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Exploration and Practice of a New Paradigm for Cultivating Interdisciplinary Innovative Talents in Biomedicine Empowered by Artificial Intelligence

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Abstract: Based on the construction foundation of the national first-class undergraduate major in Biotechnology and the national and provincial first-class courses of the college, and standing on the overall goal of cultivating high-quality interdisciplinary talents of the University of Jinan, this paper intends to explore the "333" Training System for Biomedical Innovative Talents featuring "Ideological and Political Education Integration · Digital-Intelligent Empowerment". The first "3" refers to the "three-wheel drive", which constructs the educational philosophy of "Ideological and Political Education for Moral Cultivation, Digital-Intelligent Empowerment, and Innovative Output" to drive the cultivation of three core attainments: "Patriotism and Social Commitment, Digital Awareness, and Innovative Spirit". The second "3" denotes the "triple digital integration", which establishes a digital transformation paradigm of "Platform-based Curriculum Teaching, Blended Teaching Mode, and Visualized Evaluation System" to promote the improvement of students' autonomous learning ability. The third "3" represents the "tripartite collaboration", which builds a tripartite collaborative education model involving "universities, enterprises, and society" to enhance the effectiveness of the "three-wheel drive" education. Through the above reforms, a replicable and promotable new paradigm for cultivating interdisciplinary innovative talents in biomedicine is formed.

Keywords: Digital-intelligent empowerment; Digital transformation; Collaborative education; Biomedicine; Innovative talents

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1. Research significance

The biomedical industry is a strategic emerging industry related to the national economy, people's livelihood and national security, and the core pillar of the "Healthy China 2030" initiative. At present, global biomedical technologies are deeply integrating with artificial intelligence, big data, robotics, and other technologies, driving the industry to achieve leaping development toward digital-intelligence. This puts forward brand-new requirements for talent cultivation: there is an urgent need for interdisciplinary innovative talents with scientific research and innovation capabilities, interdisciplinary integration capabilities, practical application capabilities,

and lifelong learning capabilities. However, China's existing biomedical talent training system has a significant disconnect between "digital-intelligent integration" and "ideological and political education", making it difficult to meet the urgent needs of national strategies and industrial upgrading.

"For whom to cultivate talents, what kind of talents to cultivate, and how to cultivate talents" are the fundamental issues of education. First, "for whom to cultivate talents" is a prominent embodiment of the political attribute of education and the core issue for China to build a strong education country. In May 2020, the Ministry of Education issued the Guidelines for the Construction of Curriculum-based Ideological and Political Education in Higher Education Institutions, clearly requiring the construction of an all-staff, whole-process and all-round education pattern to solve the problem of disconnection between professional education and ideological and political education. Although curriculum-based ideological and political education has now been integrated into all courses, its effective implementation throughout the entire talent training process still needs to be strengthened [1]. Second, "what kind of talents to cultivate" is the core goal of talent training in higher education. With the rapid development of science and technology, the biotech industry has become an important driving force for global economic growth. China's 14th Five-Year Plan lists biotechnology as a national strategic emerging industry, and industrial structure upgrading is in urgent need of interdisciplinary innovative talents with scientific research and innovation capabilities, interdisciplinary integration capabilities, practical application capabilities and lifelong learning capabilities [2]. Nevertheless, there is still a gap between the traditional biomedical talent training model and the current demand for new-type talents. Finally, "how to cultivate talents" is the main direction of higher education reform. The report to the 20th National Congress of the Communist Party of China wrote "promoting education digitalization" into the National Congress report for the first time, marking the entry of China's education digitalization into a new stage. In March 2025, the Ministry of Education released the White Paper on China's Smart Education and officially launched the "National Education Digitalization Strategic Action 2.0" [3]. However, traditional teaching methods and evaluation systems cannot adapt to the requirements of personalized learning, interdisciplinary projects and innovation capability cultivation in the digital-intelligent era, and the training system as a whole lags behind technological development and industrial transformation.

