Rongxia Zhuang · Dejian Liu ·
Demetrios Sampson ·
Danimir Mandic · Siyi Zou · Yu Huang ·
Ronghuai Huang   *Editors*

Smart Education in China and Central & Eastern European Countries

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Editors

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Editors
Rongxia Zhuang
Smart Learning Institute
Beijing Normal University
Beijing, China

Demetrios Sampson ⓘ
Department of Digital Systems
University of Piraeus
Piraeus, Greece

Siyi Zou
Global Public Sector
Enterprise Business Group
Huawei, China

Ronghuai Huang
Beijing Normal University
Beijing, China

Dejian Liu
Beijing Normal University
Beijing, China

Danimir Mandic
Teacher Education Faculty
University of Belgrade
Belgrade, Serbia

Yu Huang
Global Public Sector
Enterprise Business Group
Huawei, China

Preface

In 2020, the book *Comparative Analysis of ICT in Education Between China and Central and Eastern European Countries* was published, which mainly focused on taking stock and comparing the state of the art in deploying ICT in the education field among China and Central and Eastern European Countries. As a follow-up, this book revisits the current situation of smart education, including policies, infrastructure and major national initiatives for China and Central Eastern European Countries, this time within the lens of the global pandemic due to COVID-19.

The world we live in is changing rapidly due to technological advancements and unexpectedly due to the COVID-19 pandemic. These changes go beyond the national governments' regular plans for sustainable development in all aspects of economic and social life. The global COVID-19 pandemic has impacted every aspect of our daily lives, and education is not an exception. As the United Nations Educational, Scientific and Cultural Organization (UNESCO) stated in the initiatives of Futures of Education, society is facing a crisis that builds up with "*persistent inequalities, social fragmentation, and political extremism.*"[1] To deal with such crises, responsive, consistent and effective planning is required.

Different types of technology have been re-invented within the past two years, vastly affected by the global pandemic years. In most part of the world, a major national digital transformation has been accelerated to respond to the pandemic's urgent challenges. Digital technologies that could support people in remote working and studying have been widely used. National initiatives for enhancing digital competences both for the majority of the citizens and specific professionals (such as school teachers) have been undertaken. The technical infrastructure has been updated and upgraded to support online merged offline operations at all aspects of economic, social and personal life.

The digital transformation has impacted the society at large and changed the way people used to perceive social activities. Especially in the field of education, the key actors involved (namely students, teachers, parents and administrators) have

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[1] UNESCO. (n.d.). The initiative. Retrieved January 20, 2022, from https://en.unesco.org/futuresof education/initiative.

benefited from the technology during the pandemic and, as a result, are keen to incorporate technology within the post-pandemic era. Also, the wide deployment of digital technologies in the education field requires certain digital competencies from teachers and students to effectively use them during the teaching and learning process. UNESCO had published the ICT Competency Framework for Teachers version 3 in 2018, which aimed to provide tools for teachers to effectively use new technologies during the teaching and learning process. Moreover, the framework contains a set of competencies that teachers can integrate into their professional practice, and thus make the progress of students learning easier than before.[2] Meanwhile, Christine Redecker from the European Commission Joint Research Center had published *European Framework for the Digital Competence of Educators: DigCompEdu* in 2017, aiming to work as a framework guidance for implementing policies and programs national and regional.[3] In addition, it not only helps to promote the establishment of programs and policies, but also provides an approach for member states to exchange best practices of digital competence models on all levels of education.

Under the urgent and rapid global changes, education has to respond to the complexity and diversity of societies at large, with sustainability, resilience, flexibility and quality. UNESCO's Sustainable Development Goal 4 aimed to achieve the goal of sustainability and improve the quality of education in the world. In addition, the flexibility and resilience of education stand out during the pandemic years. Various types of digital applications and teaching modes, such as TV/radio and online teaching classes, were used during the long COVID-19 lockdown periods to support continuing teaching and learning.

As a result, the trend of education in the future could include providing learning "*multiplicity of sites beyond formal schools and at planned and spontaneous times.*"[4] In the post-pandemic era, digital technologies are more mature, the population is more digitally competent and the basic infrastructure is more solid. Countries in Central Eastern Europe and China are now developing action plans and strategy policies to further build a digital environment for teachers and students, who are the most important actors involved in the teaching and learning process, to embrace the coming digital society. For example, China has introduced Smart Education Demonstration Area Construction Program in 2019, aimed at cooperating with local government to provide precise and personalized service to students and parents with the most innovative digital technology. The program intends to collect data from the users and learning process and use them to facilitate learning at any pace, any time, and

[2] UNESCO. (2018). UNESCO ICT Competency Framework for Teachers: Version 3. Retrieved March 24, 2022, from https://unesdoc.unesco.org/ark:/48223/pf0000265721.

[3] Redecker, C. (2017). European Framework for the Digital Competence of Educators: DigCompEdu (Y. Punie, Ed., JRC Science for Policy Report No. JRC107466). Luxembourg: Publications Office of the European Union. https://doi.org/doi:10.2760/159770.

