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Six-Dimensional Closed-Loop Composite Talent Cultivation System for AI-Driven Medical Imaging Professionals

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Abstract: Addressing key challenges in interdisciplinary talent cultivation—including fragmented medical-engineering knowledge frameworks for relevant majors in local universities, students' inadequate capacity to deploy AI algorithms for practical scenarios, disrupted innovation chains, and insufficient integration of industry and education—this paper proposes a six-stage closed-loop talent cultivation framework. This framework consists of six interconnected and progressive phases: fundamental AI knowledge acquisition, academic competition training, research project-enabled capability cultivation, large-scale innovation project incubation, clinical outcome validation, and high-quality dissertation completion. This framework sequentially consolidates students' foundational AI literacy, enables systematic hands-on engineering practice, grants students access to state-of-the-art research resources and authentic clinical data, supports the full-cycle development of innovative research outputs, facilitates the clinical translation of research findings, and guarantees the completion of high-quality academic dissertations. Simultaneously, it feeds exemplary research and practical achievements back into undergraduate teaching, thereby constructing a self-sustaining cyclical educational ecosystem. Two years of practical teaching reform implementation has verified that the proposed framework can comprehensively improve students' interdisciplinary core competencies and provide a reproducible and scalable practical paradigm for talent cultivation in the medical-engineering interdisciplinary domain under the background of the New Engineering Education initiative.

Keywords: AI in Medical Imaging; Closed-loop Education; Academic Competitions; Research-to-Practice Feedback; Large-scale Innovation Projects; Clinical Translation.

1. Introduction

1.1. Industry Demand and Existing Shortcomings in Talent Development

Against the backdrop of the implementation of the Healthy China Strategy and the booming growth of the medical artificial intelligence (MedAI) industry, highly demanded interdisciplinary talents specialized in clinical diagnosis and medical device development are required to proficiently master core competencies covering medical imaging anatomy, imaging mechanisms, deep learning algorithms, and CT intelligent reconstruction technologies [1]. An investigation into the current talent cultivation system for smart medicine-related majors in regional universities reveals obvious stage-wise fragmentation in the entire training process, leading to six prominent core deficiencies. First, basic disciplinary courses including mathematics, physics, and computer programming are poorly aligned with professional medical AI courses[2]. Students exhibit deficient capabilities in mathematical modeling and program coding, which hinders their independent completion of practical engineering tasks such as medical lesion segmentation and low-dose CT image reconstruction. Second, classroom theoretical teaching is decoupled from practical engineering training platforms. Furthermore, academic competitions and course-based practical training are implemented independently with no effective connection, failing to construct a hierarchical and progressive competency training pathway. Third, national and provincial research resources are predominantly open to graduate students, which greatly restricts undergraduates' access to state-of-the-art imaging algorithms and anonymized real-world clinical imaging datasets. Fourth, project selection for the Undergraduate Innovation and Entrepreneurship Training Program suffers from severe homogenization. Most student projects merely stay at the simulation verification stage and lack effective verification in authentic clinical application scenarios. Fifth, there is a lack of effective clinical translation channels for students' innovative achievements, and the outputs of academic competitions and undergraduate innovation projects are poorly matched with the practical demands of the healthcare industry. Sixth, undergraduate graduation theses face insufficient and single-source research materials, which are mostly limited to the replication of existing theoretical methods. This dilemma makes it difficult to produce high-quality provincial-level outstanding dissertations that integrate algorithm design, experimental verification, and clinical data validation.

1.2. Research Approach and Core Framework

To tackle the stage-wise fragmentation problems existing in the current talent cultivation chain, this study relies on a provincial teaching reform project to carry out a two-year systematic educational reform practice and constructs a six-dimensional closed-loop talent cultivation framework. The logical architecture of the proposed framework is composed of six progressive links: AI-oriented mathematics and programming fundamentals act as the initial capability foundation; academic competition training polishes students' basic practical competencies; provincial and ministerial research projects grant students access to state-of-the-art technologies and authentic clinical datasets; large-scale undergraduate innovation projects facilitate the full incubation of innovative thinking and research ecosystems; clinical application practice verifies the practical value of relevant research outputs; and high-quality undergraduate dissertations function as the comprehensive outcome carrier of the entire cultivation process. Furthermore, exemplary dissertations, competition awards, and innovative project achievements can be iteratively applied to update the teaching cases of basic disciplinary courses. Such feedback realizes effective backward feeding into the fundamental AI teaching stage, ultimately forming a complete cyclical and iterative talent cultivation ecosystem.

