hence, the government should strategically incentivize multi-sector partners to actively contribute and collaborate, sharing their resources and knowledge for the betterment of society. This can be achieved by improving communication channels between different sectors, fostering cooperation to tackle significant challenges in teaching practices, and effectively promoting smart education.

Figure 5. The policy content corresponds to the smart education framework (Overarching Considerations for Smart Education)

Overarching Considerations for Smart Education



Source: Prepared by the authors.

8. Conclusion

In the new wave of technological revolution and industrial transformation, digital technology is increasingly becoming a driving force that fundamentally transforms human social thinking, organizational structures, and operational models. Many definitions of smart education focus on the powerful and influential ways in which these technologies open new vistas for learning (such as personalized learning anytime, anywhere), teaching and education management (Bajaj; Sharma 2018; Pedró et al., 2019) and on their potential for catalyzing education transformation.

With a due support at the governmental level, China demonstrates the highest level of involvement, both in the construction of demonstration areas or the guidelines to clarify the development standards for each aspect of smart education.

Overall, four pillars have provided a rich descriptive and interpretive account that offers other countries a better understanding of the strategies to drive and support ICT in education and, therefore, a better position to adapt the strategies for their own context. Meanwhile, through the analysis of policy documents, it is found that smart education has become an important strategic approach for achieving sustainable development in education in China. Within the national smart education framework, "forward-thinking governance and policy initiatives" elevates sustainable development in education to a national strategic level., "smart learning environments" provides technological support for achieving sustainable development in education, "transformative teaching and learning facilitated by technology" is the necessary path for the sustainable development of education, and "overarching considerations for the implementation of smart education" ensures that education meets the requirements of sustainable development and responds to the needs of all stakeholders.

In recent years, there has been a high international concern for the sustainable development in education. In 2022, UNESCO proposed Sustainable Development Goal 4: Nations should ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Therefore, the United Nations and UNESCO have provided guiding recommendations to strengthen global capacity for the sustainable development of education: a) The *Report on the 2022 Transforming Education Summit* called for establishing gateways to public digital learning, which aim to ensure that every learner, teacher, and family can easily access, search, and use high-quality digital educational content aligned with the curriculum to enhance their learning (United Nations, 2023) ; b) *Transforming education together: The Global Education Coalition in action* launched the "Digital Transformation Collaboration" initiative and proposed the 5C Transformation Theory: Coordination and

leadership, Cost and sustainability, Connectivity and infrastructure, Capacities and culture, and Content and curriculum. These five components could be seen as the elements required to provide all learners with the necessary skills to benefit from digital learning, while protecting them in digital environments (UNESCO, 2023).

Sustainable development depends on every child receiving quality education. Not only China, but all countries should actively develop and implement rewarding smart education strategies and solutions can expand access to quality education and lifelong learning opportunities to promote the realization of Sustainable Development Goal 4.

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11. Attachments

Table 1: National-level policies on smart education (partial) from 2013 to 2023

RELEASE DATE	ISSUE DEPARTMENT	POLICY NAME	HYPERLINK
2012/3/13	Ministry of Education	Notice on the "Ten-Year Development Plan for Education Informatization (2011-2020)".	https://www.gov.cn/gzdt/2012-03/31/content_2104056.htm
2016/7/15	Ministry of Education	Opinions on Further Enhancing the Equipment Work of Primary and Secondary Schools under the New Situation	http://www.moe.gov.cn/srcsite/A06/jcys_jyzb/201607/t20160725_272874.html
2016/9/14	State Council General Office	Release of "Core Competencies for Chinese Students' Development"	http://www.scio.gov.cn/zhzc/8/4/Document/1491185/1491185.htm
2017/7/18	Ministry of Education and six other departments	Notice of the Second Period Special Education Improvement Plan (2017-2020)	http://www.moe.gov.cn/srcsite/A06/s3331/201707/t20170720_309687.html
2018/2/1	Ministry of Education	Key Points on Work of the MOE for 2018	http://www.moe.gov.cn/srcsite/A02/s7049/201802/t20180206_326950.html
2018/4/18	Ministry of Education	Notice of the Ministry of education on printing and distributing the action plan for educational informatization 2.0	http://www.moe.gov.cn/srcsite/A16/s3342/201804/t20180425_334188.html
2018/4/18	Ministry of Education	Action Plan of ICT in Education (2.0 version)	http://www.moe.gov.cn/srcsite/A16/s3342/201804/t20180425_334188.html

