Dilemma and Countermeasure Research on the Construction of Virtual Simulation Laboratory in Chinese Medical Schools

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Abstract. Digital education reform is an inevitable trend of education reform in China. In the contemporary background, digital transformation of simulation virtual equipment construction and other digital transformation have taken place in Chinese medical school laboratories. This paper starts with the development of virtual simulation laboratory of clinical medicine in China, introduces the basic construction of virtual simulation laboratory used for medical teaching, analyses the dilemma of virtual simulation laboratory construction and popularization at the present stage, and explores the methods and countermeasures of digital wisdom experiment building.

Keywords: higher education, medical simulation education, virtual simulation experiments, simulation laboratory, clinical medicine, teaching reform.

1 Introduction

In the era of "Internet +", the importance of virtual simulation experiments is increasingly prominent, digital education, information technology education in many of China's colleges and universities carrying out .[1] In order to further improve the teaching experience, stimulate students' enthusiasm for learning, many of China's medical colleges and universities have also carried out the construction of virtual simulation laboratory projects. The construction of virtual simulation laboratories is complex, the resource allocation requirements are high, and there are many difficulties in putting them into use, which leads to the difficulty of landing virtual simulation laboratories in colleges and universities, but since the start of the construction of the national virtual simulation experimental teaching centre in 2013, 300 national virtual simulation experimental teaching centers have been built.[2] Take the simulator as an example, nowadays the simulation of intelligent technology is not only realistic in appearance, but also can simulate the abnormal signs of disease and changes in various pathophysiological indicators, which solves the problem of the lack of medical education resources.[3] Perfect experimental operating system and platform sharing resources of virtual simulation experiments promote the synchronisation of online and offline teaching. the continuous

Y. Feng et al. (eds.), *Proceedings of the 4th International Conference on Internet, Education and Information Technology (IEIT 2024)*, Atlantis Highlights in Social Sciences, Education and Humanities 26,
https://doi.org/10.2991/978-94-6463-574-4_16

improvement and application of the system also symbolizes the progress and development of China's medical education, and will certainly bring a new breakthrough in medical laboratory education.

2 Development of Clinical Medical virtual Simulation Laboratory in China

In the 1990s, due to the qualitative leap of modern bionics and computer software technology, American METI (medical education technologies incorporation) company exploited HPS (human patient simulator) & ECS (emergency-care simulator), integrating computer network technology into the teaching system, applying clinical simulation and computer network method to undergraduate clinical medicine teaching .[4-6] In 2007, Nanjing Medical University actively innovated the reform of medical laboratory teaching, taking teaching innovation as the leader, independently developed "virtual anatomy laboratory", "virtual function laboratory", "digital simulation morphology laboratory", "molecular simulation laboratory", "Molecular Biology Virtual Laboratory System" and other high-quality experimental systems. We have established a network experimental teaching platform including courseware, learning materials, videos, etc., which is a tailor-made independent learning platform for medical students. In 2013, the Ministry of Education made relevant deployments for the construction of national virtual simulation experimental teaching centers. As of 2015, a total of 200 national virtual simulation experimental teaching centers had been built in China. In 2017, the identification of virtual simulation experimental projects was carried out, and the project declaration of various universities grew rapidly, with 303, 766, and 1010 items declared in 2017, 2018, and 2019 respectively. [7-9] As of March 2019, the Ministry of Education identified 401 national virtual simulation experimental projects. In 2021, the construction of vocational education demonstrative virtual simulation realization bases was launched.[10-12]In 2022, the Ministry of Education formally put forward the implementation of the national education digital strategy action.[13] Now ilab-X has more than 3500 virtual simulation experimental projects. Human anatomy laboratory, for example, how to build and develop a good human anatomy laboratory, related to the teaching effect of the human anatomy course, but the human anatomy laboratory specimens are limited, gross specimen preservation needs formaldehyde solution soaking, formaldehyde solution volatile, irritating, long time inhalation of the human body's respiratory, digestive, blood, and the skin and so on can cause different degrees of damage.[14] The "digital man" is a rapid development of information digitization system. The system, through the computer three-dimensional model reconstruction of human anatomy images, shows all aspects of the human body's various components, students can first learn independently through the "digital man", and then consolidate the operation on the physical specimens. Solid specimens on the consolidation of the operation, the teacher can through the "digital man" to the students of the three-dimensional explanation, which not only improves the efficiency of the experimental anatomy learning, but also for the human anatomy experimental teaching provides a convenient. In addition to human anatomy, virtual simulation experiments in clinical medicine undergraduate

stage of function, pathology, physiology and other disciplines also play a landmark role. Generally speaking, nowadays the simulation experiment technology is more often used to assist the classroom teaching of professional courses in the "repetitive training of experimental practical skills" or "simulation of scientific principles", and its basic teaching design ideas are in line with the logic of didacticism, and also effectively assist the students of universities and colleges in their daily learning, but it does not really follow the principle of designing from the perspective of promoting the occurrence and generativity of students' learning.[15]

