

Chapter 1

Conceptual Framework of Smart Education in China



The development course of human civilization is not only a history of scientific and technological innovation but also a history of educational advancement. The modern education system was created during industrialization, from which it inherits distinctive features such as large scale, standardization, and specialization. The advent of the digital era has challenged the classroom teaching mode built up during industrialization. Taking the initiative to promote the digital transformation in education and develop smart education is a strategic move to cope with contemporary changes and an integral part of education modernization.

1.1 Connotations and Characteristics of Smart Education

1.1.1 Connotations of Smart Education

As a new form of education in the digital era, smart education is essentially distinct from education forms in the industrial era.

Smart education is an important goal of the digital transformation of education and represents the future of education development. Based on learning and development patterns of learners and via modern technologies, smart education empowers and drives the learning sector. Smart education helps to reach the full alignment between individual development and societal development that makes it possible to provide suitable education for each learner and to prepare a systematic talent pipeline for societal development. Smart education is dedicated to quality and personalized lifelong learning that will be available for anyone anywhere anytime. Smart education reshapes learning content through nurturing learners' higher-order thinking skills, integrated innovation capacity and lifelong learning literacy to eventually contribute to quality education. Smart education will construct a new paradigm of

teaching and learning by integrating physical, social, and digital spaces to create new learning scenarios and promote human-technology integration. Centered around data governance and driven by digital intelligence, smart education promotes the education process optimization and reengineering, and advances the modernization of system and capacity for education governance, to improve educational efficiency, effectiveness, and benefits.

Though in a nascent stage, smart education has already enabled learning resources sharing and teacher-student communication cross-time-and-space. Preliminary results have been observed in achieving regional education equality, enhancing the bottom line of education quality, and improving digital literacy and skills of teachers and students. In the future, more learning resources will be shared, teaching paradigms innovated, teacher-student relationship reshaped, education process reengineered, talent training quality improved, and intellectual capital of the society fully leveraged. Smart education will empower the transformation of education on all fronts, promote digital transformation of education in a holistic manner, disrupt outdated educational paradigms, and systematically construct a new relationship between education and society.

China has solid foundations and distinctive characteristics for the development of smart education. First, China attaches great importance to upholding the values of putting people first and running education to the satisfaction of people. Second, China put much stress on the inheritance and development of traditional education philosophies, such as education for all without discrimination, aptitude-based teaching, and the unity of knowledge and practice. Third, China values the appropriate blending of a top-down approach to macro adoption of initiatives and a bottom-up approach to ecological construction.

1.1.2 Characteristics of Smart Education

Buttressed by a digitalized education environment, personalized teaching and learning, and precise education governance (see Fig. 1.1), smart education builds a more open, flexible, and high-quality education system that is accessible and applicable to all to cultivate a new generation of talents that has stronger value belief, digital literacy, creativity, and lifelong learning skills.

i. Education environment: ubiquitous and intelligent learning space

Smart and agile facilities. Through the integration with cloud networking, an education infrastructure system that connects everything and combines reality with virtuality is built, thus constituting an online learning space featuring comprehensive perception, ubiquitous connection, and deep interaction. Smart campuses and teaching venues that are continuously strengthened and smart learning terminals that deploy across the board could help smart education meet diverse and personalized demands for teaching and learning.