Therefore, exploring the "new paradigm for biomedical innovative talent training featuring Ideological and Political Education Integration · Digital-Intelligent Empowerment" is not only a response to the fundamental requirement of "cultivating talents for the Party and the country", but also a practice of the development concept of "technology empowering education". It provides a systematic solution for cultivating new-type biomedical talents with both patriotism and social commitment and innovation capabilities.

2. Research status at home and abroad

At home, some universities with biomedical majors have carried out reforms of training models for innovative top-notch talents and high-quality applied talents adapted to the new productive forces: first-class universities such as Peking University, Fudan University, Sichuan University and China Pharmaceutical University, adhering to the guiding ideology of "broad caliber, solid foundation and interdisciplinary integration", take new drug R&D as the traction to build a "Pharmacy + X" talent training model, strengthen disciplinary knowledge, expand general education and cutting-edge courses, and deepen practical education [4]; the School of Pharmacy of Fudan University proposed a three-level training system of "Foundation - Advanced - Excellence", reshaped the curriculum map, deeply integrated AI technology into pharmaceutical education, and explored a characteristic path of in-depth integration of AI and pharmaceutical education [5]; Sun Yat-sen University launched the pre-

college course Meet AI-01 to lead freshmen on an AI exploration journey, and at the same time implemented the "X + AI" double bachelor's degree program to provide students with interdisciplinary learning paths [6]; Shanghai Jiao Tong University, focusing on key fields such as biomedicine and AI empowerment, built a special class training system, strengthened the characteristics of industry-specific classes, and cultivated interdisciplinary talents with a more innovative model [7]; Zhejiang University proposed a "K-CPS" intelligent technology chain with knowledge graph as the core and explored a new teaching paradigm in universities [8]; the Modern Biomedical Industry College of Jiangsu Ocean University explored a training model of "four platforms and five joint collaborations for cultivating applied pharmaceutical industry talents" [9]; Zhejiang Sci-Tech University explored a "full-chain" training model for biological innovative talents driven by "double helix" (university-enterprise cooperation, integration of science and education, integration of industry and education, and combination of virtual and real) and empowered by "full cycle" [10]; the School of Bioengineering of Zunyi Medical University explored a training model of "industry-university-research cooperation for cultivating innovative and entrepreneurial biomedical talents" [11]; Southeast University carried out the "AI + Education" teaching reform in the cultivation of new-type talents empowered by AI, providing students with a personalized learning experience [12].

Abroad, relevant research was carried out earlier. For example, Stanford University launched an AI-empowered talent training model with the flipped axis of "competence first, knowledge second", focusing on the cultivation of innovation capabilities and application of knowledge, and its training effect is prominent [13]; the 2025 Future of Education Report investigated the impact of artificial intelligence on education in European countries such as Austria, Germany, Spain, France, Italy and the United Kingdom, and the results showed that technology is reshaping the teaching paradigm, and artificial intelligence is evolving from an auxiliary tool to a core educational element, which is expected to promote the realization of personalized education [14]; Japan has established an AI education promotion plan, focusing on improving teachers' technology application capabilities through professional development projects and promoting AI to become part of instructional design [15].

Aiming at the three key problems of curriculum-based ideological and political education (superficial integration and disconnection), digitalization lag and practical disconnection, this paper systematically designs the "three-wheel drive" educational philosophy, and organically integrates ideological and political education for moral cultivation, digital-intelligent empowerment and innovative output into the entire process of talent training. By building the "triple digital integration" new teaching paradigm and constructing a smart curriculum teaching platform, personalized learning and process evaluation are realized. The "tripartite collaboration" mechanism is innovated to break disciplinary barriers, introduce real enterprise projects and social practice, and build a multidisciplinary interdisciplinary teaching and practice platform. The aim is to cultivate interdisciplinary biomedical talents with patriotism and social commitment, digital literacy and innovation capabilities, and to form a promotable new education system.