2018/10/8	Ministry of Education	Opinions on Accelerating the Construction of High-Level Undergraduate Education to Comprehensively Improve Talent Cultivation	http://www.moe.gov.cn/srcsite/A08/s7056/201810/t20181017_351887.html
2019/3/20	Ministry of Education	Opinions on the Implementation of the Digital Teaching Competence Improvement Project 2.0 for Nationwide Primary and Secondary School Teachers	https://www.gov.cn/zhengce/zhengceku/2019-10/23/content_5443970.htm
2021/2/19	Ministry of Education	Notice on the Recommendation and Selection of the Smart Education Pilot Zone Construction Project	http://www.moe.gov.cn/srcsite/A16/s3342/202104/t20210401_523802.html
2021/7/3	Cyberspace Administration of China	Digital China Development Report (2020)	https://www.gov.cn/xinwen/2021-07/03/content_5622668.htm
2021/7/8	Ministry of Education and five other departments	Guiding opinions on promoting the construction of new educational infrastructure and building a high-quality education support system	http://www.moe.gov.cn/srcsite/A16/s3342/202107/t20210720_545783.html
2021/11/29	Ministry of Education	The report on the monitoring results of the moral education status and the quality of scientific learning in national compulsory education has been released	http://www.moe.gov.cn/jyb_xwfb/gzdt_gzdt/s5987/202111/t20211129_583124.html
2022/3/20	State Council General Office	Opinions on Strengthening the Governance of Science and Technology Ethics	https://www.gov.cn/zhengce/2022-03/20/content_5680105.htm
2022/3/25	Ministry of Education	Compulsory Education Curriculum Programme and Curriculum Standards (2022 Edition)	https://www.gov.cn/zhengce/zhengceku/2022-04/21/content_5686535.htm
2022/4/2	Ministry of Education and seven other departments	New Era Basic Education Strong Teacher Plan	https://www.gov.cn/zhengce/zhengceku/2022-04/14/content_5685205.htm
2022/5/22	State Council General Office	Opinions on Promoting the Implementation of the National Cultural Digitization Strategy	https://www.gov.cn/zhengce/2022-05/22/content_5691759.htm
2022/10/7	State Council General Office	Opinions on Strengthening the Construction of High-Skilled Talents in the New Era	https://www.gov.cn/zhengce/2022-10/07/content_5716030.htm
2022/11/15	Ministry of Education	Notice of the General Office of the Ministry of Education on the pilot work of information technology to support the comprehensive quality evaluation of students	http://www.moe.gov.cn/srcsite/A16/s3342/202211/t20221118_995825.html
2022/11/15	Ministry of Education	Notice on Carrying Out Pilot Work on Information Technology Support for Comprehensive Evaluation of Student's Comprehensive Quality	http://www.moe.gov.cn/srcsite/A16/s3342/202211/t20221118_995825.html

Source: Prepared by the authors.

Table 2 - Reports on smart education achievements (partial) from 2013 to 2023

RELEASE DATE	ISSUE DEPARTMENT	POLICY NAME	HYPERLINK
2022/9/27	Ministry of Education	The achievements of education reform and development in China since the 18th National Congress of the Communist Party	http://www.moe.gov.cn/fbh/live/2022/54875/sfcl/202209/t20220927_665124.html
2022/9/26	Guangdong News Network	The Smart and Transparent Evaluation of the Quality of Primary and Secondary Education in Guangzhou City will be launched in 2022.	http://www.gd.chinanews.com.cn/2022/2022-09-26/423867.shtml
2023/1/4	Chinese Government Network	The Internet access rate in primary and secondary schools has reached 100%, and over three-fourths of schools have achieved wireless network coverage	https://www.gov.cn/xinwen/2023-01/04/content_5734921.htm

Source: Prepared by the authors.

Table 3 - Smart education policies in selected provinces of China

PROVINCE	RELEASE DATE	POLICY NAME	HYPERLINK
Shanghai	2018/9/27	Shanghai Education Informatization 2.0 Action Plan (2018-2022)	http://jwc.sspu.edu.cn/wcm/files/upload/CMSjwc/201809/201809270659025.pdf
	2021/5/27	Minhang District's "14th Five-Year Plan" for Education Reform and Development	http://www.shmh.gov.cn/shmh/shmh/upload/202105/0507_103728117_167.pdf
Beijing	2018/7/17	Beijing Education Informatization Three-Year Action Plan (2018-2020)	http://edu.china.com.cn/2018-07/17/content_57566263.htm
	2022/3/14	Notice on the "14th Five-Year Plan for Education Informatization in Beijing"	https://www.beijing.gov.cn/zhengce/zhengcefagui/202203/t20220316_2631467.html
Guangdong	2017/5/25	Guangdong Province's "13th Five-Year Plan" for the Development of Education Informatization.	https://www.edu.cn/xxh/focus/df/201705/t20170525_1519294.shtml
	2021/11	Guangdong Province's "14th Five-Year Plan" for Education Development.	https://www.gd.gov.cn/zwgk/wjk/qbwj/yf/content/post_3602375.html

Source: Prepared by the authors.