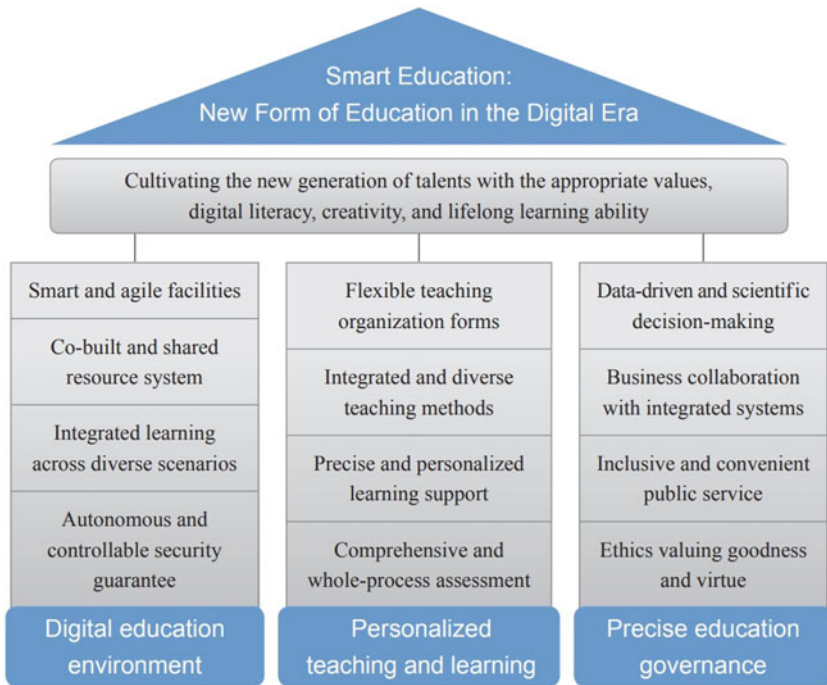


Fig. 1.1 Smart education: the conceptual framework

Co-built and shared resource system. Smart education integrates and develops various education platforms at all levels, on the basis of a united smart education platform with connectivity, complete applications and collaborative services. It improves the mechanism of resource development, dynamic upgrading, and societal consolidation to form a multi-type, systematic, and high-quality digital education resource system.

Integrated learning across diverse scenarios. Through combining school education with cyber learning and social practices, smart education nurtures a virtuous ecosystem characterized by online-offline and virtual-reality integration and connection inside and outside school. Smart education also builds a digital certification system to allow extensive mutual recognition and free conversion of learning achievements, and to support learners to carry out lifelong learning anytime, anywhere.

Autonomous and controllable security guarantee. Smart education establishes a long-term mechanism guarding education cybersecurity and the physical and mental well-being of students. It also forms a whole cycle of security management and classified precise protection for education data. Cybersecurity auditing measures are continuously bolstered, evaluation and daily supervision of new technologies and applications are carried out regularly, and the ability to prevent and mitigate major security risks is significantly enhanced.

ii. Education implementation: adapted to individual needs

Flexible teaching organization forms. Smart education employs digital technology to reshape instructional organization forms, flexibly sets course subjects and learning plans, and carries out cross-regional, cross-school, interdisciplinary and cross time and space teaching activities. It builds up communities for teachers and learners that transcend time and space limits, allows the online circulation and sharing of quality teaching resources, and enables schools to cooperate with other schools, businesses, and local governments to improve the quality of institutions-families-society collaborative education.

Integrated and diverse teaching and learning methods. Smart education comprehensively improves teachers' competencies, integrates online and offline learner-centered teaching, supports classroom innovations, and contributes to deep learning. It widely implements project-based, inquiry-oriented, experiential, and cooperative teaching, and reengineers the teaching process. It also supports the new type of dual-teacher classes led by a human teacher and a virtual teacher or an intelligent tutor.

Precise and personalized learning support. Smart education carries out data-driven learning analysis and accurate diagnosis, constructs knowledge graphs based on systematic logics of knowledge, sends targeted learning resources based on knowledge mapping, realizes learner-centered personalized learning while adopting a large-scale education approach, and meets learners' multi-tiered and diverse needs.

Comprehensive and whole-process assessments. Smart education leverages learning analysis and the adjoint data collection tools to achieve dynamic assessment, diagnosis, and feedback on learners' learning progress, supports all-round and whole-process assessment of moral, intellectual, physical, social, aesthetic, and labor education development, and makes education evaluation more science-based, professional and objective.

iii. Education governance: precise and intelligent management service

Data-driven and scientific decision-making. Smart education constructs and utilizes big data in education and reinforces data mining and analysis to dynamically follow the trends of education reform and development, enhances evidence-based decisions and diagnoses, and improves scientific decision-making of education. It builds a collective decision-making system with human-machine coordination and helps governments, schools, and society in collaborative governance on multiple facets.