2. Research Methods and Design of the Six-Dimensional Closed-loop Cultivation System

2.1. Closed-loop Overall Architecture

The six cultivation phases adopt a progressive and interconnected structural design to realize resource interoperability and iterative outcome transformation, forming a complete closed-cycle operational logic as detailed below:

Phase 1: AI Fundamental Literacy Training (Mathematics and Programming)–Building solid interdisciplinary foundational competencies;

Phase 2: Systematic Robot and AI Competition Training–Driving the effective transformation from theoretical knowledge to practical engineering capabilities;

Phase 3: Provincial and Ministerial Research Project Empowerment–Granting students access to state-of-the-art medical imaging technologies and authentic clinical datasets;

Phase 4: Large-Scale Big Data Innovation Project Incubation–Realizing the systematic engineering implementation and optimization of innovative research solutions;

Phase 5: Clinical Translation of AI Imaging Research Outcomes–Verifying the practical application and industrial value of innovative achievements;

Phase 6: Development of High-Quality Provincial-Level Undergraduate Dissertations–Synthesizing full-cycle research and practical outcomes, and feeding verified innovative results back into foundational teaching resource optimization and iteration.

2.2. Step 1: Tiered Instruction in AI Fundamentals (Mathematics plus Programming Language)

This study constructs a three-level hierarchical curriculum system covering mathematical fundamentals, programming tool applications, and medical-engineering integration to remediate undergraduates' insufficient foundational competencies in medical AI.

2.2.1. The Mathematical Foundation Module

This module delivers core courses including Advanced Medical Mathematics, Linear Algebra, and Probability Theory and Mathematical Statistics, and integrates specialized mathematical models involving machine learning loss functions, CT imaging principles, and sparse reconstruction into conventional teaching content. Furthermore, the teaching team has compiled two supporting textbooks, namely Advanced Medical Mathematics[3] and Engineering Mathematics, which provide solid mathematical support for undergraduates' subsequent learning of deep learning algorithms and medical image reconstruction technologies.

2.2.2. The Programming Tool Module

This module provides two core specialized courses, namely Fundamentals of Computer Programming and MATLAB: Computer Vision and Machine Cognitive Systems and adopts a dual-language teaching framework based on Python and MATLAB. In addition, the teaching team independently develops visualization educational software for CT image reconstruction, which integrates over ten classic reconstruction algorithms, including TV regularization and guided filtering. An open online code repository is established and matched with more than 60 practical algorithm demonstration videos, allowing students to finish self-directed foundational coding practices covering image reading and writing, filtering, and segmentation before offline classroom teaching.

2.2.3. Interdisciplinary Medicine Engineering Integration Course

Based on two provincial first-class core courses, namely Medical Image Processing and Medical Imaging Instruments, this module further delivers Introduction to Artificial Intelligence and Machine Learning and Its Applications[4]. Adopting authentic clinical cases of lung CT and DR imaging as practical teaching carriers, the course systematically elaborates the full-process workflow of medical image-oriented AI engineering development. This teaching design enables students to acquire comprehensive foundational competencies for participating in academic competitions, scientific research projects, and large-scale innovative training practices.

2.3. Step 2: Regularized Training for Robot and Artificial Intelligence Competitions

This study takes academic competitions as a comprehensive evaluation and practice platform to inspect students' mastered AI foundational competencies and constructs a hierarchical and progressive training mechanism following the closed-loop progression of course-based practical training, freshman and sophomore introductory competitions, and upper-grade advanced competitions.

