Journal of Contemporary Educational Research, 2024, Volume 8, Issue 9
http://ojs.bbwpublisher.com/index.php/JCER
ISSN Online: 2208-8474
ISSN Print: 2208-8466

# Hybrid Teaching Reform of Veterinary Microbiology Based on the Combination of Virtual Simulation and Problem-Based Learning

**Jiedan Liao***

School of Life Science and Engineering, Foshan University, Foshan 528225, Guangdong Province, China

***Corresponding author:** Jiedan Liao, liaojiedan@163.com



**Abstract:** The Veterinary Microbiology course is centered around the diagnosis and testing of pathogenic microorganisms, with the core value of "moral education and character development." It reconstructs multidimensional teaching resources by integrating disciplinary achievements with clinical cases and implements a hybrid teaching approach combining virtual simulation and problem-based learning (PBL) through the "three stages + four models + three reflections" framework. Dual-qualification teachers employ various teaching methods, create a "six-in-one" model for ideological and political education, and conduct formative assessments based on the principles of diversified objectives and process emphasis. The hybrid teaching reform addresses issues such as fragmented knowledge, insufficient class hours, weak animal disease diagnostic abilities among students, limited application and expansion of knowledge points, and students' lack of proactive critical thinking skills. The application of hybrid teaching has shown significant advantages and effectiveness, providing a reference for teaching reform in similar microbiology courses.

**Keywords:** Veterinary Microbiology; Hybrid teaching; Virtual simulation; Problem-based learning; Teaching reform

**Online publication:** September 26, 2024

## 1. Introduction

The development of the "Internet+" concept has promoted reform in the field of education, giving rise to new educational concepts and forms [1]. At the same time, the development of information technology has spawned a number of massive open online course (MOOC) platforms and intelligent teaching tools, forming a hybrid online and offline teaching based on pre-class, in-class, and post-class teaching activities of mobile communication equipment and network information technology. Teachers, online learning platforms, and their staff provide students with online and offline teaching environments, teaching resources, and teaching methods, so as to better stimulate students' initiative, enthusiasm, and creativity in learning [1]. With the rapid development of new media technology in the Internet era, the transformation of the teaching environment has brought new challenges to college teaching. Online and offline hybrid teaching has grasped the characteristics of modern students, and information-based teaching means have brought new perspectives to teaching reform [1]. The proposal for hybrid

teaching in China can be traced back to 2004. Professor Kekang He of Beijing Normal University actively advocated the introduction of the hybrid learning concept into the course teaching practice [2,3]. Since 2013, hybrid teaching has begun to explore connotation development, advocating the "student-centered" principle. Through the combination of mobile devices, network environment, and teaching strategies, students can build a teaching situation with high participation and a strong sense of experience, and strive to achieve knowledge transmission, skill training, and value shaping in talent training [4]. The hybrid first-class undergraduate course is the effective integration and optimization of the core elements and hybrid teaching elements with the help of the "Internet gene," focusing on course education, top quality, rich content and frontier, teaching mode innovation, etc. so as to realize teacher-led instruction, multifaceted and interactive evaluations, and comprehensive student-teacher interactions [5]. Chen believed that hybrid teaching provides reliable theoretical support for cultivating innovative talents in universities [6].

Veterinary Microbiology courses have the characteristics of broad coverage, wide scope, and strong practicality, but the students cannot meet the requirements of employers for animal disease diagnosis and practical skills. The teaching team of the Veterinary Microbiology course has identified key issues in the training of undergraduate students in animal medicine, particularly the emphasis on theory over practice, teacher-centered teaching, and students' lack of innovation awareness and practical skills. By analyzing factors such as national policies, the livestock industry background, employer surveys, student learning conditions, and the current state of the teaching faculty, the team has summarized three major pain points of the course. In response, they propose leveraging the advantages of online teaching in the "Internet+" era by integrating the Veterinary Microbiology online open course from the Guangdong-Hong Kong-Macao Greater Bay Area Alliance platform with a hybrid teaching approach that combines virtual simulation and problem-based learning (PBL). By utilizing various information technologies, the course aims to enhance student engagement across teaching resources, course-based ideological and political education, teaching design, and course assessments. This approach shifts students from passive to active learning, transitioning from surface learning to deep learning. The course is designed to be socially responsive, aiming to cultivate application-oriented senior veterinary technical talents who possess leadership awareness, entrepreneurial spirit, practical skills, an understanding of agriculture, rural areas, and farmers ("three rural issues"), and a deep sense of patriotism—qualities that align with the requirements of local economic and social development.