[4] International Commission on the Futures of Education. (2021). Reimagining our futures together: A new social contract for education. Retrieved February 10, 2022, from https://unesdoc.unesco.org/ark:/48223/pf0000379707.

any place. This way, the quality and equality of education will be promoted while the students obtain better experiences, high efficiency, and highly adapted content during the learning process.[5]

Moreover, the European Union published Digital Action Plan (2021–2027) recently while school life had been significantly affected by the COVID-19 pandemic. The two priorities of the action plan were nevertheless similar to the aim of China's Smart Education Demonstration Area Construction Program, namely, to establish a digital education environment and enhance the digital skills and competencies for digital transformation.[6] Since it is an updated version of the previous EU Digital Education Action Plan, it emphasizes that the impact of COVID-19 had significantly pushed the development of digital transformation on society and the economy. As the EU Digital Education Action Plan (2021–2027) stated: "*the pandemic has demonstrated that having an education and training system which is fit for the digital age is essential.*"[7]

As the digital age is coming, technology and education empower each other. Currently, digital transformation has become the core of education reform and development. Countries and institutions worldwide are preparing for the digital transformation. Smart education can be seen as a high-end form of digital transformation in education. Smart education (system) is considered as the educational behaviors (system) provided by schools, regions, or governments, with the characteristics of high learning experience, learning content adaptation, and teaching efficiency. Smart education has been attached great importance in many countries. However, although China and Central Eastern Europe Countries have plans and take actions to establish further advanced digital education (smart education) to fulfill the needs of achieving the Education 2030 Agenda, the gap between the development of smart technologies and the maturity of the digital transformation still exists in each country. This book, therefore, presents China and Central Eastern European Countries' experts' understanding of smart education, experiences and action plans for establishing a smart education environment. Due to the differences in the understanding and practice of smart education in various countries, this book focuses on the sharing of multitheoretical understandings based on policies and best practices, allowing the readers to have a comprehensive view of smart education.

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[5] Ministry of Education. (2019, January 10). Notice of the General Office of the Ministry of Education on the Recommendation and Selection of the "Smart Education Demonstration Area" Construction Program Retrieved February 10, 2022, from https://www.moe.gov.cn/srcsite/A16/s3342/201901/t20190110_366518.html.

[6] European Commission. (2021). Digital Education Action Plan (2021–2027). Retrieved February 10, 2022, from https://education.ec.europa.eu/focus-topics/digital/education-action-plan.

[7] See Footnote 6.

and authors Ana Sekulovska Jovkovska, Angeliki Karamatsouki, Benő Csapó, Boban Melović, Borut Čampelj, Charalampos Karagiannidis, Eva Jereb, George Chorozidis, Gyöngyvér Molnár, Haoyue Wang, Ilze Ivanova, Ineta Kristovska, Jian Hu, Maja Homen, Mario Dumancic, Pranvera Kraja, Siyka Chavdarova-Kostova, Yunwu Wang, Yuqing Li, Zizhen Feng.

Beijing, China   Ronghuai Huang

Contents

Chapter 1
Introduction

Rongxia Zhuang, Ronghuai Huang, Zizhen Feng, and Jian Hu

1.1 Introduction

The understanding of smart education is different in the world since it is a broad topic, and countries, including China and Central Eastern Europe (CEE), develop action plans, projects, and programs, respectively, to build a digital smart education environment according to various perspectives. Also, the term used to describe smart education is different among China and CEE countries. The term is mentioned as smart education in China, while the European countries described it more as digital education, ICT in education, and/or digital transformation in education. Moreover, the definition and the focused part of smart education/digital education are understood slightly differently by the countries' educators who contributed to this book. As the educators involved in this book mentioned in a pre-interview of the book, one necessary factor in the achievement of smart education is technology. Without digital technology, it is impossible to realize the establishment of a smart education environment, which is a common goal of the future society. Despite the various understanding of smart education, the expectation of establishing the digital society and education environment through implementing advanced technologies is arising worldwide.

R. Zhuang (✉) · R. Huang · Z. Feng · J. Hu
Smart Learning Institute, Beijing Normal University, Beijing, China
e-mail: zhuangrx@bnu.edu.cn

R. Huang
e-mail: huangrh@bnu.edu.cn

Z. Feng
e-mail: fengzizhen1997@163.com

J. Hu
e-mail: hujian_2012@outlook.com

1.2   Main Points of Smart Education

At the beginning, the authors' opinions and thoughts, who are coming from Central Eastern Europe countries, on the definition of smart education, had been collaboratively collected and tried to have a common understanding of smart education. Although the aspects of smart education are broad, it is still necessary to think about the foundations of smart education. Therefore, the authors of this book collaboratively defined the diverse "version" of the definition in each country based on different situations and practices, to express different insights on this topic.

Professor Siyka Chavdarova from Bulgaria considers smart education as a powerful tool for realizing inclusiveness in education, which is also one of the main aims of smart education. They think smart education should be realized based on "*students/teachers/parents and other stakeholders competencies to know, to understand, to do and to want to realize smart education,*" and are willing to be self-developed through long-term learning in this field since smart education is a sustainable continually developing process. Another point of view provided by experts Borut Čampelj and Eva Jereb in Slovenia is that smart education should combine personalized and collaborative learning, which brings students interests and become active in all learning phases. Professor Danimir Mandic from Serbia considered smart technology an important tool for teachers to look after students' behavior and evaluate each step during the teaching process. "*It is highly important to have feedback from smart technology systems,*" wrote Professor Danimir Mandic in the collaborative project document. He thinks the system of students' learning assessment will be changing from measuring learning outcomes at subject domains separately to measuring all students' activities, including interests, motivations, and understanding, within a smart education environment.

One common point that multiple countries had brought up is the establishment of the e-community for teachers and students. This viewpoint mostly puts the focus on the digital skill and competence development for students and teachers, which will further prepare them to accommodate a digitalized education environment. Also, during the discussion at the beginning of this book's writing, the experts who are also contributing to the book all agree with the perspective that smart education is not only about education using technology, but about innovative and transformative educational and pedagogical methods. Only in this way, the digitalization of education can be sustainable in the long term. Another perspective that all experts agreed with is that we need to study deeper how teaching and learning is changing within smart education environments supported by intelligent technologies, toward developing new smart pedagogies.