2.3.1. Competition Topic Selection Rules

All competition entries are confined to three core medical imaging research directions: CT limited-angle reconstruction[5], low-dose image noise reduction[6], and multi-modal lesion analysis. These themed tasks cover mainstream and clinically valuable research domains of medical AI, including medical image segmentation and intelligent imaging-assisted diagnostic robotics.

2.3.2. Tiered Talent Development System

Grade-based hierarchical competition training is implemented: junior undergraduates participate in foundational AI competitions based on core curriculum knowledge, whereas senior students take advantage of their accumulated experience in research sub-projects and large-scale innovative training programs to participate in provincial and national high-level robotics and artificial intelligence competitions.

2.3.3. Comprehensive Resource Support System

The specialized medical AI imaging laboratory provides 7 accessible GPU computing resources and standardized anonymized public medical imaging datasets. Meanwhile, professional faculty supervisors offer whole-process continuous academic and technical guidance covering algorithm debugging, system deployment, and competition defense optimization.

2.3.4. Achievement Feedback Mechanism

This study builds a closed-loop achievement feedback mechanism that integrates award-winning algorithms and mature engineering practice cases into the question bank of foundational medical AI practical courses and iteratively updates in-class hands-on training projects.

2.4. Step 3: Empowering Education through Provincial/Ministerial-Level and Higher Research Projects

Based on high-level research projects undertaken by the teaching team, including programs supported by the National Natural Science Foundation of China (NSFC) and Hubei Provincial Natural Science Foundation, this study constructs an undergraduate-oriented research penetration mechanism to enable undergraduates' access to frontier scientific research resources. This mechanism provides solid core resource and technical support for students' participation in academic competitions and large-scale innovative training projects.

2.4.1. Opening Access to Research Resources

The teaching team opens full access to self-developed core research resources for undergraduates, including original algorithm frameworks covering limited-angle CT reconstruction[7], photon-counting imaging[8], and self-supervised denoising[9], multi-modal clinical imaging datasets, and independently patented imaging experimental systems.

2.4.2. Implementation of the Undergraduate Research Assistant Program

This study launches a standardized Undergraduate Research Assistant Program. The reform measures include the configuration of specialized student research workstations, systematic guidance for undergraduates to participate in medical image annotation, algorithm simulation, and controlled experimental verification, and priority authorization for students to explore frontier research topics for academic competitions and large-scale innovative training projects.

2.4.3. Promoting the Educational Transformation of Scientific Research Outcomes

This study realizes the educational transformation and iterative application of scientific research achievements. Authorized CT reconstruction invention patents and formally published SCI-indexed simulation protocols are fully transformed into high-quality classroom teaching cases and competitive innovation framework resources.

2.5. Step 4: Incubation of Innovation Outcomes from Undergraduate Innovation and Entrepreneurship Training Program Projects

This study proposes a novel three-dimensional project screening and incubation model integrating fundamental competencies, mature competition-derived solutions, and disciplinary research sub-projects. This hierarchical mechanism supports the tiered cultivation of high-level innovation projects at the university, provincial, and national levels.

2.5.1. Tiered Topic Selection Approach

School-level innovation projects are tailored for junior undergraduates, focusing on the practical implementation of fundamental medical image processing algorithms. In contrast, provincial and national high-level projects are designed for middle and senior undergraduates, which build upon validated competition achievements and provincial/ministerial research sub-projects to develop integrated intelligent medical image diagnostic systems.

2.5.2. Tripartite Collaborative Mentorship System

This study establishes a tripartite collaborative mentorship system consisting of university algorithm researchers, radiologists from top-tier tertiary hospitals, and professional engineers from medical device enterprises. The joint multi-party guidance fully covers the whole industrial chain of algorithm design, clinical demand verification, and translational product development.

2.5.3. Hardware and Computing Power Support

The specialized medical AI laboratory provides students with full-time free access to professional GPU workstations and dedicated medical imaging simulation software to support high-efficiency algorithm training and experimental verification.

2.5.4. Project Achievement Handover Mechanism

Complete system prototypes, standardized development documents, and validated comparative experimental data derived from undergraduate innovation projects are retained and reused as core supporting materials for subsequent clinical trial verification and undergraduate dissertation research.