## 2. Overview of the course

Veterinary Microbiology is a mandatory course for second-year students in the Animal Medicine program. Since its establishment in 1998, the theoretical and experimental courses have been recognized as the first-class undergraduate courses in Guangdong Province. Veterinary Microbiology MOOC has been available on several online platforms such as the Guangdong-Hong Kong-Macao Greater Bay Area, Xuexi Qiangguo, Superstar, and Rain Classroom. The course mainly aims to train students in the concept of aseptic technique and to equip them with the veterinary microbiology skills needed to conduct infectious pathogen detection, testing, and microbial identification in production settings. At the same time, it will cultivate students' rigorous and realistic scientific attitude, improve their ability to analyze and solve problems, and lay a theoretical foundation and experimental skills for the later study of livestock infectious diseases, poultry epidemiology, veterinary health inspection, veterinary clinical diagnostics, veterinary surgery, and other professional courses.

### 2.1. Teaching pain points

The talent training under the background of the new agricultural science should highlight the cultivation of

"professional dedication, craftsman spirit, and sense of responsibility," and focus on improving students' ability to diagnose, prevent, and control the pathogens of animal diseases. The field of veterinary science is rapidly evolving, with an extensive and complex curriculum. However, textbooks are often outdated in areas such as emerging infectious diseases and diagnostic technologies, with strong practical requirements but weak practical training. There exist the following pain points in course teaching: (1) Theoretical knowledge is abundant, but the number of class hours is limited. Due to time and space constraints, there is insufficient detailed guidance from teachers and limited classroom interaction. (2) The clinical characteristics of new pathogens are not adequately reflected in the teaching content, leading to weak diagnostic abilities in students for animal diseases. (3) There is limited application and expansion of theoretical and practical teaching, and students lack proactive critical thinking skills.

### 2.2. Curriculum objectives of hybrid teaching

The online open course in Veterinary Microbiology is grounded in constructivist learning theory, tailored to meet social development needs and the university's talent cultivation goals. Based on an analysis of teaching requirements and student learning conditions, the course sets objectives in knowledge, skills, literacy, and values. According to the teaching characteristics of online open courses, the curriculum objectives of hybrid teaching are formulated: reconstructing teaching resources and curriculum system to establish the knowledge structure of the microbial system; sharing virtual simulation practice teaching curriculum resources to promote the deep integration of information technology and education teaching; emphasizing basic quality, professional knowledge, and skills to cultivate students' abilities to solve complex animal diseases; focusing on the cultivation of basic scientific research quality and innovative practice capability, and establish students' confidence and determination to serve agriculture, rural areas, and farmers through innovation.

Through the hybrid teaching reform, the students can use the basic methods and experimental techniques of veterinary microbiology research in the diagnosis, prevention, and control of infectious diseases in the process of production practice. With the help of microbial knowledge, we provide technical means for the diagnosis, prevention, and treatment of infectious diseases, as well as the elimination of animal and zoonotic diseases, thus ensuring the healthy and rapid development of agriculture and animal husbandry, and cultivating high-quality veterinary technical talents with a solid foundation, strong practical skills, innovative spirit, and entrepreneurial courage.

## 3. Hybrid teaching reform based on the combination of virtual simulation and PBL

With the expansion of the scale of livestock and poultry breeding and the increasing complexity of animal pathogens, new infectious diseases or new characteristics of existing diseases are emerging in clinical practice, so students need to have interdisciplinary integrated analytical skills. They need to develop comprehensive skills in diagnosing disease pathogens, testing for pathogenic microorganisms, and applying theoretical knowledge to practical situations. Moreover, they should be able to integrate knowledge from various disciplines to solve problems related to the isolation and identification of animal disease pathogens and disease prevention and control. Hybrid teaching includes a mix of teaching spaces, teaching times, teaching methods, and teaching evaluation [7,8]. The birth of "double-line hybrid teaching" mode is fundamentally the product of "technological advantage" and "classroom reform demand" [7]. It deeply integrates online education and offline traditional teaching, complements the advantages of both, promotes the sharing of high-quality resources, extends classroom teaching space, redivides teaching links and teaching functions, and realizes deep learning. Chen *et al*. focused on pre-class preparation, in-class implementation, post-class resource dissemination, and evaluation

methods to conduct online learning, flipped classrooms, classroom discussions, and homework on the "SPOC-classroom" platform [9]. The course team has adopted a student-centered hybrid teaching reform approach across four dimensions: interdisciplinary integration, learning subject, learning space, and learning location. The teaching team has designed the course to facilitate layered teaching, where students help each other learn; location-independent learning with strong analytical skills; mixed clinical case studies; and teamwork-based learning anytime, anywhere.