As UNESCO stated in the Education 2030 Framework for Action, the primary goal of Sustainable Development Goal 4: "*ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*" (UNESCO, 2016) is the starting point of deploying digital technologies in education. According to UNESCO, technology-supported education should make properties such as quantitative, algorithm-friendly, molecular, and easily storable become "*self-sustaining,*

autonomous and independent of human management" (UNESCO, 2021). The understanding of smart education for UNESCO is broader and considers the topic from a long-term perspective. Also, UNESCO ICT Competency Framework for Teachers mentions the prevalence of ICTs has accelerated the progress of Sustainable Goals. UNESCO recognized ICTs "*have a significant potential to accelerate progress, to bridge the digital divide and support the development of inclusive Knowledge Societies based on human rights, the achievement of gender equality and empowerment* (UNESCO, 2018)." Based on this perspective, it affects not only Goal 4, Quality education; but also related Goal 5, Gender equality, Goal 9, Infrastructure; Goal 10, Reduce inequality within and across the countries; Goal 16, Peace, justice and strong institutions; and last Goal 17, Partnerships for the goals.

Similarly, the Organization for Economic Cooperation and Development (OECD) published a joint work *How Learning Continued during the COVID-19 Pandemic*, which emphasized OECD member countries' various coping methods toward COVID-19. The pandemic has pushed forward the development of digital education as K12 schools have been shut down and students' learning processes have been interrupted. Global digital education cannot be well formed without innovative practices (frontiers), field practices (practice), and policymaking (policy) (OECD, 2022). The global digital education agenda summarized five areas that the previous aspects should consider: analysis, indicators, standards, capacity development, and development and evaluation. Along with the five areas and the three aspects, the progress of digital education is considered comprehensively. Also, the focus on the detailed areas and aspects promotes the digital transformation that UNESCO emphasized in SDG4 to make education sustainable and equitable.

Education plays an important role in people's daily life. Whether adult or children, they all have the desire and needs to access education. Digital technologies, such as artificial intelligence, robotics, and big data, will, even more, enhance the importance of education. The initial EU Digital Education Action Plan considered that digital transformation would accelerate the new technologies, ultimately impacting people's social, study, and work-life (European Commission, 2018). However, there are also challenges to digital transformation, which is unpreparedness for the future education. A vivid example is COVID-19's impact on global education. It interrupts the normal pace of school life and, most importantly, students' learning process. Still, the impact promotes the appearance of innovative technologies to deal with the problem that school shutdown brings.

The three initial priorities of the European Commission's Digital Education Action Plan were focused on deploying digital technologies in the teaching and learning process, promoting digital skills during the digital transformation process, and improving the whole system by using data analysis and foresight (European Commission, 2018). Through the three priorities, it is clear that digital education in the European region is also focusing on the learning environment and education system, like what OECD has mentioned previously.

The international institutions mostly put the focus of digital education on three parts. First is the use of digital technologies, including but not limited to AI technologies, big data, and cloud infrastructures, during the teaching and learning process.

The second is to ensure teachers' and students' ability to use digital tools during teaching and learning. Digital literacy is the key to making full use of digital tools involved in education. Last but not least, the governance of the education system by the government at different levels is another key factor of digital transformation. Strategic planning makes digital education becoming long-lasting and reliable.

1.3 Policies Around the World

The definitions of the smart education concept are different from region to region, and since countries are at different stages of development, the digital education policy focuses are varied.

1.3.1 OECD Digital Education Outlook 2021

The OECD generally focuses on the technologies that can be integrated into education and digitalize the whole education system through technologies. The publication *Pushing the frontiers with AI, blockchain, and robots* that OECD published in 2021 was an illustration of how future technologies are going to affect education, what type of smart technologies can be applied to the teaching and learning methods, and how do technologies help education to cope with future education. It summarized the three fields that technology can use within education: artificial intelligence and learning analytics; robotics; and blockchain (OECD, 2021).

The policymaking directions that the OECD suggests for governments consider both positive and negative effects of smart technology, and social is identified as the key factor to successfully adopting the technology (OECD, 2021). The OECD revolves around six main features of smart technology that can be policy pointers, namely:

Smart technologies as a socio-technical system. First, smart technology is introduced as a socio-technical system, which considering the current smart technologies applied in education, still needs human intervention and supervision.

Algorithm Accuracy. Since smart technology is rapidly developing and is not mature today, policymakers need to ensure the algorithm accuracy considering its possible limitations.

Designing for use : the usefulness and cost-efficiency of the smart technology needed to be prioritized, rather than thinking only about the possibility of designing a smart tool.

Smart technology and data governance: transparency, fairness, and ethics . Data collection and algorithms are two main parts that governments need to regulate and monitor. Not only because it can strongly affect and violate people's privacy, but also to prevent the possibility of smart technology reproducing social biases. It is also concerned with the fairness and transparency of the algorithm and the trust of

users since smart technologies are socio-technical products and interaction between humans and machines is necessary.

Infrastructure and the public good . One of the necessities that smart technology required today is a strong Internet connection and supporting infrastructures, which point to software and hardware that are involved in learning and teaching. Also, digital resources, such as courseware package teachers use, are another type of infrastructure; people's digital skill is also counted as infrastructure by some, which is proficiency in the use of digital resources.

Research and development. Further research to produce evidence on smart technology's effectiveness in teaching and learning is always a priority, along with all other aspects discussed. Policymakers should be aware of it and support networks of evidence on different types of technology use in education.