2.6. Step 5: Clinical Application Validation of AI-Generated Imaging Results

Through in-depth cooperation with local high-level tertiary hospitals and medical technology enterprises, this study establishes a university-hospital-enterprise collaborative training and practice base to conduct systematic clinical validation of medical imaging AI innovative achievements. This mechanism completes the key missing link in the full-cycle closed-loop talent cultivation system and realizes the end-to-end implementation of innovative training outcomes.

2.6.1. Medical-Enterprise Collaborative Mechanism Establishment

This study formulates long-term strategic cooperation agreements focusing on clinical data sharing and standardized clinical trial verification, and co-constructs a specialized university-hospital-enterprise integrated practical training platform.

2.6.2. Standardized Clinical Iteration Process

Based on mature AI lesion detection and low-dose CT reconstruction systems derived from undergraduate STEM innovation projects and academic competition achievements, this study adopts authentic clinical data for practical deployment. Physicians' professional evaluation and feedback are systematically collected to support iterative algorithm optimization and performance improvement.

2.6.3. Clarified Technology Transfer Pathway

This study realizes industry-university technological docking by integrating mature medical imaging AI prototypes with enterprise engineering resources to promote standardized product prototype development. Such translational practices generate standardized clinical trial reports and utility model patent innovation proposals.

2.6.4. Standardized Clinical Data Repository Construction

This study establishes a standardized clinical data and experimental resource repository, which takes validated clinical imaging samples, professional physician assessment reports, and comparative algorithm iteration experimental data as core empirical supporting evidence for undergraduate dissertations.

2.7. Step 6: Production of Provincial Outstanding Bachelor's Degree Theses and Closed-loop Feedback

By synthesizing multi-dimensional empirical materials accumulated throughout the first five cultivation stages, including curriculum learning outcomes, competition practices, scientific research data, innovative project achievements, and clinical experimental records, this study constructs a full-process supportive system for undergraduate dissertation compilation. Furthermore, excellent provincial-level dissertations are retrospectively integrated into foundational teaching resource banks, ultimately closing the whole iterative educational loop of the six-dimensional cultivation framework.

2.7.1. Multi-dimensional Sourcing of Thesis Research Materials

The research materials for undergraduate dissertations are collected from diversified and systematic sources, including experimental records from mathematical programming courses, complete competitive deliverables from AI innovation competitions, simulation data from provincial and ministerial research projects, standardized development documents from large-scale undergraduate innovation projects, and authoritative hospital clinical test reports. Dissertation writing requires the organic integration of theoretical derivation, algorithm implementation, engineering practice, and clinical validation, effectively avoiding the limitations of single theoretical-oriented writing modes.

2.7.2. Construction of Talent Cultivation Closed-loop Feedback Mechanism

This study constructs a sustainable closed-loop feedback mechanism for talent cultivation. Relying on mature innovative engineering cases and standardized full-process development practices summarized from provincial-level outstanding undergraduate dissertations, this study builds a standardized project resource pipeline for the AI + Medical Imaging Innovation Project Practice curriculum. These high-quality empirical resources are applied to the iterative updating of teaching cases for core courses including Machine Learning and Its Applications and re-integrated into the foundational medical AI teaching system, realizing the continuous optimization and iterative upgrading of the entire six-dimensional talent cultivation framework.

2.8. Teaching Reform Implementation Cycle

This teaching reform practice is implemented in two progressive phases to ensure the standardized, systematic, and iterative development of the six-dimensional closed-loop talent cultivation system.

Phase I (September 2024–August 2025): Foundation Construction Stage–This stage focuses on foundational system development and initial resource deployment, including constructing a hierarchical curriculum system covering mathematical fundamentals and computer programming, establishing systematic training teams for medical AI academic competitions, opening full-scale undergraduate participation channels for provincial and ministerial research projects, and launching the first batch of standardized undergraduate innovation and entrepreneurship training projects.