## 3.1. Course resource construction

The online learning space for hybrid teaching is built on three platforms, based on the provincial first-class undergraduate online courses built by the course group, from the campus hybrid teaching SPOC platform to the online open course alliance for universities in the Guangdong-Hong Kong-Macao Greater Bay Area for universities in the province. The teaching platform integrates interactive and open discussion questions related to knowledge points and guides students to think about pathogen diagnosis and life perception. To improve the humanistic quality of the new agricultural students, the platform features exemplary assignments from previous students and encourages the students to maintain rigor and strive for excellence in scientific endeavors. Based on the intelligent teaching tools, a set of interactive courseware covering the whole process of hybrid teaching is formed in the classroom. In view of the key and difficult problems, the micro-course video library has been built. In addition to the limited classroom learning, personalized learning guidance for students has been realized, and the hyperlinked library of knowledge points related to microbial knowledge points, popular science articles, and science and technology news has been accumulated. A microbial-style ideological and political case bank has been built, and ideological and political elements have been integrated into the course in terms of both time and space.

Online learning resources combining teaching content and subject frontier hotspots, the teaching team assists online teaching through teaching platforms and different teaching software. The veterinary microbiology teaching resource includes 33 unit lesson plans, teaching PowerPoints, 200 unit tests, and 43 MOOC videos. Extracurricular resources include excellent works of previous students, 67 video resource databases, extracurricular expansion resource documents, etc. The platform provides public accounts, videos, animation, literature, animal laws and regulations, and news to provide extracurricular resources for students. The platform also offers resources like live-streamed videos by teachers on rural revitalization, a clinical case library, case atlases, and a research achievement case library, all aimed at supporting students in diagnosing animal diseases and fulfilling the "Internet + Teaching" online education requirements.

## 3.2. Problem-based learning

Compared with the traditional teaching mode, PBL teaching mode is more conducive to stimulating students' drive to learn, cultivating students' innovative spirit, teamwork consciousness, and comprehensive ability to solve problems [10]. Both problem-based PBL and project-based PBL methods are widely favored because they focus on the subjective role of students in learning and develop their learning ability by asking students to jointly explore questions in the 21st century [11]. For project learning results, PBL project-based learning emphasizes the diversity of students' learning results and emphasizes the use of new media and technologies to creatively produce new programs and works based on the knowledge and content, that is, to highlight students' creative expression. Dong and Jing put forward that university teachers should combine the favorable conditions of the software and hardware environment of universities, deeply understand the essence of PBL project-based learning, grasp the key links, and deal with the three relationships, so as to implement the application effect of

PBL project-based learning [12].

In Veterinary Microbiology, PBL teaching and teamwork are integrated throughout the teaching and learning process. The course adopts online and offline learning activities in the form of small classes and fixed groups. By utilizing the school's veterinary hospital as a practical teaching base and participating in extracurricular activities, student teams engage directly with local farmers and clinical cases. They design research projects based on real-world production needs, independently studying topics such as veterinary clinical diagnosis, animal pathology, and veterinary pharmacology. The teams then collaborate across disciplines to propose solutions and present their findings. Teamwork and peer learning stimulate students' interest in learning and, through communication, discussion, and reflection, foster the creation of knowledge. Teachers' feedback further deepens students' understanding, promoting deep learning. Reflection on learning enables the creation of knowledge, while teachers' guidance deepens this learning, enhancing teamwork and fostering innovative and entrepreneurial thinking. The PBL teaching approach, driven by projects, embodies "student-centered" interdisciplinary deep learning and reflection, enhancing teamwork and innovative entrepreneurial thinking. The teaching objectives shift from basic cognition to the design, implementation, and evaluation of diagnostic procedures for pathogenic microorganisms.