Business collaboration with integrated systems. Smart education optimizes education processes with digital technology, integrates various education management systems, repurposes evaluation and supervision methods, and carries out online teaching and research to support the integrated management of education. It also improves data exchange and business collaboration across regions and departments at all levels to realize whole-process smart supervision.

Inclusive and convenient public services. Smart education adopts digital technology to build an integrated public education service system, implements the integrated processing of education services, forms a new mode of online smart service, and promotes the upgrading from an integrated net to an inclusive and convenient net so that the outcomes of education development can benefit all people more equitably.

Ethics valuing goodness and virtue. Upholding the principle of utilizing technology for the greater good, and developing digital applications that conform to the general laws of education and fit the physical and mental development of learners, smart education completes and improves education data governance mechanisms, respects teachers' and students' rights to privacy and information, enhances the transparency of algorithmic rules, builds a credible artificial intelligence system, and guarantees that teachers and students make decisions on their own.

iv. Talent cultivation: a new generation of talents willing to reform and innovate

Values rooted in the contemporary world. Smart education fosters talents who can tap the advantages of digital technology, adhere to the core socialist values, strive for the shared aspiration to achieve socialism with Chinese characteristics, and have the values and responsibilities to realize the great rejuvenation of the Chinese nation and build a community with a shared future for mankind. They respect cultural differences, actively promote the ability of cross-cultural understanding and communication, enrich the spiritual world, and build up mental strengths.

Digital literacy for the era. Smart education fosters talents who are proficient in using digital technology in their learning, actively participate in social practices, and have acute data awareness, a sharp mind for computing, collaborative learning ability, cybersecurity awareness, and good social-emotional literacy. They consciously abide by the ethics of the smart society, improve their digital competency, and can better adapt themselves to the digital era.

Creative mind to make changes. Smart education fosters talents with creative consciousness, scientific spirit and critical thinking, who are good at identifying and proposing problems, developing reasonable solutions, and solving problems creatively. They are adept at using digital technology to catalyze innovation and are able to either transform ideas into tangible results or make improvements to readily available solutions.

Ability to learn throughout a lifetime. Smart education fosters talents who have a strong will, always maintain learning motivation, make lifelong learning plans according to their needs, and can effectively manage their learning process. They can carry out continued self-evaluation and introspection, keep their knowledge and mindset up to date, improve themselves in practice, and lead an extraordinary life with pragmatic efforts.

1.2 Smart Education Development Index

1.2.1 Background

i. The connotations and characteristics of smart education

In the previous section, smart education was defined as a new form of education in the digital era, and as an important goal of the digital transformation of education, it represents the future direction of learning. Based on learning and development patterns of talents and via modern technologies, smart education empowers and drives the learning sector, which leads to full alignment between personal and social development. Each learner could access suitable education and a talent pipeline could be prepared for social development. Smart education is dedicated to quality and personalized lifelong learning which will be available for everyone everywhere all the time. It reshapes learning content. Aimed at quality education, smart education will nurture learners' advanced intellectual competence, integrated innovation capacity and lifelong learning trait. Smart education will build a new paradigm of teaching and learning by integrating physical, social, and digital space to create new learning scenarios and coordinate people and technology. Centered around data governance and driven by digital intelligence technology, smart education reinvents learning processes. As a result, governance system and governance capacity of education will be modernized, and efficiency, effectiveness and benefits of education improved. All the above theories are the cornerstones of Smart Education Development Index.

ii. Vivid practical experience of China's education informatization

Over the years, China has taken a series of powerful and significant measures to promote the construction of the basic application environment of education informatization as a whole, build a resource development and application system covering all levels and types of education, strengthen the construction of the teaching team that is compatible with the digital era, establish and improve the information system of education management, establish demonstration zones for education informatization and smart education in all forms of education at all levels, and vigorously implement *China's Strategic Action Plan for Education Digitalization*. The rich and vivid practical experience has been accumulated in China. The practices have become the realistic basis for building the Smart Education Development Index.