2.1 Clinical Medicine Virtual Simulation Laboratory Basic Construction Content

Information technology features, a high degree of simulation of the experimental environment and object[16] As well as to meet the teaching requirements of the whole academic period, these three aspects constitute the essential characteristics of the national virtual simulation experimental teaching centre. In addition to the important technical characteristics of virtual simulation experimental teaching in clinical medicine, there are two very important points: ① the construction of a highly simulated virtual experimental environment and experimental objects, ② virtual simulation experiments are designed and implemented for undergraduate teaching of clinical medicine, which should meet the requirements of the syllabus.(Fig.1)

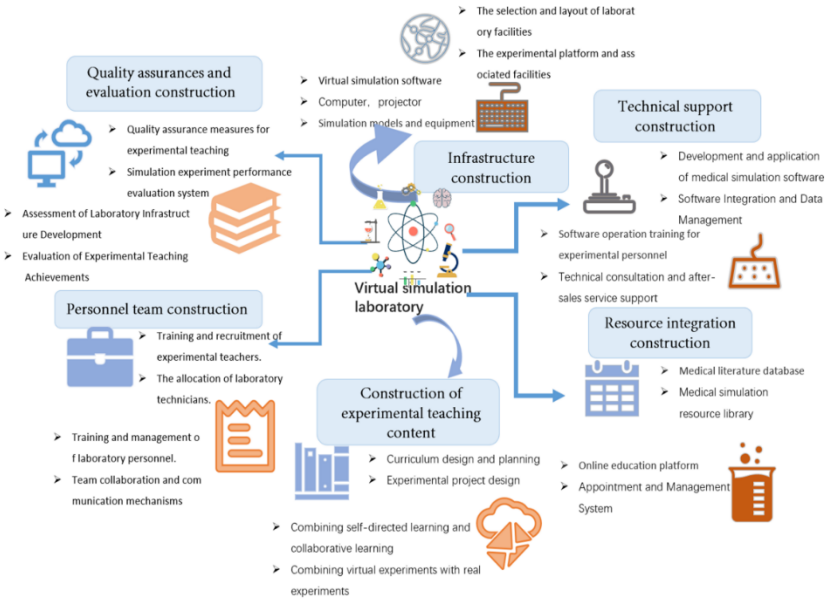

Fig. 1. Clinical medicine virtual simulation laboratory basic construction content

2.2 Virtual Simulation Experimental Teaching Resources and Environment Construction

Laboratory equipment, venues, teachers, online class learning materials and so on belong to the virtual simulation laboratory teaching resources. Networking of teaching resources not only reduces teaching costs and improves teaching quality, but also facilitates the penetration of green laboratory teaching. Common interactive resources for students to learn on their own, but also to promote academic exchanges and progress between different universities. Experimental teaching aims to cultivate students' comprehensive design and innovation ability, in order to improve the efficiency of experimental teaching, improve the experimental operation experience, and meet the learning needs of clinical medical students at different stages. Based on the needs of basic medical laboratory operations in the lower grades, learning resources, physical or virtual software platforms should be provided; for the higher grades, the laboratory should be prepared with simulators, clinical instruments such as the da Vinci hand, and other experimental equipment used to improve clinical skills.

2.3 Virtual Simulation Experimental Teaching Network Technology Construction

Construct scalability, compatibility, forward-looking sharing platform, use multi-sensing, intelligent sensing technology, create artificial intelligence mathematical models, three-dimensional imaging technology, introduce AR, VR virtual reality technology.[17] Take the important experiment of pharmacology "the effect of cardiac glycosides on the failing heart of rabbits in the body" as an example, the success rate of this experiment is extremely low for beginners. The real experimental and clinical scenes simulated based on VR technology provide students with an immersive practical experience. In the virtual operation, different options and results are set, and errors are allowed to reinforce the knowledge points. And add virtual heart changes before and after drug administration to visualise the results more intuitively. Simulate the clinical treatment scene, students participate in it, in-depth understanding of the practical application of cardiac glycosides in the clinic. Today's advanced science and technology enhance the teaching effect while also improving students' comfort level. Explore new modes and new ways of school-enterprise co-construction and co-management, and establish a sustainable development of the virtual simulation experimental teaching service support system.