1.3.2 European Union Digital Education Action Plan (2021–2027)

Digital Education Action Plan (2021–2027) is the updated version of the Digital Education Action Plan (2018–2020). It is aimed to "*support the adaptation of the education and training systems of Member States to the digital age*" (European Commission, 2021). It is published to relieve the impact of COVID-19, which simultaneously brings a significant step of digital transformation and urgent challenges. Compared to the three initial priorities, the new version of the Digital Education Action Plan has reorganized the priorities from three into two, but still includes a variety of aspects that both government and society industries need to be concerned about when proceeding with the action.

One priority focuses on the development of the digital education ecosystem, which has six actions for governments to consider. The government should provide an inclusive digital transformation environment including but not limited to investment, accessibility of technologies, and equipment gaps so that digital education can be realized for all. In addition, COVID-19 had brought education into the form of blended teaching and learning. The Action Plan proposes a framework for digital resources to measure the needs of learners, teachers, and others involved in the process. Internet connectivity, data usage, and artificial intelligence in education are still important. Although they are used in people's daily lives, still, there are regions and people who cannot reach such facilities. Therefore, governments need to make sure that citizens are aware of those facilities' possible risks and use them better. Last, the plan should include digital transformation in institutions, which is a big portion of digital technology usage. This area requires planning on monitoring, resources, and support from the government.

Another priority is emphasizing the digital competence and skills of society during the digital transformation. The actions provided by the Action Plan first tend to enhance people's digital skill awareness and update the competence framework to

include artificial intelligence and big data-related skill. Also, the European Commission proposed the *European Digital Skills Certificate* (EDSC) for employees which is easily recognized by the employer and is unified within the European region despite other diversified certificates. Since many people do not have experience with digital education, the EU has gradually put digital technology as a subject in primary education. At the same time, the EU will collect data across Europe to capture and analyze the status of people's digital skills and to expand the coverage of promoting digital competence policymaking. The pilot project Digital Opportunity Traineeship implemented by the EU started in 2021 and will continue until 2027. It is aimed to provide digital training to high education students so they can handle the digital skills needed in the labor market. Last but not least, the Action Plan is expected to encourage more women to join the ICT-related fields, which requires more digital skill training for women. Certain policies are promoted in this area; for example, girls and women E-STEAM festivals are organized to promote women's digital competencies.

1.3.3 China Smart Education Demonstration Area Construction Program

The *2.0 Version of the Action Plan for Educational Informationalization* was published by the Ministry of Education of the People's Republic of China in 2018 (MoE, 2018), and the Smart Education Demonstration Area is established based on this action plan. The demonstration area is built as a sample for the whole country and provides precise and personalized services and supports for students/teachers/parents with digital technologies (MoE, 2019). With a high level of readiness and efficiency, both students' and teachers' experiences will be promoted within the program. Furthermore, the inequality of education will be reduced under the program, and the quality of education is aimed to advance during and after the program.

To push innovative digitalization and form advanced experiences and cases, the smart education demonstration area is selected with the following criteria: (MoE, 2019).

The first is to promote students/teachers' digital literacy, awareness, computational thinking, digital learning, and information social responsibility by constructing relevant curricula and practices. The curriculum can include a practical ICT curriculum, innovative courses and activities, and AI experimental courses and programs.

Second, the demonstration area should explore new teaching modes to push the integration of digital technology and practical education, highlight the learner-centered teaching and learning modes, the integration of AI technology and ICT tools into education, and promote the efficiency of education. Also, the enhanced efficiency of teaching and learning by AI teaching assistants and learning partners can ease the burden on both teachers and learners.

Third, the general standard of data collection and application must be set. Then, the evaluation indicator system and assessment model of students' comprehensive quality should be constructed. The demonstration area should flexibly use big data collection and AI technology to precisely assess students' comprehensive quality evaluation. The matching between the educational service providers and the needs of learning will also be enhanced.

Fourth, the demonstration area should contain personalized teaching support smart system supported by network cover. Data should be shared among schools, families, and society through the connection between educational data and government data centers for larger learning spaces. The exchange of data between public service platforms of educational resources and public service platforms of educational management should be realized, supporting personalized and adaptive learning, and teaching capability.

Fifth, equal and inclusive education is demanded by achieving the solutions and policies on open education resources. Based on the national public service systems of digital education resources, the mechanism of the resource sharing and the service provider will be explored, with the participation of research institutions and enterprises. It effectively supports teaching and learning practices by integrating technologies and comprehensively enhances the capability to serve the digitalization of education in regions. Also, the coverage of high-quality educational resources should be expanded for a more sustainable educational system.

Sixth, the government will promote the new mode of educational governance by using AI and big data. Big data and AI should be used to promote the educational system's policymaking, teaching and learning reform, and school management. Intelligent technology should be used to sense, collect and monitor information about the campus environment and keep abreast of the dynamics of teachers and students. The integration and sharing of education and government information systems, the "Internet + government services" in education, and the modernization of the education governance system and governance capabilities should be promoted.

1.4 Concluding Remarks

One of the mainstream thinking of smart education comes from Zhiting Zhu and his colleagues, who consider smart education as a big system constructed with three essential elements: smart environment, smart pedagogy, and smart learners (Zhu et al., 2016). Zhu proposed a research framework of smart education in the work, in which the three elements of smart education supplement each other. According to Zhu, the smart learning environment can reduce students' cognitive load by providing technology tools that are easy, comfortable, and effective to use. Smart pedagogies and smart environments can influence each other. A better smart environment can affect the generation of smart pedagogies, and both elements support the development of smart learners. What Zhu and colleagues brought up was that smart education contains three elements, which are supplementary to each other. The concept of

smart education in the future will be further established to interact with other smart systems within a smart city (Zhu et al., 2016).