## 3.3. Curriculum ideological and political teaching design

The deep integration of technology and education has brought new educational concepts, modes, and teaching methods, accelerated the reform of educational concepts, learning methods, and teaching means, changed the teaching scene, and promoted the close integration of ideological and political construction of curriculum and hybrid teaching reform [13]. Yang *et al*. believed that curriculum ideological and political education refers to a new form of ideological and political education that takes the curriculum as the carrier and effectively integrates ideological and political elements into all links of course teaching, realizing the effective aggregation and coordinated operation of various educational elements, forms a joint force of education, and jointly serves the fundamental task of cultivating morality and cultivating people [14]. The hybrid teaching reform is closely linked with the ideological and political construction of the curriculum, and the emphasis on students is an effective way to implement the ideological and political construction of the curriculum and becomes a new way to cultivate talents in the ideological and political teaching of professional courses in colleges and universities. At present, the hybrid ideological and political teaching in colleges and universities is faced with difficulties such as insufficient teaching competence of professional teachers, insufficient interaction between students and the learning environment, imperfect evaluation systems, and insufficient overall integration [15]. The teaching team designs ideological and political courses by improving teachers' ideological and political awareness and skills, reconstructing teaching content, methods of curriculum ideological and political integration, information platform and resources, and the practice community of ideological and political education inside and outside the school.

The ideological and political teaching design of the Veterinary Microbiology course mainly focuses on the ideological and political case database of integrated courses. Through absorption-internalization-feedback, it changes passive into active cognition and promotes the advanced motivation of teaching. The feelings of knowing, loving, and understanding agriculture will run through the process of diagnosis and prevention of animal diseases. The content of the course is closely related to the syllabus and integrates ideological and political elements, and teachers and students create a microenvironment of ideological and political materials. For example, in Koch's postulates, students take online MOOCs and group discussions, think about the content, application, and limitations of Koch's postulates, and how they relate to tuberculosis pathogen identification.

Students watch videos on tuberculosis and Koch's postulates to understand the struggles and perseverance of scientists in the identification process. In the class, the students discussed enthusiastically, expressing their appreciation for Koch's hard work and rigorous scientific attitude, and clarifying the responsibility of veterinarians in their professional positions. Through the derivative of extracurricular knowledge, students share excellent civil policies in the prevention and control of human tuberculosis, reflect the superiority of socialism, and develop patriotic feelings. The teaching objectives are clear, with emphasis on key points and a systematic ideological and political design, creating a nurturing educational environment. The approach integrates the college, major, teachers, theory, practice, and extracurricular activities into a "six-in-one" ideological and political model. By focusing on talent cultivation goals, comprehensively embedding ideological and political education into the curriculum, and fostering a school-enterprise ideological and political education community, the course creates a conducive environment for ideological and political education. Practical education is realized through class theme activities and rural revitalization projects in the second classroom.

## 3.4. Practical training of virtual simulation experimental teaching platform

The construction of virtual simulation experimental teaching projects aims to promote the active exploration of new modes of experimental teaching that combine online and offline approaches, with a focus on personalized, intelligent, and ubiquitous learning. This initiative seeks to establish a new system for higher education information-based experimental teaching projects that is well-structured, effective in teaching, and open for sharing, thereby supporting the overall improvement of educational quality in higher education [16]. The development of online virtual simulation experimental teaching projects can partially address the shortcomings of traditional experimental teaching. Virtual simulation technology allows for the simulation of certain dangerous scenarios or experiments that cannot be conducted in real environments. For instance, microbiological cultivation and experiments involving harmful substances, which cannot be performed in typical laboratories, can be simulated through virtual means [17]. The course is a core carrier for achieving the fundamental task of moral education. Therefore, it is essential to fully utilize the value of virtual simulation experimental teaching projects in fostering moral and ethical development [18].

In the field of Veterinary Microbiology, certain experiments are based on a national virtual simulation experimental platform for internet-based shared teaching practices. This platform provides online learning and practical tasks related to the diagnosis of highly pathogenic pathogens, enhancing students' innovation and interactive behavior, and increasing the course's complexity and challenge. By utilizing the virtual simulation experimental teaching platform for practical training, the course addresses the experimental challenges of testing and diagnosing highly pathogenic microorganisms in animal diseases, thereby increasing student engagement in challenging projects. Virtual simulation experimental teaching focuses on the integration of online and offline components, expanding experimental teaching scenarios, promoting technological development, and improving the credibility, comprehensiveness, and multi-layered reform of experimental teaching concepts [19]. In alignment with the educational essence of "individual development and comprehensive development," the construction of virtual simulation experimental teaching projects in higher education uses data empowerment to re-engineer the models and processes of teaching content, teaching methods, educational supply, and educational governance [20]. In the microbiology course, efforts are made to integrate and optimize experimental teaching resources, emphasize the translation of scientific research achievements into practical teaching, and collaboratively advance the construction of a virtual simulation teaching sharing platform for animal medicine. Key areas of development include the creation of teaching resources, the establishment of school-enterprise platforms, the integration of industry and education, training for experimental teaching teams,

and the improvement of practical teaching management systems.