2.4 Integration of Teaching and Learning and Clear Programme Orientation

The purpose of virtual simulation is to improve the degree of combination of theoretical teaching and practical learning, and the analysis of the use of virtual simulation experimental projects can respond to the actual needs of teachers and students for the course. The MOOC platform of the Dream Road medical virtual experiment statistics about the major medical schools medical students on the learning heat of the virtual laboratory project module (as shown in Figure 1) comprehensive analysis: for the undergraduate

college five 2019 grade internship stage students, the most used is the clinical medicine module of the relevant content; 2018 grade use of the popular module is concentrated in molecular biology and nursing; 2017- 2019 class popular modules are distributed in:molecular biology, microbiology, laboratory zoology and other basic laboratory operations.According to the statistics in the 2015 and 2016 class students, focus on the selection of more clinically and practically relevant practical laboratory projects, such as endotracheal intubation, paediatric cardiopulmonary resuscitation techniques; in the 2017-2019 class students, focus on the selection of basic research related content such as cardiopulmonary resuscitation, asepsis,which is in line with the training programme and study habits of each grade .

It is noteworthy that in Chinese medicine institutions, there is no significant tendency in the frequency of use of modules related to Chinese medicine and traditional Chinese medicine[18] (Fig.2),presuming that it isrelated tot the lack construction of Chinese medicine-related content .while in the basic medical discipline content, animal experiment operation, microbiology experiment operation and other modules, the using habits of Chinese medicine colleges and universities are similar to the comprehensive colleges and universities, it can be seen that Chinese medicine colleges and universities are also vigorously promote the operation of the learning of basic medical science and the importance of scientific research. Nanjing University of Traditional Chinese Medicine, for example, was awarded the first national virtual simulation experimental teaching centre in 2015.(Fig.3)

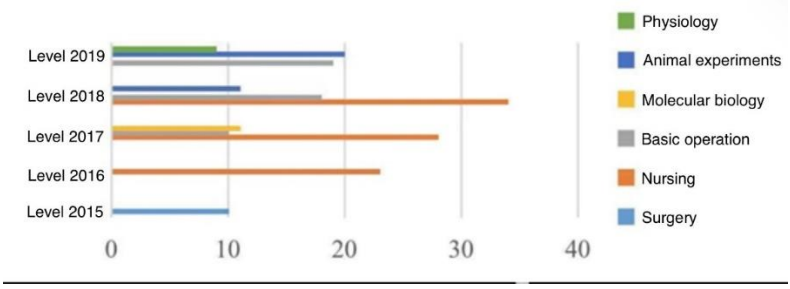

Fig. 2. Top five accessed lab courses in pharmaceutical institutions on MOOC platforms

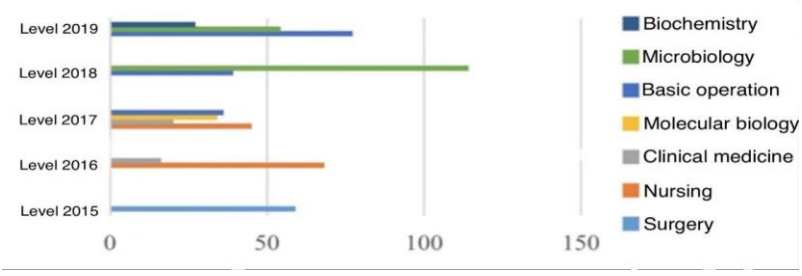

Fig. 3. Top 5 visited lab courses in Chinese medicine colleges and universities on MOOC platforms

2.5 Operation and Management of Virtual Simulation Experimental Teaching Centre

With the open sharing and full use of virtual simulation experimental teaching resources as the goal, systematically formulate and effectively implement policies and measures to guarantee virtual simulation experimental teaching, such as teachers' performance appraisal, fund use management, maintenance and sustainable development of experimental teaching centres, and establish a mechanism for assessing, evaluating and feeding back the teaching effect that is conducive to motivating students to learn and improving their innovation ability.

Technical personnel management: virtual simulation experiments integrate the knowledge of interdisciplinary technical fields, which requires teachers engaged in virtual simulation experimental teaching should not only be well versed in the field of experimental teaching and technology, but also have a high base of information literacy, to be able to familiarise themselves with, and accurately according to the requirements of the virtual experiments, the relevant departments to carry out training of professionals, industry training and software vendors training ,in order to continuously update and adjust the experimental methods and tools To make the experimental teaching content presentation to maintain the scientific and advanced.