3. Top-level design and implementation path of the "Three-Wheel Drive" educational philosophy

3.1. Unblock the curriculum-based ideological and political education chain, and implement curriculum-based ideological and political education in every course and each teaching link

3.1.1. Construct the "three integration" model of curriculum-based ideological and political education

Curriculum-based ideological and political education is implemented in the teaching of each course, and the

"three integration" plan is promoted—integration into syllabi, integration into classrooms, and integration into assessments. Ideological and political objectives, ideological and political matrix tables and ideological and political assessment methods are added to the syllabi; in classroom teaching, ideological and political elements are introduced through various scenarios, and ideological and political education is subtly integrated into professional course education, and the implementation effect of curriculum-based ideological and political education is tested through formative evaluation.

3.1.2. Implement the "one course, one ideological and political case" plan

In accordance with the school's evaluation criteria for curriculum-based ideological and political teaching cases, ideological and political teaching cases are formulated for each theoretical course, with expert guidance and continuous optimization to ensure that each course has a clear ideological and political implementation plan.

3.1.3. Construct the six-dimensional integrated curriculum-based ideological and political teaching model of "Scenario Stimulation - Three-Question Interaction - Activity Driving - Inquiry Promotion - Thinking Activation - Ideological Inspiration"

In theoretical teaching: stimulate students' emotional resonance through real scenarios; establish a closed-loop interaction of "teacher-student-AI" through three-question interaction (asking, counter-asking, and probing); arouse students' learning enthusiasm through classroom activities such as group discussions and debates; promote students' active thinking through inquiry activities such as project design and case analysis; enhance students' innovative thinking through scientific research projects and simulated application for science and technology innovation competitions; shape students' values of patriotism, responsibility and social service through the planning of social practice activities.

In experimental and practical teaching, the six-dimensional integrated curriculum-based ideological and political teaching model is adopted to give full play to the effect of the "tripartite collaboration" education involving universities, enterprises and society. It immerses students in scenarios of solving real problems, improves their ability to respond to and solve real problems, promotes their autonomous learning, and encourages their active innovation. Thus, it guides students to establish an autonomous learning cognition line from "learning to learn", and form an emotional line of scientific cognition of biomedicine from "initial curiosity → approaching love → in-depth exploration → active innovation".

3.2. Construction and practice of the "Triple Digital Integration" teaching paradigm

An online teaching platform is built to integrate digital technology into the entire process of "teaching-learning-management-evaluation". The specific implementation paths are as follows.

3.2.1. Break the barriers between courses, and build a curriculum SPOC teaching platform and a curriculum system map

Optimize the curriculum system and build a modular curriculum system of "general education + professional basic courses + professional expansion courses + intensive practice"; ensure that each theoretical and experimental course has a "one course, one SPOC teaching platform"; build a curriculum system problem map and associate the data of the curriculum SPOC teaching platform to avoid repetitive teaching, establish a crisscross curriculum system network, and help cultivate students' autonomous learning ability and interdisciplinary awareness.

3.2.2. Carry out AI + blended teaching reform and innovate the teaching model

Based on the SPOC platform, carry out blended teaching reform, deeply couple the five-star teaching method with digital tools, and construct and practice the teaching model of "four-stage orientation - dual-line integration - five-star progression - six-dimensional integration"; carry out the reform of process assessment and reduce the proportion of summative assessment.

Advanced information technology is effectively integrated into teaching. At this stage, AI has been integrated into the entire teaching process, AI usage norms have been formulated, and a framework for cultivating students' AI literacy has been established. Taking the provincial first-class course Microbiology (a smart course) as a model, knowledge graphs, problem graphs, competency graphs and ideological and political graphs are comprehensively constructed, forming a synergistic integration of "classic efficiency-enhancing classrooms and AI intelligence-enhancing classrooms" to support students' autonomous learning.