### 3.5. Hybrid teaching of "three-stage, four-mode, and three-reflection"

The "Internet+" information technology framework constructs online open course teaching resources by adopting teaching strategies that align with online learners. It employs various teaching methods, such as case-based, hybrid, and inquiry-based approaches, to enhance learning interest and effectiveness, creating a new generation of "smart classrooms." Hybrid teaching utilizes a "three-stage, four-mode, and three-reflection" teaching model, integrating the intelligent learning environment into every aspect of teaching. The three stages are "gradual segmentation of teaching goals, teaching design, and teaching evaluation," while the four modes include "integration of ideological and political education, PBL interactive teaching, online-offline hybrid teaching, and clinical practice integration." The three reflections are "reflection on process evaluation, peer learning reflection, and team collaboration reflection." This approach actively creates a smart teaching environment by applying high-quality online and offline course resources for hybrid teaching.

The design of hybrid teaching involves laying a foundation of basic knowledge before class, stimulating thinking, combining in-class activities such as flipped classrooms and pathogen diagnosis exercises, and reinforcing learning after class to improve efficiency. Course knowledge is divided into low-level, mid-level, and high-level modules, corresponding to online learning, in-class discussions, and inquiry-based learning. Before class, students are guided to self-study through online platforms, using pre-tests to motivate pre-class preparation and provide a basis for classroom teaching. In-class activities focus on participatory learning to stimulate deep thinking. After class, online platforms are used for post-tests and summaries, with individual and group extension tasks designed to enhance critical thinking and practical skills, followed by mutual reflection and feedback between students and teachers. Various hybrid teaching modes, including flipped classrooms, challenge-based projects, and group collaboration, cater to diverse student needs. Major assignments, open-ended questions, and clinical case analyses provide students with perspectives on clinical disease diagnosis and treatment.

### 3.6. Course assessment

Curriculum evaluation is an important means to reflect the teaching effect [21]. Course objectives examine the educational goal of cultivating virtue and moral integrity, focusing on the development of moral character, professional technical skills, and scientific literacy in teaching design. Course teaching is assessed from various aspects, including teaching resources, content, processes, methods, and approaches, and applicable research is conducted on evaluation criteria [8]. A diversified learning evaluation system is established, exploring a multi-faceted assessment model that combines formative and comprehensive evaluations, integrating both online and offline methods. This helps to scientifically determine key assessment criteria for hybrid teaching.

In the "student-centered" learning evaluation, the principles of diverse objectives and process emphasis are applied, combining formative and summative assessments. This approach focuses on evaluating professional knowledge and skills while also considering detailed aspects such as job skills, team spirit, and professional qualities. In the regular assessments, which account for 60% of the total grade, special attention is given to evaluating professional knowledge and skills, as well as incorporating elements of ideological and political education related to job skills, teamwork, and professional ethics. In the "final group presentation defense," evaluations are based on factors such as PowerPoint creation, team collaboration, and peer assessments within the group. The final exam papers reflect the inclusion of ideological and political education elements. This evaluation system promotes autonomous, process-oriented, and experiential learning. It facilitates resource

sharing, problem discussion, and collaborative learning among students and between students and teachers, enhancing interaction in and out of the classroom and stimulating student interest in learning.

## 4. Teaching reform effects

Student feedback is the driving force behind educational reform. The following are excerpts from student course evaluations: "This has been the most interactive classroom experience since starting college." "The teacher's hybrid teaching approach is excellent, and team collaboration has significant benefits." "The teacher encourages independent thinking and values sharing in the classroom." "The teacher's teaching motivates me to gain more knowledge." The hybrid teaching reform combining virtual simulation and PBL has enhanced students' enthusiasm for learning, practical skills, innovation, and challenge. It is worth referencing and promoting.

## Funding

(1) Education Research and Reform Project of the Online Open Course Alliance in the Guangdong-Hong Kong-Macao Greater Bay Area in 2023 (WGKM2023158)
(2) Research Topic of the Online Open Curriculum Steering Committee of Guangdong Province in 2022 (2022ZXKC462)
(3) Foshan Philosophy and Social Science Planning Project in 2024 (2024-GJ037)
(4) Innovation Project of Guangdong Graduate Education (2022JGXM129, 2022JGXM128, 2023ANLK-080)
(5) Demonstration Project of Ideological and Political Reform of Guangdong Education Department (Guangdong Higher Education Letter [2021] No. 21)
(6) Guangdong Provincial Department of Education, Provincial First-Class Undergraduate Courses (Guangdong Higher Education Letter [2023] No. 33)

## Disclosure statement

The author declares no conflict of interest.

