Construction of Digital Education Infrastructure: Demands, Technologies and Plans

Shijie Wang[a] and Fuan Wen[b]
Beijing Key Laboratory of Network System and Network Culture, Beijing University of Posts and Telecommunications, Beijing, China

Keywords: Digitization of Education, New Infrastructure For Education, Key Technologies, Construction Plans, Digital Twin.

Abstract: With the advent of the 5G era, various technologies such as big data, artificial intelligence, cloud computing, Internet of Things, and virtual reality have been continuously updated and iterated, providing technical support for the construction of digital education infrastructure. However, the standards of these infrastructures are still not unified, resulting in different directions and uneven quality of education digital transformation. Therefore, starting from the background of education digital transformation, this paper introduces the current situation of education digital development at home and abroad, describes the policy direction of new education infrastructure, and deeply explores six aspects and twenty directions of education digital infrastructure construction. The following section of this article discusses key technologies used to construct the infrastructure for digital education and offers a four-layer technical framework. Finally, construction plans are suggested for the development of future educational infrastructure: physical space and its digital twin; digital resources in virtual space; and new digital education management. This paper has important reference value for the future education digital infrastructure construction, and also plays a certain role in promoting the development of the future education metaverse.

1 INTRODUCTION

The integration of digital technology and education is progressing in an unavoidable direction, and the digital transformation of education is a key strategy to support future innovation and reform in education. Some nations create pertinent educational plans. Based on the development of students' individualized education and lifelong learning, the "Stanford 2025" educational plan developed by the United States replaces the traditional old concept with a new concept fit for comprehensive talents in the new era (Stanford, 2025). The EU published the Action Plan for Digital Education (2021–2027) in September 2020 with the goal of promoting the alignment of education and training with the systems of member states (European Commission, 2020). It outlines a single European vision for high-quality, inclusive, and accessible digital education. Introducing the digital era. The "Key Points of Digital Transformation of Education and Training" document, published by the European Union in July 2022, makes the suggestion that different learning environments should be created to support the study and learning of educators, both teachers and students. India's National Education Policy (2020), which aims to make the country a global knowledge power, is based on the global educational ecology and the development trend of future education (Wang et al., 2020). It was suggested in the "14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Vision 2035" on March 12, 2021, to insist on giving priority to the development of education, improve people's quality of life, promote people's all-around development, and fully exploit the benefits of online education in order to improve the system for lifelong learning and create a learning society (New China News Agency, 2021).

[a] https://orcid.org/0000-0003-3798-7198
[b] https://orcid.org/0000-0003-4988-0443

Wang, S. and Wen, F.
Construction of Digital Education Infrastructure: Demands, Technologies and Plans.
DOI: 10.5220/0011914600003613
In *Proceedings of the 2nd International Conference on New Media Development and Modernized Education (NMDME 2022)*, pages 513-519
ISBN: 978-989-758-630-9

The current digital transformation of education is still in its infancy, according to domestic researchers like Zhu Zhiting, and the obvious place to start for this transition is for education to adapt to the external environment and internal development (Zhu et al., 2022). The development status and practical difficulties of digital educational resources have been sorted out by academics like Ke Qingchao, who have also interpreted and explained the three main construction directions of new resources and tools, resource supply systems, and resource supervision systems (Ke et al., 2021). Although academics have expressed their own perspectives throughout the research on the digital transformation of education, none of their research content has clarified the demands and plans for the creation of a digital education infrastructure. As a result, this paper summarizes the standards of the education digital infrastructure from many angles and thoroughly condenses and excavates the substance of the new national education infrastructure. In order to provide guidance for the direction of education digitalization transformation, construction plans of education digitalization infrastructure are proposed after researching the already-existing standards connected to their construction.

2 STANDARDS RELATED AND CONSTRUTION DEMANDS

In this paper, after consulting a variety of materials, we have screened out the core standards and specifications related to the content of digital education in education. (Table 1).