At the same time, smart education is considered a three-layer structure by Ronghuai Huang. This widely used smart education model in China is constructed by a smart learning environment, technology-enhanced learning, and evidence-based governance (Huang, 2021). A smart learning environment is supposed to provide personalized services for teachers and students with digital tools. It can be a combination of physical and virtual environments. The second layer, technology-enhanced learning, includes personalized learning and adaptive teaching for students. As the new learning mode tends to make students able to learn at anytime, anywhere, anyway, and at any pace, the appearance of digital technology makes the new mode possible. The third layer, which is also the most important part of smart education, is at the governance level. The governance should be a top-to-bottom structure, including national, province, institution, and school levels. The government should ensure knowledge productivity and the quality of talent development for the future (Huang, 2021).

The structure of smart education in Huang's work is understood and explained in a detailed and comprehensive way. However, there is still a diversified understanding of smart education worldwide. With such variation, the development of smart education, including the establishment of a digital environment, innovation of digital technology, and, most important, policymaking among digital transformation, is progressing differently among countries. The book will share the current situation of smart education among China and Central Eastern European countries from aspects of basic infrastructure, policymaking, and implementation cases. Together, we will learn and share experiences to respond to future challenges.

The policy pointers from the OECD, EU, and China's Ministry of Education are focused on different areas within their regions and adapted to situations. However, the main focus of the policies is similar, which is to make the whole society engaged in a digital education environment and adapt themselves to the process of digital transformation. Based on the goal of SDG 4, the world attempts to realize sustainable education through digital transformation. COVID-19 has boosted the process by disrupting normal school mode and promoting online learning. To have a better experience for teachers and students, digital technologies were invented faster compared to that before the pandemic.

Despite the description and implementation being different, there are two strategic directions from the policies introduced above.

When considering digitalization, it is also important to consider people's capability to accept and utiliz smart technology. Without such ability, digital transformation's effectiveness will reduce and affect people's daily life. Therefore, improving people's digital literacy, skills, and competencies is considered in a wide range. The personal ability has to keep up with the improving hardware to keep pace together and facilitate the future challenges that digital transformation could bring.

The establishment of a sustainable and effective smart education environment includes effort from the government, institutions, and schools, and, most importantly, the innovative digital tools applied in the environment. The content and application

of digital resources are other important aspects of digitalized education environment since it involves interactions between humans and machines, a so-called socio-technical system, and it is the actual part that can present the achievement of a digital system. (OECD, 2021).

The trends of education in the future will inevitably involve technologies. It is the world's common goal to reach SDG 4 by 2030 and to realize digital transformation. The only difference can be the speed of achieving the goal. However, to some extent, the pandemic has sped up the pace, which brings sudden challenges for society to deal with, particularly in the education field. We are expecting to see a better digital education in the future with such planning and action plans.

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Chapter 2
Report on Smart Education in China

Yunwu Wang

Abstract China's education is guided by The Global Education 2030 Agenda and focuses on fair, inclusive, and quality education. An important strategic choice for China's educational reform and development in the new era is to support and lead the modernization of education with educational informatization. As a new form of ICT in education, smart education has become an inevitable trend of future education, which is highly concerned by policymakers and practitioners. In recent years, China has accelerated the transformation of digital education, successively issued policies related to smart education, and vigorously promoted the application of 5G, AI, blockchain, big data, and other new-generation information technologies in education. In 2018, China launched the smart education demonstration areas project, setting off a groundbreaking exploration of the future form of education. The "5G + smart education" application pilot project has pushed the development of smart education in China to a new wave. Nowadays, the National Smart Education Platform for Public Service is becoming the international business card of Chinese education, which has attracted widespread attention at home and abroad.

Keywords Smart education · Smart campus · Educational governance · Digital literacy and skills

2.1 National Smart Education Profile

2.1.1 Overview of Education in China

Education is an important foundation for human civilization, national revitalization, and social and economic development. China closely collaborates with the international community to implement *The Global Education 2030 Agenda* to jointly build a Community of Shared Future for Mankind. To this end, the Chinese government has long prioritized the development of all levels of education, continued to

Y. Wang (✉)
School of Wisdom Education, Jiangsu Normal University, Xuzhou, China
e-mail: 286500442@qq.com

increase investments in education, and built a high-quality education system so that all Chinese people can enjoy better and fairer education. During the 13th Five-Year Plan period, China actively promoted the reform and development of education. As a result, remarkable achievements were made in all kinds of the education level of middle and high-income countries, which provide strong talent and intellectual support for building a prosperous society in all respects and a powerful socialist modernization country.

Today, China has built the largest education system in the world with a significant impact on the development of national human resources. According to the seventh national census, the population of China is 1411.78 million,[1] and the population has continued to maintain a low-speed growth trend in the past 10 years. The education status of the population and the quality of the population has been continuously improved. China has made great efforts to develop all kinds of education at all levels and eliminate illiteracy among young and middle-aged people. More than 218 million people in China have received a university education. The average number of years of education for the population aged 15 and above increased from 9.08 to 9.91, and the illiteracy rate decreased from 4.08 to 2.67% (National Bureau of Statistics, 2021). The average number of years of education for the new labor force has reached 13.8. By 2020, China has 537.1 thousand schools of all types and at all levels, with 289 million students in academic education and 17,929.7 thousand full-time teachers (Ministry of Education, 2020a).