3.2.3. Establish a four-in-one digital system of "teaching-learning-evaluation-management"

Utilize platforms such as Chaoxing Learning Platform, Rain Classroom and Smart Tree to build SPOC teaching platforms for professional theoretical courses, experimental courses, graduation internships and comprehensive experiments, realize the digitalization and visualization of online and offline "teaching-learning-evaluation" data, and explore personalized teaching plans; realize the digital management of archived data by using the Chaoxing Learning Platform, Alumni Bond internship data reporting system and VIP thesis management system.

3.3. Construction and implementation plan of the "Tripartite Collaboration" education model

Focus on tripartite collaborative education and build a practical education model of "Outcome-Oriented → Tripartite Collaboration → Four-Chain Interaction". Guided by students' significant achievements such as the approval of scientific research projects, awards in discipline competitions, paper publication, patent application and social service, practical teaching including in-class experiments, internships and social practice is carried out. The main measures are as follows.

3.3.1. Integration of science and education

On-campus dual teachers (lecturers + research supervisors) collaborate to establish a science-education integration chain: build a progressive experimental system of "basic experiments - virtual simulation experiments - comprehensive experiments - project training" to consolidate theoretical and experimental skills and cultivate students' scientific research literacy.

3.3.2. Integration of industry and education

University-enterprise dual teachers (academic supervisors + enterprise mentors) collaborate to establish an industry-education integration chain: build a comprehensive innovation capability driving chain of "on-campus training - enterprise internship - science and technology innovation competition - innovation and entrepreneurship" to improve students' professional competence.

3.3.3. Interdisciplinary integration

Four types of teachers (lecturers + research supervisors + academic supervisors + enterprise mentors) jointly establish an interdisciplinary integration chain: explore interdisciplinary characteristic practices such as the

micro-major of “Biomass Spectrometry” and the innovation class of “Synthetic Biology” to enhance students’ cross-border integration and independent innovation capabilities.

3.3.4. Comprehensive innovation

Establish a social practice comprehensive innovation chain: serve the society through social practice such as science popularization, community service, rural service and mountain area teaching assistance, to enhance students’ sense of social responsibility and improve their comprehensive quality.

4. Conclusion

This study proposes the “three-wheel drive” biomedical innovative talent training philosophy with the core of “digital-intelligent integration, digital-intelligent empowerment and innovation leadership”, which closely aligns with the development trend of higher education and the actual needs of the industry. It innovatively promotes the in-depth integration of curriculum-based ideological and political education, digital-intelligent technology and the talent training chain, realizing the transformation of value shaping from “didactic” to “immersive”; through the way of “data chain replacing experience chain, innovation flow driving the whole-process training”, it achieves the “gene-editing-style” precise innovation of biomedical professional education.

The “333” biomedical talent training system, integrating “ideological and political education, digitalization and innovation,” is constructed, and three innovative breakthroughs in the education paradigm are realized through systematic design. With the “three-wheel drive” as the core driving force, a talent attainment framework for the coordinated development of “Patriotism and Social Commitment - Digital Awareness - Innovative Spirit” is built. Through the “triple digital integration (Platform-based Curriculum Teaching, Blended Teaching Mode, Visualized Evaluation System)”, the disciplinary paradigm of digital transformation for biotechnology professional education is constructed.

On this basis, an integrated digital system of “teaching-learning-evaluation-management” is established, the teaching model of “four-stage orientation - dual-line integration - five-star progression - six-dimensional integration” is built, a spiral upward ability training path is formed, a digital and visualized evaluation system is constructed, and the specific path for the construction and practice of smart courses is proposed.

Through “tripartite collaboration”, an innovative practical education mechanism is built with learning outcomes as the orientation. Taking students’ scientific research projects, science and technology innovation competitions, paper publication, patent application and social service as output goals, four measures are taken—”on-campus dual teachers promoting the integration of science and education, university-enterprise dual teachers promoting the integration of industry and education, four types of teachers collaborating to promote interdisciplinary integration, and social practice promoting comprehensive innovation”—to form a closed loop of innovative practice of “four-chain interaction”, and build a practical education model of “Outcome-Oriented → Tripartite Collaboration → Four-Chain Interaction”.

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