Table 1: Standards and specifications related to education digital construction

Number	Release Time	Name	Content
1	December 2019	*Information Technology - General Specification for Virtual Reality Head Mounted Display Devices*	This standard specifies the classification, basic requirements, test methods, inspection rules and signs, packaging, transportation and storage of virtual reality head-mounted display devices.
2	March 2021	*Specification for Digital Campus Construction of Colleges and Universities (Trial)*	The specification requires the coordinated development of digital campus infrastructure, information resources, application systems, network security, and security systems to avoid information islands.
3	October 2021	*Data Center Digital Twin Technical Specification*	The group standard specifies the basic requirements for digital twins of data center infrastructure, the classification of digital twins, and the application and evaluation of digital twins.
4	January 2022	*General Specification for Virtual Reality Teaching Resources*	This specification is applicable to the evaluation of virtual reality teaching resources in three aspects: subject construction, teaching function, and technical indicators, as well as the comprehensive evaluation of one or a series of virtual reality teaching resources.

Through the above standards, we have a preliminary understanding of various cutting-edge technologies and application standards related to the construction of education digitalization, but they are not systematic and complete, and we cannot have a comprehensive understanding of the construction of education digitalization infrastructure.

The China's Ministry of Education and the other six departments recommended to follow innovation and leadership in their "Guiding Opinions on Promoting the Construction of New Educational Infrastructure and Building a High-quality Education Support System" on July 21, 2021. Deeply implement 5G, AI, big data, cloud computing, blockchain, and other new generation information technologies, fully exploit data's potential as a new factor of production, and advance education's digital transformation (The Ministry of Education, 2021). This paper digs deep from the aforementioned published documents, with six aspects and twenty directions (Figure 1).

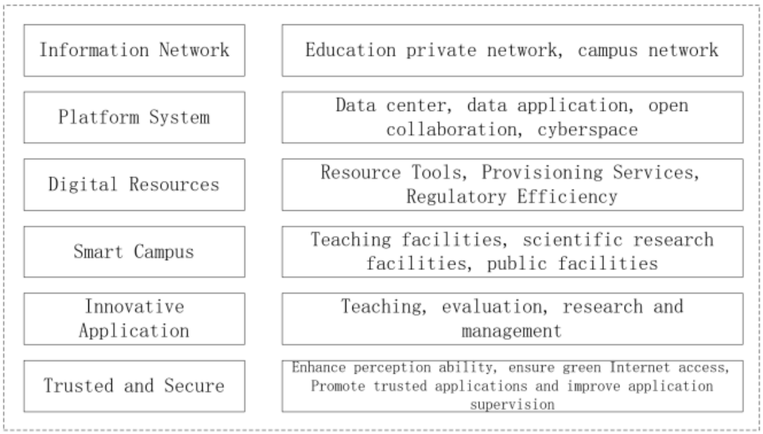

Figure 1: New infrastructure construction demands for education

The national policy in the area of education, which is a significant sector to drive new infrastructure, is extended by the new infrastructure for education, which is not just a demand inside the educational system. The development of new networks, platforms, security, resources, campuses, and apps is a key component of the new education infrastructure, which aims to create a new generation of infrastructure that is tailored to the needs of the education sector in the modern period. In this view, the new educational infrastructure heralds the actual advent of education information technology 3.0, which will significantly aid in the creation of high-quality educational systems and educational development methods like a learning society. The goal of the new educational infrastructure, according to Zhu Zhiting and others is to create a digital education ecosystem with a full system, thorough optimization, and sustainable development (Zhu et al., 2021). Along with initial demands, the technical factors of education digital building must be taken into account.

3 KEY TECHNOLOGIES OF DIGITAL EDUCATION INFRASTRUCTURE

This study suggests a four-layer framework of key technologies for the creation of digital education infrastructure through the aforementioned construction plan. (Figure 2).