iii. International experience in digital monitoring and evaluation of education

The international community pays close attention to the digital monitoring and evaluation of education, and the corresponding achievements are increasingly fruitful. The databases of the World Bank, UNESCO, the Organisation for Economic Cooperation and Development (OECD), the International Telecommunication Union (ITU) and other international organizations document the data of relevant indicators. A series of influential international research reports, such as the *Global Competitiveness Report of the World Economic Forum*, the *Digital Economy and Social Index of*

the European Commission, the Organisation for Economic Co-operation and Development's Education Overview, as well as the Teaching and Learning International Survey (TALIS), the International Computer and Information Literacy Study (ICILS) Index of Readiness for Digital Lifelong Learning (IRDLL), *Worldwide Education for the Future Index (WEFFI)* and other research projects with high international appeal have developed and used corresponding indicators. In addition, the United States, Canada, Australia and other developed countries in education have developed a series of evaluation index systems for education informatization, which are also worthy of reference. A large number of international research results have greatly expanded the international vision of the design of the Smart Education Development Index.

1.2.2 Principles

i. Purpose-oriented

The Smart Education Development Index aims to objectively describe the development status, evaluate the development level, diagnose practical problems, find solutions, identify future trends, offer developmental guidance, and provide strong support for the quality development of smart education.

ii. Scientific

The Smart Education Development Index must scientifically reflect the broadest conceptual consensus of the global smart education development, fully reflect the common requirements of the world's smart education development, and objectively reflect the concerns of various important plans and specific policies and measures of China's current education development, so as to provide an evaluation standard framework for comprehensively leading the healthy and orderly development of smart education. All evaluated dimensions and indicators strictly follow and strive to accurately reflect the connotations and characteristics of smart education.

iii. Systemic

Smart education is a complex system that includes educators, students, educational resources, school conditions, educational environments, educational policies and many other elements. The Indicator System of Smart Education Development should fully reflect the internal mechanism of smart education basing on the elements, consider the interdependence and interaction among the elements, and identify the relationship and level among the indicators appropriately, to reflect the development level of smart education comprehensively.

iv. Feasible

The Smart Education Development Index is an important tool for evaluating and analyzing the development status of smart education quantitatively, comparatively,

and objectively. The constructing of indicator system should be based on measurable and accessible data. All indicators should be determined by reliable, credible and available data.

v. Trend-setting

The Smart Education Development Index not only reflects the status of smart education, but also guides the future development. The design of indicator system should consider both making judgement of the actual level of smart education development, and developing leading indicators of smart education according to the development tendency of the field to promote the quality development of smart education.

1.2.3 Indicators

The Smart Education Development Index is calculated on the basis of Indicator System of Smart Education Development. The evaluation index system of smart education development is a bridge connecting the theory and practice of smart education, a yardstick to measure the development level of smart education, and an important tool to guide and lead the development of smart education.

The Indicator System of Smart Education Development takes the core index model as the design framework. Based on fully reflecting the connotations and characteristics of intelligent education, it consists of four primary dimensions: environment, teaching and learning, governance, and talent literacy, and 12 sub-dimensions, including facilities, equipment, and digital education resources, with a total of 32 indicators (see Table 1.1). For the specific data source of each indicator, see “Appendix A: Explanations for the Indicator System of Smart Education Development”.

The Chinese Smart Education Development Index is calculated based on the composite indicator system, and the sector-specific smart education development indexes are based on the calculation of three sub-sector development indicator systems. As the indicators of each indicator system have certain differences, they are independent and not comparable with each other.

1.2.4 Data and Calculation

i. Data source

The measured data of China Smart Education Development Index is mainly from the departments of Ministry of Education, such as the Department of Development Planning, the Department of Science, Technology and Informatization, the Department of Basic Education, the Department of Vocational and Adult Education, the Department of Higher Education, the Department of Teacher Education. Data also comes