Network Operation and Maintenance Safety Management: The virtual laboratory teaching platform makes the laboratory venues and equipment open 24 hours a day, and users can access the laboratory teaching system at any time as long as they have a terminal with network equipment to learn virtual simulation laboratory courses, so that the sharing of information and experimental resources can be maximised. The virtual simulation laboratory is composed of online experimental platform and offline physical laboratory, and the maintenance of security management and the completion of the platform data statistics are conducive to promoting the improvement of the network performance evaluation system and the implementation of the joint system of teaching and examination.

3 Dilemmas Facing the Construction of Clinical Medicine Virtual Simulation Laboratories

3.1 The Virtual Simulation Experiment is not Very Innovative

Virtual simulation laboratory teaching is the supplement and extension of traditional laboratory teaching. Taking the diagnosis and treatment process of clinical patients as an example, the virtual experiment online teaching system makes use of the dynamic mathematical model and the existing online class mode to simulate the real treatment process and real reaction phenomena in real time through the 3D simulation experimental device of standardised patients, so as to produce the experimental phenomena and experimental results matching the physical experiments. The way of presenting the experimental process purely by the conventional experimental process lacks innovation and also cannot completely replace the real experiments in traditional laboratories, which have many possibilities of uncertainty and thus cultivate the ability of students

to find problems and solve problems by independent thinking. Nowadays, the implementation of the curriculum, which focuses on construction but not on improvement, restricts students' exploration of knowledge, neglects the cultivation of students' subjective initiative in learning, and deviates from the original intention of virtual simulation experiment construction.[19]

3.2 The Interaction Mode of the Experiment is Relatively Single, and the Integration Degree with the Course Is Insufficient

Most of the domestic colleges and universities rely on enterprises to develop virtual simulation experiments through public bidding or directly buy ready-made resources to carry out virtual simulation teaching. The degree of development of the experimental courses is low, usually deviating from the teaching materials, lacking characteristics, and even more unable to stimulate students' learning occurrence. Happening learning refers to the spontaneous construction of a meaningful understanding of information by the learner, a new paradigm and way of interpretation set by the student and belonging to him/herself, weaving the information into a solid whole.[15] The disconnect between curriculum and instruction makes it difficult for users to learn deeply and thus lose confidence in their use. Due to the high threshold of the medical profession, its specialisation and the difficulty of the curriculum, it is difficult for the teacher to make use of the disciplinary and professional strengths of the university if he/she lacks communication with the technicians. This leads to a disconnect between the experiments and the course content, so that the experimental teaching does not complement the course teaching well.

3.3 Lack of Sharing Channels for Virtual Simulation Experimental Teaching, Lack of Resource Interoperability

The scope of application of virtual simulation experimental teaching resources is limited, and most colleges and universities are reluctant to serve students from outside schools under the self-interested consideration of the requirements of the standard policy, which restricts the degree of expression of the circulation of course resources sharing. For example, the construction of an experimental scene will cost hundreds of thousands or even millions of dollars, which is a considerable investment for public colleges and universities.[20] Most domestic colleges and universities developed simulation experiments in their own schools, and because of the development of different environments, the virtual simulation experiments of major universities are not compatible, so that the use of which is not smooth, seriously impeding the open dissemination of virtual simulation experimental teaching resources. Therefore, the state of laboratory creation today, it is easy to duplicate the phenomenon of development and waste of resources.

3.4 Expensive and Under-budgeted for Implementation on the Ground

Most of the medical instruments and equipment offer high prices, a wide range of accessories, technology, the introduction of talents need financial reserves.[6] At present, many provincial dual non-medical schools are in the state of virtual simulation experimental platform and the introduction of laboratory development, virtual simulation experimental platform market price ranges from 100,000 to 300,000, based on which the construction of simulation laboratories need to be configured with high-performance computers, high-definition monitors, sensors and other equipment. In the independent development phase and the use phase of the virtual simulation experimental project, it will certainly need to invest more research funds for the introduction of VR, AR and other emerging technologies. The wide range of equipment and instruments leads to high management and maintenance costs of the laboratory, and the lack of financial resources in many provincial dual non-medical schools makes it difficult to popularise on a large scale.