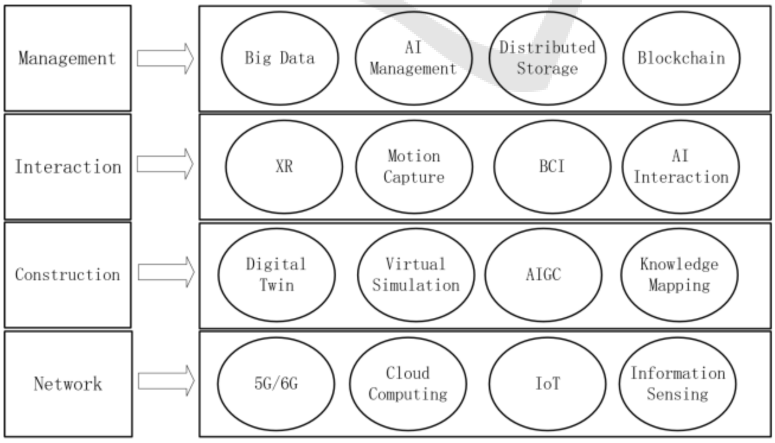

Figure 2: Framework of key technologies for digital education infrastructure

The network layer, which comprises mostly technologies like 5G/6G, cloud computing, the Internet of Things, and information sensing, is the top layer (Li et al., 2018). This layer is the fundamental network assurance for future digital education, which not only helps students access a variety of digital resources instantly but also significantly boosts the quality of instruction. The construction layer, which makes up the majority of the second layer, is composed primarily of technologies like digital twin, virtual simulation, AIGC, and knowledge graph. As was already mentioned, the future educational setting combines the physical and digital worlds. A virtual classroom is built with the aid of digital twins. In a virtual simulation environment, teachers and students can simultaneously conduct a number of experiments while creating a customised learning environment for chemical processes. Students will connect the educational information from many locations through the built-in educational space, create a systematized knowledge structure, and help to better synthesize and summarize the knowledge they have acquired. The XR, motion capture, brain-computer interface, and AI interaction make up the interaction layer, the third layer, respectively. Students' learning habits will be significantly altered by this layer as they use XR technology to study knowledge anywhere and at any time in the virtual world (ProQuest, 2019). At the same time, cutting-edge activities are carried out using brain-computer interface and intelligent interactive technology, and feedback from virtual teaching assistants enables people to learn and develop. The management layer, which comprises big data, AI management, distributed storage, and blockchain technology, is the fourth layer. This layer primarily assists education administrators in storing and managing different teaching data, teacher and student information, etc., as well as managing the classroom environment and teaching resources in a coordinated manner. Second, blockchain technology can be specifically used for intra-campus payments, digital certification, multi-step certification, automatic recognition and credit transfer, multi-step certification, multi-step certification, and student financial aid. This would ensure the high-quality development of education and considerably increase the management of education efficiency.

After construction demands and technical framework of Digital Education Infrastructure are clarified, this study begins with the future development of education and comprehensively outlines the construction plan of education digital infrastructure in three aspects: physical space, virtual space, and teaching management. This is in accordance with the aforementioned norms as well as the six aspects and twenty directions in the policy document.

4 THE CONSTRUCTION PLAN OF DIGITAL EDUCATION INFRASTRUCTURE

This study divides the development of digital education infrastructure into three main directions: physical space and its digital twin, digital resources in virtual spaces and new digital education management. Physical spaces include classrooms, laboratories, libraries, creative rooms, communication areas, and other places on campus. By mapping out the appropriate twin space and sending back the information data of the physical environment in real time, these actual locations create a dynamic digital twin of the entire physical space. Online, offline, and virtual simulation materials are all included in the category of teaching resources. These resources add to the virtual environment that the digital twin has generated while also receiving input from the virtual environment. The picture below depicts the total construction plan for the education digital infrastructure. (Figure 3).

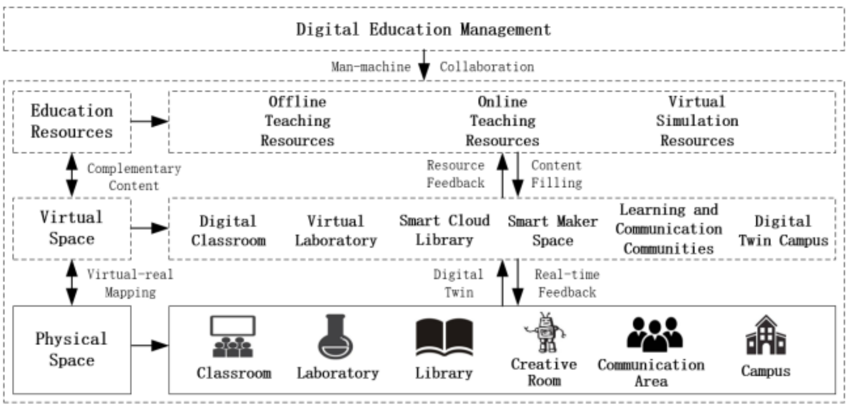

Figure 3: Construction framework of digital education infrastructure

4.1 Physical Space and Its Digital Twin

In order to complete the development of education digitalization, the physical space should first be founded on intelligent hardware equipment. To ensure that teachers or students can see the content of the virtual scene in real time, the first step in terms of hardware standards is to install a sizable 3D screen. The second is the XR head display, which is now how users access the virtual environment (Zhao et al., 2020). Equipment for motion capture is the third. The process data of teaching and learning is the most crucial component of digital education. The classroom behavior data table is then produced to describe the teachers' and students' classroom using motion capture technology. This allows for the real-time collection of behavior data from teachers or pupils. Using behavioral portraiture can help teachers educate and students learn. These pieces of hardware serve as the foundation for all scenes set in real space. Other scene types can also add accessories that reflect the features of their respective settings. For instance, a virtual lab may provide unique experimental tools, and a maker area could add 3D printers that let students create their own designs. (Table 2).