Since December 2019, coronavirus disease 2019 (COVID-19) has spread all over the world. It seriously threatens the health and life safety of all mankind and brings important influence and challenge to people's life, economy, and education. More than 90% of students around the world have been affected due to the impact of the pandemic and the long lockdown periods that led to the suspension of face-to-face classroom activities (UNESCO, 2020). The pandemic has been an important testbed for education governance in all countries around the world, reflecting the level of education emergency governance, and aggravating the education inequality among countries, regions, and schools. All countries in the world responded positively and vigorously carried out Emergency Remote Teaching (The World Bank, 2022). In 2020, across China, universities, primary and secondary schools launched the largest online education programs in history, covering 300 million people under the call of the Ministry of Education "classes suspended but learning continues." Online education has changed the form of learning, teaching, and administration, and accelerated the development of online merge offline (OMO) education. This massive-scale online education has opened an unprecedented experimental exploration in the history of education. China's online education has gained a lot of experience and provided "China's proposals" for global learners to carry out online education. For example, the Smart Learning Institute of Beijing Normal University has issued

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[1] The national population refers to the population of 31 provinces, autonomous regions, municipalities directly under the central government and active servicemen in mainland China, excluding Hong Kong, Macao and Taiwan residents and foreigners living in 31 provinces, autonomous regions and municipalities directly under the central government.

Table 2.1 Guidance on online education in COVID-19 outbreak

Guidance	Release time
Handbook on facilitating flexible learning during educational disruption: The Chinese experience in maintaining undisrupted learning in COVID-19 outbreak	March, 2020
Guidance on active learning at home during educational disruption: Promoting student's self-regulation skills in COVID-19 outbreak	March, 2020
Guidance on flexible learning during campus closures: Ensuring course quality of higher education in COVID-19 outbreak	April, 2020
Guidance on open educational practices during school closures: Utilizing OER under COVID-19 pandemic in line with UNESCO OER recommendation	May, 2020
Personal data and privacy protection in online learning: Guidance for students, teachers and parents	June, 2020
Guidance on providing open and distance learning for students with disabilities during school closures: Enhancing inclusive learning under COVID-19	August, 2020
Interactive book on artificial intelligence to combat pandemics: Vivid stories in prevention and control of COVID-19	August, 2020
VSE primer: Concept, technology, architecture, and implementation of virtual and simulation experiment	August, 2020
Ensuring effective distance learning under COVID-19 school closures: Guidance for teachers	December, 2020

guidance manuals on flexible learning, home-based active learning, college teaching design, open education action, and data and privacy protection, etc., as shown in Table 2.1, providing solutions for online education around the world.

2.1.2 Overview of Smart Education in China

2.1.2.1 Achievements of ICT in Education

In China, there is a consensus among all education key actors that "information technology has a revolutionary impact on the development of education," and the whole society's understanding of educational informatization has advanced. Since the 13th Five-Year Plan (2016–2020), China has highlighted the great importance of educational informatization. Educational informatization has demonstrated the deepening of ICT deployment in education, the emergence of innovative best practice cases, and the significant improvement of governance capability. Educational informatization has entered the stage of integration and innovation from the initial application stage. It plays a prominent role in promoting educational equity, improving educational quality, and supporting the promotion of educational modernization. During

the period of COVID-19 pandemic, the development path with experience and cases of China's educational informatization have won universal recognition in the world (China Educational Equipment Industry Association, 2020).

By December 2020, the export bandwidth of China's Internet had reached 11,511,397 Mbps, with an increase of 30.4% over 2019. By December 2021, China's fiberoptic broadband users account for 94.3%, the gigabit optical network covers more than 120 million households, and the end-to-end user experience speed of fixed broadband has reached 51.2 Mbps. By December 2021, China has opened 1425 thousand 5G base stations in total, and the 5G network has covered all prefecture-level cities, more than 95% of county areas, and 35% of township areas in China (China Internet Network Information Center, 2022).

China's *Education Informatization 2.0 Action* has achieved remarkable results. The basic network environment of the school has basically achieved full coverage. The supply of high-quality resources and the level of teaching application have been greatly improved. Moreover, the public service system of digital educational resources has been completed. The modernization of information-based support for educational governance, teachers' digital literacy and application ability, and the training and protection ability of network security talents have been significantly enhanced and achieved remarkable results.

By the end of 2020, the Internet access rate of primary and secondary schools in China has increased from 79.37% at the end of 2016 to 100% at the end of 2020. The proportion of schools with 100 M export bandwidth is 99.92, and 98.35% of primary and secondary schools have multimedia classrooms, which further strengthens the basic conditions of information-based teaching. From 2016 to 2020, the coverage of online multimedia classrooms in national basic education continued to grow, from 61.37% in 2016 to 78.2% in 2020 (National Internet Information Office, 2021). From a regional perspective, the coverage rate of online multimedia classrooms in Zhejiang, Guangdong, Beijing, Shanghai, Tianjin, and Chongqing ranks among the top in China, with more than 90%.

2.1.2.2   From ICT to Smart Education

Presently, governments and scholars worldwide have not reached an agreement on the definition of smart education. Smart education can be regarded as the advanced stage of ICT in education (educational informatization) or the digital transformation of education. The essence of smart education can be understood as a new educational form supported by new smart technologies, such as 5G, AI, big data, blockchain, robots, and VR/AR/MR. Smart education also needs the support of new ideas, new media, new methods, and new strategies.

Smart education can be understood as a smart education system, which is defined as "an educational behavior (system) with high learning experience, high content adaptability, and high teaching efficiency provided by schools, regions, or countries, and it can use modern science and technology to provide a series of differentiated

support and on-demand services for students, teachers, and parents." It can comprehensively collect and use the status data of participant groups and education and teaching process data to promote fairness, continuously improve performance, and breed excellence in education" (Huang, 2014). The vision of smart education is to build a smart country and smart cities besides changing the teaching mode and cultivate outstanding talents. The smart education system includes three realms: smart learning environment, new teaching mode, and modern education system. Smart education has five essential characteristics: perception, adaptation, care, fairness, and harmony. It transmits educational wisdom through a smart learning environment, enlightens students' wisdom through new teaching modes, and breeds human wisdom through a modern education system.