3.5 Insufficient Experimental Teaching Resources such as Experimental Equipment, Experimental Space and Insufficient Teacher Strength

From the very beginning of the demonstration experiment to the early 20th century, when it was proposed to speed up the laboratory reform and explore the innovative experimental mode, China's experimental teaching has been gradually enriched and personalised. With the general unfolding of experimental courses, the demand for experimental equipment, experimental sites and instruments in colleges and universities has gradually become larger.[21] In order to cultivate medical talents and promote the development of China's medical career, many medical schools have adopted the mode of enrollment expansion[22]. The state regulations stipulate that the teacher-student ratio should be less than 1:20 in undergraduate teaching classes, but the optimal teacher-student ratio is 1:2 in the trainee internship stage. The increase of medical students has led to a increase in the quantity and quality of teachers demanded by the medical education industry, and the proficiency of teachers in ICT will directly affect the advancement of online teaching and its quality. In the context of the smart era, traditional skills can no longer meet the needs of the times, and the barriers between disciplines are being eliminated, and inter-professional talents are in short supply. In terms of ICT awareness, teachers should firmly believe that digital development is an inevitable trend of the times and have a clear understanding of the serious impact of the development of digital technology on traditional teaching methods, thus making it difficult to keep abreast of the times and take the good opportunities that digital development brings to the reform of traditional teaching as a breakthrough point to promote teaching reform.

4 Virtual Simulation Laboratory Improvement Strategies

4.1 Enrichment of Online Teaching Resources

With the development of VR technology, virtual simulation experiments envisioning the level of clinical skills are combined with VR technology, so that the originally dangerous and risky experimental operations are practiced before the virtual experiments, which not only reduces the risk, but also positively improves the doctor-patient problems caused by the lack of clinical experience of medical students during the internship stage.[23] Strengthen the communication and collaboration among universities to unify the technical standards and expand the benefits. In addition, some colleges and universities are concerned about the sharing of experimental resources and intellectual property protection can not be balanced between the problem should be truly implemented, resource sharing at the same time to improve the protection of intellectual property rights, virtual simulation of experimental teaching resources are the fruits of intellectual labour, with obvious knowledge of the right to own, so there is a need to improve the protection of intellectual property rights, effective protection of research and development of the interests of the developer.

4.2 Strengthening Endogenous Dynamics

Build open communities for self-directed learning, using forms of social media that are popular with younger demographics. These types of interactions are often free of the seriousness, stereotypes, and time constraints of the classroom. Encourage student-centred design of virtual simulation labs for teaching and learning, and continually promoteand improve shared application services. Deep learning theory suggests that student learning is based on embodied cognition, i.e., students' cognition involvement of the body, cognition dependent on the body, encourage the participation of the body perceptual-motor system, the dynamic interaction between the body and the environment, so that the students produce experience and adaptive learning to obtain good learning outcomes.[21] On the basis of the construction, we will follow up the use of feedback research to enhance the fineness, the combination of reality and comfort of the product, and build an experimental context suitable for the creation of medical students' embodied cognition, so as to help students to improve their learning efficiency in deep learning.

4.3 Improving the Online Teaching System

Now the simulation software can be updated and upgraded at low cost, but there is still a "digital divide", which leads to the incompatibility of the curriculum resource reading equipment and resource management platform, which restricts the accessibility of virtual simulation experimental teaching projects in colleges and universities. Such as virtual simulation experimental teaching simulation of the real experimental environment used in the IvR technology is constantly updated, the traditional facilities and equip-

ment and input ports of colleges and universities have put forward new technical requirements, therefore, the school should actively update the hardware and software facilities and equipment, so as to improve the effectiveness of the use of experimental projects related to the use of curriculum resources. After years of development, the number and coverage of virtual simulation experiments are large, expanding students' knowledge and meeting the needs of students' comprehensive and innovative design experiments.

4.4 Introducing the Joint Teaching-Examination System to promote the Integration of "Teaching-learning-assessing"

Clinical medicine virtual simulation experiment project is mainly divided into two modules: basic medicine experiment module and clinical medicine practice experiment module. Basic medical experiment module is mainly used for undergraduate students to learn basic medical courses and clinical practice module is mainly used for interns to consolidate the learning of clinical knowledge, clinical practice. In order to have more targeted learning, the teaching content of the programme and the teaching focus of different modules should be focused on learning and comprehensive assessment. For example, the basic medical module should focus on testing the user's mastery of knowledge and proficiency in application, while the clinical practice module should focus on assessing the user's practical ability and resilience.