Table 2: Construction content of physical space and its digital twin

Aspect	Construction content
Learning Space	Fully Digital Classroom, Virtual Laboratory, Smart Cloud Library, Smart Maker Space, Learning and Communication Communities, Digital Twin Campus
Hardware	3D Screen, XR Head Display, Motion Capture Device, 3D Printer, etc
Function	Human-machine Collaboration, Personalized Learning

In terms of functionality, for teachers and students to use these digital twin learning spaces effectively, they must have elements that support human-computer collaboration. Additionally, they must offer features for personalized learning so that instructors and students can create their own unique environments for instruction and learning. Thirdly, intelligent teaching assistant functions need to be developed to help teachers and students answer questions at any time.

4.2 Digital Resources in Virtual Space

Online knowledge sources and virtual simulation resources are two types of digital resources in the virtual environment. Online teaching resources fall under the first category and typically include teaching design documents, microlectures, online practice questions, and other materials. Teachers' design concepts for the entire course are typically included in instructional design documents. Microlectures primarily assist students in grasping some information elements beforehand. Micro-classes in middle schools last for 10-15 minutes, while those in primary schools last for 5–10 minutes. Students can pick the online practice questions they require because they are typically hand chosen or intelligently suggested through the question bank.

Virtual simulation resources, which often fall into three categories: panoramic resources, 3D simulation resources, and scientific simulation resources, make up the second category. First, the simulation model must be able to replicate the system's or object's objective structure, function, and motion law (Liu et al., 2017). Second, the scene presentation must be based on the essential parts, choose the proper content and form, and utilize the goal of experimental education as the guiding principle. Reflect the experimental setting, and motion-related equations must follow established rules, etc. Minimum and recommended virtual resource package sizes are within 300 MB and 100 MB, respectively. Refresh the display at a rate of 30 frames per second. Recommendations for the experimental environment's fidelity: The experimental environment closely resembles the actual experimental surroundings stated in the design script on the basis of adhering to the actual scenario and common sense. Recommendations for experimental outcomes: The experimental results should be presented in vivid colors, sound effects, text, and other techniques to ensure that they are accurate. Serious flaws in the experimental process should be clearly shown with warnings. Since there is now no authoritative standard for virtual simulation resources, threshold access rules must be established for virtual simulation experiment teaching resources, and high-level, disciplinary-advantageous virtual simulation teaching resources must constantly be improved.

Table 3: Construction content of digital resources in virtual space

Aspect	Construction content
Type	Online Knowledge Resources, Virtual Simulation Resources
Character	Simulation, Reliability, Fidelity, Convenience

4.3 New Digital Education Management

The better completion of the construction plan will be encouraged by appropriate management techniques. In this study, a brand-new framework for managing digital education is proposed. It includes machine-assisted management and manual-decision management. (Table 4).

Table 4: Construction content of new digital education management

Aspect	Construction content
Mode	Machine-assisted Management, Manual-decision Management
Character	Automation, Unification, Datamation

Machine-assisted management will be an important management model for digital education. To facilitate the automation of the smart education process, Palanivel et al. advocated integrating RPA into the educational system (Palanivel et al., 2020). The burden of teachers' non-teaching responsibilities is lightened by assigning a large number of labor-intensive, repetitive, and time-consuming campus administrative activities to software robots. Teachers will then have more time and energy to devote to their work of instructing and educating others. In order to manage teacher teaching courses and student learning, intelligent machines are simultaneously utilized to collect data on the processes of student learning and teacher teaching. Teachers instruct students using objective data, while students give feedback. (Figure 4). Reforming the way the educational system evaluates students is also necessary, as are developing data collection standards, standards for data interoperability, standards for comprehensive quality student data collection across all domains, and standards for the development of new student ability types. On the other hand, manual-decision management involves making choices regarding the organization of some important instructional activities and the revision of talent training management. People are still required for important educational tasks because present intelligent technology only has limited artificial intelligence.