Table 1.1 Indicator System of Smart Education Development

Dimension	Sub-dimension	Indicator
Environment	ICT infrastructure	Percentage of educational institutions with a broadband connection, including both fixed and mobile (%)
		Percentage of educational institutions with WLANs network coverage (%)
		Percentage of classrooms with multimedia device(s) (%)
		Number of digital devices per teacher (device/person)
	Digital education resources	Average amount of digital educational resources by person (piece/person)
		Number of digital curricular resources per 100 students (class hours/100 people)
		Coverage rate of digital educational resources (%)
	Cyber learning space	Percentage of teachers with cyber learning space (%)
		Percentage of students with cyber learning space (%)
	Teaching and learning	Digital literacy of teachers
Utilization of resources		Effective utilization rate of digital educational resources (%)
		Effective utilization rate of curricular resources on the Smart Education of China platform (%)
		User activity indices of the Smart Education of China platform (time/person)
		Hit rate of resources recommended to users by the Smart Education of China platform (%)
Transformation in teaching and learning practices		Coverage rate of hybrid education (%)
		Coverage rate of online teacher training (%)
		Coverage rate of online personalized learning (%)
		Percentage of users learning with online videos (%)
Transformation in assessments		Coverage rate of ICT-based formative assessments (%)
	Coverage rate of AI-based assessments (%)	
Governance	Data accessibility	Percentage of students, teachers and institutions in which the identity data was collected in (national) core database(s) (%)
		Percentage of region-level educational management system in which data is available to national Education Data Exchange Network (%)
	ICT-based management	Coverage rate of one-stop online educational affairs and services (%)
		Coverage rate of ICT engaged educational supervision (%)
		Percentage of educational institutions with ICT-related policy (%)

(continued)

Table 1.1 (continued)

Dimension	Sub-dimension	Indicator
		Percentage of educational institutions with data driven decision-making process (%)
	Cyber and data security	Percentage of schools with cybersecurity policy (%)
Talent literacy	Digital literacy of students	Proportion of students with sufficient digital literacy (%)
		Percentage of graduates from ICT-related majors (%)
		Indices of students' lifelong learning ability
	Laborer digital skills	Indices of average digital skills of population between ages 16 and 74
		Indices of digital skills among active population

from the Center for Scientific Research and Development in Higher Education Institutes, Ministry of Education, National Center for Educational Technology (National Resource Center for Basic Education, Ministry of Education), Higher Education Evaluation Center, Higher Education Press, Educational Informatization Strategy Research Base (Central China), Ministry of Education and other relevant departments, bureaus and units, as well as some data in Digital Economy and Social Index, 2019 Global Competitiveness Report, 2022 Global Digital Overview Report.

ii. Indicator normalization

To facilitate a more scientific comparison of different indicators and avoid the impact of different units and ranges among different indicators, before calculating the China Smart Education Development Index, the data of the indicators are normalized using the extremum method. The formula is:

$$Y = \frac{X - X_{\min}}{X_{\max} - X_{\min}}$$

In this formula, Y represents the normalized value of indicators. X is the original value of the indicator, X_{\min} represents the minimum value of the indicator, X_{\max} represents the maximum value of the indicator. The maximum and minimum values are determined by theoretical values, as well as the descriptive statistics of collected data. As a result, the normalized values of all indicators locate in the interval [0, 1].

iii. Weights

When aggregating the normalized values of indicators to produce the indexes, it is necessary to consider the weights of all indicators and dimensions. For setting the weight of all indicators and dimensions, referring to the calculation scheme of relevant international indexes, we use equal weight.

iv. Aggregating the normalized values

The formulas of China Smart Education Development Index (*SEDI*) and dimensional indexes (*DDI_i*) are:

$$SEDI = \sum_{i=1}^4 w \cdot DDI_i$$

$$DDI_i = \sum_{j=1}^{n_i} \frac{1}{n_i} \cdot Z_{ij}$$

Where, w is the weight of the dimensions, and $w = \frac{1}{4}$. The number of sub-dimensions within dimension i in the Indicator System of China Smart Education Development is n_i . The value of sub-dimension j in dimension i is Z_{ij} .

The indexes of sub-dimensions are calculated by referencing the same formula as dimensional indexes.

v. Missing data

In the data collection and calculation process of China Smart Education Development Index, the missing data is processed according to different situations. For indicators that data cannot be collected but have alternative indicator with available data, the alternative indicator data is used in the calculation. For indicators that both its data and alternative indicator data are not available temporarily, the indicators are not used in calculation. The indicators of which data cannot be normalized due to no theoretical optimal value are not included in the index calculation. For indicators with available but insufficient data, existing data is used to calculate the index.