4.5 Adopt Joint School-enterprise co-operation to Increase the Introduction of Technology

Taking the teaching demand as the traction, adopting the school-enterprise joint way to cooperate and build the virtual simulation experimental teaching project is an effective way to promote the integration of medical research and use.[24] According to some statistics, Israel is the country with the highest number of patent applications and scientific and technological papers per capita in the world, and the 7th in absolute number in the world. Israel's famous biotechnology incubator---Alon-medtec, which has 12 medical equipment, health and cosmetic technology companies under its umbrella, including: ClipTip medical and Anchora medical (including ClipTip medical and Anchora medical (including ClipTip medical and Anchora medical). These include: ClipTip medical and Anchora medical (laparoscopic devices), EVA Visual (handheld high-resolution 3D scanners), ArchimedUS medical (cosmetic application devices) and BrainMARC (wearable EEG devices). Another example is the Synifi platform, part of SRI in the US, which will enable the commercialisation and scale-up of automated drug testing for rapid drug production.[25]

Colleges and universities, due to technical strength and financial constraints, it is difficult to independently complete the development of virtual simulation experimental projects. And mature enterprises in addition to technical resources and funds also have the advantage of promoting the application and branding. For example, in the experimental teaching of application-oriented majors, more consideration should be given to how to effectively transform the virtual simulation interactive links.The network course

should be increased based on the mobile interactive experiments of the holding device, as well as remote collaborative experiments based on remote technology, etc. The students can operate the experimental instrumentation and equipment through the remote control technology, remotely observe the experimental process and results, collect experimental data timely, and complete the data analysis and processing in the client's computer. Data analysis and processing are completed on the client computer. For schools and enterprises in the capital, talent, resources, market and other aspects of deep cooperation, to a certain extent, mature enterprises can learn from SRI will divest subsidiaries to take the enterprise joint university operation mode, give full play to the academic advantages of universities and enterprises and technical advantages, to build a technologically mature simulation laboratory.

4.6 Setting Standards and Utilising the Power of Teachers

Improving the level of teacher information technology teaching, mastering information technology and the control of medical simulation instruments is a necessary ability of a virtual simulation laboratory teacher. Secondly, carry out medical simulation education teacher training, and set the corresponding standards: received formal, systematic medical or nursing education, received standardised residency (nurse practitioner) training, etc. Laboratory equipment developer technicians lack knowledge of cutting-edge medicine and accumulated experience in clinical medicine. In order to adapt to the reform of digital medical education, the communication between the two can be enhanced, such as mobilising the powerful role of the two major industry associations: the China Medical Devices Industry Association to provide information technology training for medical workers, the China Association for Pharmaceutical Education or the Peking Union Medical College and other cutting-edge medical schools in China for the technical workers to provide medical expertise. Reference to the existing teacher training courses in foreign countries, adopt the University of Pittsburgh's Improving Simulation Educational methods course (improving simulation instructional methods) and the University of Miami master in simulation education course (University of Miami master in simulation UmasterSim).[26] Teachers are the bridge for students to receive knowledge, and maximising the power of the teaching staff can effectively explore the possibilities of students, for exploring the unknown from the known, and for fostering students' open and independent learning abilities. Improving the performance evaluation system with the help of online experimental platform is also a spur and encouragement to teachers.

4.7 The State Promotes and Supports Existing Policies

As early as ten years ago, China has successively launched a virtual simulation experimental teaching centre, introduced the higher education experimental teaching of information technology reform strategy, established the virtual simulation laboratories, which is not only an important part of the experimental teaching reform, but also an extension of the construction of experimental teaching demonstration centre. The Chinese communist party’s twentieth congress announced that "built a strong educational

country" would be included in the overall goal of China's development in 2035. at present, the traditional teaching in the digital era of continuous innovation and breakthroughs, the major universities in the construction of experimental teaching also reflects the new vitality and show new breakthroughs.[27] The state insists on launching the policy of developing and constructing virtual simulation laboratories and reforming laboratory teaching, which can continuously mobilise the provincial and municipal education administrative departments and institutions of higher education to construct experimental teaching demonstration centres, and also promote the schools and units that have already been awarded the title of national and provincial experimental teaching demonstration centres to continue to invest in the continuous construction.

5 Conclusion

In summary, the virtual simulation laboratory in colleges and universities is a product of the information technology of the times. In order to make it better benefit modern medical learning and improve the learning efficiency of medical students, we are trying to promote its laboratory education reform and laboratory development. We are striving to provide new ways and ideas for clinical thinking and diagnostic thinking training to a greater extent and scope.

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