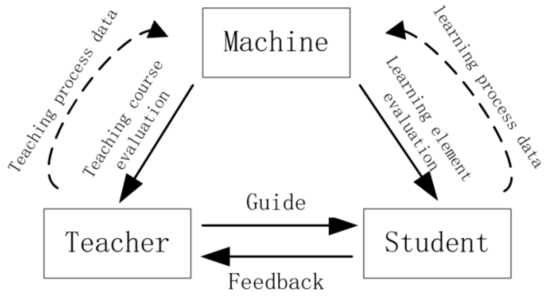

Figure 4: Evaluation structure of education digitalization

5 CONCLUSIONS

Since the digital transformation of education is still in its early stages, it is crucial to assess its requirements and create development plans. Based on the background of education digital transformation, the guidance document for new educational infrastructure is thoroughly examined and analyzed and the construction plan and key technologies of education digital infrastructure are described in this paper. The application of Metaverse in the field of education allows for the creation of digital identities for teachers, students, managers, and other stakeholders, as well as the opening up of formal and informal learning environments in the virtual world and the interaction of instructors and students there. With the widespread use and advancement of network technology, the education metaverse will gradually become a reality for us. Experts and academics in the field of education should assist the government in top-level design, assist businesses in precisely locating, develop standards for the building of necessary infrastructure, plan ahead, make deployments early, and usher in a new era of digital education networks.

[Project fund support: This article was supported by the Teaching Reform Project for Graduate Education, No. 2021Y045]

REFERENCES

European Commission. Digital education action plan 2021-2027[EB/OL].[2020-12-07].https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0624&from=EN.

Ke Qingchao, Lin Jian, Ma Xiufang, Bao Tingting. The construction direction and development path of digital education resources in the era of new education infrastructure[J].Electrical Education Research,2021,42(11):48-54.DOI:10.13811/j.cnki.eer.2021.11.007.

Liu Yafeng, Su Li, Wu Yuanxi, Yu Longjiang. Principles and Standards of Virtual Simulation Teaching Resources Construction[J].Experimental Technology and Management,2017,34(05):8-10. DOI:10.16791/j.cnki.sjg.2017.05.003 .

Li S, Xu L D, Zhao S.5G Internet of Things:A Survey[J].Journal of Industrial Information Integration, 2018 (10) :1-9.

New China News Agency. About the Outline of the Fourteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Vision 2035 [2021.3.13] https://www.gov.cn/xinwen/2021-03/13/content5592681.html.

ProQuest. Emerging Trends in Education Sector in 2019[DB/OL].[2019-03-11].https://search.proquest.com/docview/2159992511?accountid=146575.

Palanivel,K.,& Joseph,K.S.(2020),Robotic process automation to smart education[J].International Journal of Creative Research Thoughts,8(6):3775-3784.

Stanford2025. About [EB/OL].[2016-04-26]. https://www.stanford2025.com.

The Ministry of Education and other six departments. 2021-07-08 Guiding Opinions on Promoting the Construction of New Educational Infrastructure and Building a High-quality Education Support System [EB/OL].[2021-08-04].http://www.moe gov. cn/srcsite/A16/s3342/202107/420210720_545783.html.

Wang Jianliang, Wang Xiuwen. Strategic Guidelines for Educational Development in India in the Next 20 Years——Based on the Analysis of India's "National Education Policy (2020)"[J].Tsinghua University Education Research, 2021,42(02):106-116.

Zhao Jingwei, Bian Xigui, Gu Wenzhong. Ideas for the construction of virtual reality functional classrooms[J].Education and Equipment Research,2020,v.36;No.341(12):14-18.

Zhu Zhiting, Hu Jiao. Digital Transformation of Education: Future-Oriented Educational "Transgenic" Project [J]. Open Education Research, 2022, 28(05): 12-19. DOI: 10.13966/j.cnki.kfjyyj.2022.05.002.

Zhu Zhiting, Xu Qiuxuan, Wu Yonghe. Requirements and Action Suggestions for New Infrastructure Standards for Educational Informatization [J]. China Distance Education, 2021(10):1-11+76. DOI:10.13541/j.cnki.chinade.2021.10.001.