2.1.2.3 Advance Exploration of Smart Education

In recent years, China has accelerated the transformation of digital education. The development of educational informatization has entered the 2.0 stage and presents a new form of smart education. Since 2018, China has paid more and more attention to the construction of smart education, intensively issued relevant policies, and vigorously promoted the construction of smart education demonstration areas and smart campuses. On January 31, 2018, the Ministry of Education launched the "innovation demonstration of promoting smart education" for the first time. On April 13, 2018, the Ministry of Education proposed to implement the "action for innovation and development of smart education" and coordinated with relevant departments to support the establishment of "smart education demonstration areas" in several areas with positive local conditions, such as Xiong'an New Area, to carry out the exploration and practice of smart education. Universities and primary and secondary schools across the country are also actively exploring the construction of smart campuses. The smart education demonstration area and smart campus have become the practice fields of China's smart education.

2.2 Policies of Smart Education

2.2.1 Governance of Education

In February 2019, China released *China's educational modernization 2035* (Chinese Government Network, 2019), which puts forward that by 2035, China will realize educational modernization in general, enter the ranks of educational powers, become a powerful country in learning, human resources, and talents, and lay a solid foundation for building a strong, democratic, civilized, harmonious, and beautiful modern socialist country by the middle of the twenty-first century. The main development goals for 2035 are as follows: to build a modern education system

serving the whole people's lifelong learning, popularize quality preschool education, achieve high-quality and balanced compulsory education, fully popularize senior high school education, improve the service capacity of vocational education, significantly improve the competitiveness of higher education, provide a suitable education for children and adolescents with disabilities, and form a new pattern of educational governance with the participation of the whole society. "Promoting the modernization of educational governance system and governance ability" is listed as one of the ten strategic tasks facing educational modernization.

In March 2021, China issued the Outline of the 14th Five-Year Plan (2021–2025) for National Economic and Social Development and Vision 2035 of the People's Republic of China (Chinese Government Network, 2021d). In "Part V An Initiative to Build a Digital China," it is proposed to build a digital economy, accelerate the construction of a digital society, improve the construction level of a digital government, and create a healthy digital ecosystem. Digital China is committed to building 10 digital application scenarios, such as smart transportation, smart energy, smart manufacturing, smart agriculture and water conservancy, smart education, smart medical care, smart cultural and tourism services, smart communities, and smart government services. The application scenario of smart education is described as: "promoting the integration of socialized high-quality online curriculum resources into the public teaching system, promoting the online service of high-quality educational resources to weak schools in rural and remote areas, and developing scene learning and experiential learning." The term "smart education" appeared in the outline of the national economic and social development plan for the first time, which means that national policies have begun to pay more attention to smart education.

In May 2021, China launched the national intelligent social governance experimental base project and took educational governance as an important part of national intelligent social governance (Chinese Government Network, 2021a). By 2025, China will build a number of national comprehensive experimental bases and several characteristic bases for intelligent social governance, build typical application scenarios for intelligent social governance, summarize the experience, laws, and theories of intelligent social governance, issue a number of standards, norms, policies, and measures for intelligent social governance, improve the system and mechanism to adapt to intelligent social governance, and build smart social governance demonstrations to promote the modernization of national governance system and governance capacity.

China's education governance under the state of COVID-19 emergency showed remarkable results. China's pandemic prevention and control have achieved phased victory, which are not only benefited from the scientific and efficient decision-making of national leaders, but also from the tremendous efforts of scientific researchers and medical staff, as well as the efficient and effective education emergency governance. China has taken the following five key measures: (1) promoting publicity and education on pandemic prevention and control from the perspective of all media; (2) urgently developing relevant educational policies for pandemic prevention and control; (3) offering wisdom and suggestions to help modernize educational governance by think tank experts; (4) making full use of the advantages of the Internet

and vigorously carry out online education; and (5) promoting active participation of social forces in education to combat the pandemic (Wang et al., 2020).

The experience of "four early" (early detection, early report, early isolation, and early treatment) and "four concentrations" (concentrating patients, experts, resources, and treatment) formed in China's fight against the pandemic has played an important role, which is recognized as a reference by the international community. The experience of "prevention and control publicity, close monitoring, online education, and diversified participation" has also been formed in the field of education, spreading to the international community and leveraging China's strength in global education and anti-pandemic. China's education emergency governance has four characteristics: (1) diversified and coordinated governance, (2) fast response speed, (3) strong promotion, and (4) good governance effect.

2.2.2   Smart Education

Since 2014, Jiangsu Province and Haidian District of Beijing have issued smart education policies (summarized in Table 2.2) that led to exploring smart education. In 2019, China launched the construction project "smart education demonstration area." By November 2021, China has actively promoted the construction of 20 smart education demonstration areas. This denotes that China has promoted smart education to the national strategic level and regarded smart education as an important strategic choice for building a socialist power and a smart society. As a result, the country will set off a wave of smart education construction in the next few years.

2.2.3   Smart Campus

Since 2014, many provinces, cities, provinces, and schools in China have issued policies such as construction guidelines, evaluation index systems, action plans, and implementation schemes for smart campus (Table 2.3). As early as 2014, Suzhou took the lead in releasing the *Guide to the Construction of Smart Campus Demonstration School*. Under the leadership of provinces and cities such as Jiangsu province, Guangdong province, and Chongqing city, universities, and primary and secondary schools across the country have accelerated the transformation from digital campus to smart campus.