## References

[1] Sun Y, Liu R, 2022, Summary of Hybrid Teaching Research in Domestic Universities. Journal of Chongqing Jiaotong University (Social Science Edition), 22(4): 96–103.
[2] He K, 2004, Looking at the New Development of Educational Technology Theory from Blending Learning (Part A). Research on Audio-Visual Education, 2004(03): 1–6.
[3] He K, 2004, Looking at the New Development of Educational Technology Theory from Blending Learning (Part B). Research on Audio-Visual Education, 2004(04): 22–26.
[4] Wang S, 2017, Rain Classroom: A Smart Teaching Tool under the Background of Mobile Internet and Big Data. Modern Educational Technology, 27(05): 26–32.
[5] Yang X, Zheng X, Tian C, 2021, Connotation, Construction Objectives and Construction Strategies of Online and Offline Hybrid First-Class Undergraduate Courses. Modern Educational Technology, 31(09): 104–111.
[6] Chen J, 2022, On the Innovative Talent Training Model based on Hybrid Teaching. Education Journal of Renmin University of China, 2022(1): 87–98.
[7] Qiu Y, Li Z, 2020, From "Online Teaching Competency" to "Double-Line Hybrid Teaching Competency." Distance

Education in China, 41(07): 7–15.

[8] Wei Z, Luo Z, Du J, 2020, A Hybrid Teaching Research with the Goal of Improving Students' Learning Initiative. Educational Theory and Practice, 40(33): 59–61.

[9] Chen F, He J, Duanmu D, et al., 2020, Practice and Exploration of Small-Scale Restricted Online Course (SPOC) Model in Microbiology Teaching. Microbiology Notification, 47(04): 1087–1094.

[10] Sun C, Zhou H, Dong B, 2024, Application of "PBL" Teaching Mode in the Experimental Teaching of Inorganic Chemistry in the Ideological and Political Perspective—Take the Preparation of Manganese Carbonate as an Example. University Chemistry, OnlineFirst.

[11] Dong Y, Sun W, 2019, To Promote the Productive Learning (DoPBL) Model of Interdisciplinary Learning—Based on the Integration of Problem PBL and Item PBL. Journal of Distance Education, 37(02): 81–89.

[12] Dong Y, Jing Y, 2019, Inquiry on the Application of PBL Project-Based Learning in University Teaching. Modern Educational Technology, 29(9): 53–58.

[13] Xing X, Li J, 2021, New Ideas for the Development of Online Education in the "Internet+" Era. Audio-Visual Education in China, 2021(05): 57–62.

[14] Yang X, Zheng X, Liang L, 2020, Research on the Value Implication and Practical Path of Ideological and Political College Courses under the Background of "Internet+." Research on Audio-Visual Education, 41(12): 71–78.

[15] Zhang S, Gao L, Yang Y, 2023, The Teaching Dilemma and Improvement Strategies of Ideological and Political Mixture in College Courses. Educational Theory and Practice, 43(3): 57–60.

[16] Xiong H, 2020, Virtual Simulation Experimental Teaching Promotes the Integration Reform and Innovation of Theoretical Teaching and Experimental Teaching. Experimental Technology and Management, 37(5): 1–4, 16.

[17] Li Y, Zhang J, Rao X, et al., 2023, Construction and Practice of Virtual Simulation Experiment Teaching Platform in Universities based on Digitization. Laboratory Research and Exploration, 42(10): 233–238.

[18] Liu J, Ge Y, Huang J, et al., 2023, Virtual Simulation Experiment Teaching Course: A New Model of Digital Enabling Engineering Ability Training. Research on Higher Engineering Education, 2023(03): 85–88.

[19] Lu X, Zhu T, Xu J, et al., 2021, Basic Problems and Trends of Virtual Simulation Experiment Teaching in Colleges and Universities. Modern Educational Technology, 31(12): 61–68.

[20] Cheng L, 2023, The Connotation, Characteristics, Basic Principles and Policy Elements of the Digital Transformation of Education. Research on Audio-Visual Education, 44(04): 53–56.

[21] Chen W, Xu X, Qiu D, 2023, Construction and Practice of Multi-Course Evaluation System of Pathogen Biology and Immunology under Blended Teaching Mode. Chinese Journal of Immunology, OnlineFirst.