There are three types of standards for smart campuses in China: national, local, and association standards (Table 2.4). As early as 2016, Jiangsu first released the *Construction and Application Specification of Smart Campus for High Schools* (*DB32/T 3160–2016*). Since then, China has issued five national standards related to smart campus, namely (*1*) *Assessment Standard for Green Campus (GB/T 51356–2019), (2) Smart Campus Overall Framework (GB/T 36342–2018), (3) Specification for Digital Campus Construction in Primary and Secondary Schools (Trial),*

Table 2.2 Smart education policies in China 2014–2021

Region		Policy title	Release time
China		Notice of the general office of the Ministry of education on the recommendation and selection of construction projects "smart education demonstration area"	January 2019
Jiangsu	Jiangsu	Three-year action plan of Jiangsu Smart Education (2015–2017) (Draft for comments)	October 2014
		Implementation opinions of the general office of Jiangsu provincial government on promoting smart education	March 2015
	Yancheng	Implementation opinions of Yancheng Education Bureau on promoting smart education	August 2015
	Nanjing	Implementation opinions of the general office of the municipal government on promoting smart education	December 2015
		Action plan of the implementation opinions on promoting smart education	November 2016
Zhejiang	Hangzhou	Action plan for promoting the development of educational informatization and smart education in Hangzhou (2015–2017)	December 2014
	Ningbo	The 13th five-year plan for Smart Education in Ningbo (2016–2020)	March 2017
Beijing	Haidian	Medium and long-term development plan of smart education in Haidian District (2014–2020)	March 2014
		Haidian District Smart Education 2.0 action plan (2019–2022)	May 2019
Jiangxi	Yongxiu	Three-year action plan for smart education in Yongxiu county (2018–2020)	December 2017
	Rui'an	Implementation plan on further promoting the development of smart education	March 2018
Sichuan	Meishan	Meishan smart education development plan (2018–2020)	June 2018
Hunan	Changsha	Changsha smart education action plan (2019–2022)	November 2019

Table 2.2 (continued)

Region		Policy title	Release time
	Liuyang	Liuyang smart education action plan (2020–2022)	May 2020
Anhui	Anqing	Anqing smart education action plan (2019–2022)	November 2019
Hebei	Hebei	Hebei smart education action plan (2020–2022)	November 2020
	Xiong'an New District	Five-year action plan for Smart Education in Xiong'an New Area (2021–2025)	December 2020
	Handan	Handan smart education action plan (2020–2022)	January 2021

(4) *Specification for Digital Campus of Vocational Colleges, and* (5) *Construction Standard of Digital Campus in Colleges and Universities (Trial).* In addition, both provinces, cities, and associations have also issued local and group standards with their characteristics. At the same time, China has implemented Smart Education Demonstration Area Construction Program and the "5G + Smart Education" Application Pilot Project. Meanwhile, schools at all levels have set off a new wave of smart campus construction. With the support of smart campus policies, norms, and standards, the construction of smart campus has achieved remarkable results. The smart campus has become a vital practice aspect of smart education.

2.2.4 New Infrastructure for Education

China redefined new infrastructure construction at the 2018 Central Economic Work Conference, including 5G, AI, Industrial Internet, and Internet of Things (IoT). In 2020, China clearly defined seven major areas of new infrastructure: 5G, UHV, Intercity High-Speed Railway, and Urban Rail Transit, New Energy Vehicle Charging Pile, Big Data Center, AI, and Industrial Internet (see Fig. 2.1). By the end of September 2021, the number of 5G terminal connections in China had reached 445 million, exceeding more than 80% of the world's connections. China has built the world's largest 5G commercial network, which has further expanded its impact on the economy and society.

In March 2021, the Ministry of Industry and Information Technology of the People's Republic of China issued the *Action plan for coordinated development of "dual Gigabit" networks* (*2021–2023)* (Chinese Government Network, 2021c), which focuses on the implementation of six key tasks: Gigabit city construction action, carrying capacity enhancement action, industry integration and empowerment action, industry chain strengthening and chain supplement action, user experience improvement action, and security enhancement action. By 2023, the country will

Table 2.3 Smart campus policies in China 2014–2021

Region		Policy title	Release time
Jiangsu	Jiangsu	Evaluation Index system for smart campus construction of vocational schools in Jiangsu (2015 edition)	January 2016
		Guidance on smart campus construction of primary and secondary schools in Jiangsu (Trial); Guidance on the construction of smart campus in colleges and universities in Jiangsu (Trial)	May 2018
	Suzhou	Guide to the construction of smart campus demonstration school in Suzhou	May 2014
	Nanjing	Guiding opinions on smart campus construction of primary and secondary schools in Nanjing; Detailed rules for the evaluation of smart campus construction in primary and secondary schools in Nanjing (Trial)	March 2017
	Zhenjiang	Guide for smart campus construction of primary and secondary schools in Zhenjiang	February 2016
		Detailed rules for smart campus evaluation of primary and secondary schools in Zhenjiang (2018 Revision)	October 2018
	Xuzhou	Guidance on the construction of smart campus in primary and secondary schools in Xuzhou (Trial)	August 2018
Chongqing		Smart campus construction basic guide in Chongqing (Trial)	December 2016
Guangdong		Guidelines for smart campus construction of primary and secondary schools in Guangdong (Trial)	December 2017
Jiangxi	Ji'an	Implementation plan for smart campus construction of primary and secondary schools in Ji'an	November 2016