Phase II (September 2025–August 2026): Clinical Iteration and Model Summary Stage–This progressive implementation stage further deepens university-hospital- enterprise integrated clinical collaborative cooperation, carries out phased batch clinical validation trials for self-developed medical imaging AI systems, and adopts the established six-dimensional closed-loop cultivation framework to guide the compilation of high-level provincial undergraduate dissertations. Finally, this study systematically summarizes and refines the complete operational mechanism of the proposed closed-loop talent cultivation system.

3. Results of Reform Implementation

3.1. Remarkable Achievements in Foundational Teaching of AI Mathematical Programming

By implementing the hierarchical and interdisciplinary integrated curriculum construction strategy proposed in this reform, this study systematically remediates undergraduates' deficiencies in algorithmic understanding and practical coding development capabilities. A total of two provincial first-class offline courses, namely Medical Image Processing and Medical Imaging Instruments, together with a standardized virtual simulation teaching course, have been successfully constructed. Massive open online courses (MOOCs) developed based on the Rain Classroom platform have covered 1,898 on-campus and off-campus students. Furthermore, the teaching team has compiled a series of supporting textbooks covering mathematics, physics, and programming fundamentals, which have been officially adopted as designated teaching materials for medical-engineering interdisciplinary programs by multiple provincial universities.

3.2. Fruitful Outcomes in Robotics and Artificial Intelligence Competitions

Following the implementation of the standardized hierarchical competition training mechanism, undergraduate students have participated in a wide range of medical imaging, artificial intelligence, and robotic innovation competitions over the past five years. These participations have yielded over 10 national-level honors and more than 20 provincial-level awards. All competition projects are developed based on authentic clinical application scenarios, covering core research directions including CT image reconstruction and medical lesion segmentation. Compared with the pre-reform stage, competition entries have achieved substantial improvements in algorithmic integrity and engineering practicability. Such high-quality competition achievements have become the core topic source for undergraduate innovation and entrepreneurship training projects.

3.3. Effective Empowerment of Undergraduate Education via Provincial and Ministerial-Level Research Projects

High-level research resources derived from national and provincial scientific research projects, including programs supported by the National Natural Science Foundation of China (NSFC) and Provincial Natural Science Foundation, provide sustainable open access to specialized algorithm frameworks and standardized clinical imaging datasets for undergraduates. A considerable number of undergraduate students have participated in the application of invention patents and utility model patents focusing on CT imaging technology, and one undergraduate student has successfully published an SCI-indexed academic paper as a participating author. These outcomes fully verify that frontier scientific research resources can strongly underpin the innovative design and development of academic competition works and undergraduate innovation and entrepreneurship projects.

3.4. Significant Improvement in the Quality of Undergraduate Innovation and Entrepreneurship Projects

During the implementation of the six-dimensional closed-loop teaching reform, a total of two national-level undergraduate innovation and entrepreneurship training projects have been successfully approved and funded. All sponsored projects focus on the research and development of intelligent medical imaging systems driven by artificial intelligence technologies, with project topics originating from validated competition achievements and disciplinary research sub-projects. In terms of project integrity and industrial practicality, these reform-era projects have achieved remarkably better performance than the purely theory-dependent projects adopted in the pre-reform period.

3.5. Real-World Clinical Implementation of AI-Driven Imaging Innovation Achievements

Multiple sets of low-dose CT reconstruction and intelligent lung nodule detection systems independently developed by undergraduates have completed pilot verification based on authentic clinical imaging datasets. Preliminary experimental results demonstrate that partial algorithm prototypes outperform existing mainstream conventional methods, effectively realizing the translational transformation of classroom-based algorithm programming achievements to practical clinical applications.

3.6. Consistent Production of Provincial-Level Outstanding Bachelor's Degree Theses

Based on multi-dimensional empirical resources including experimental data, competition practices, and clinical research records accumulated from the full-cycle six-dimensional closed-loop cultivation system, this reform has yielded five outstanding undergraduate dissertations in Hubei Province within five consecutive years. These high-quality dissertations cover complete research dimensions involving mathematical derivation, independent algorithm development, innovative competition practice, and clinical translational validation. Such exemplary academic achievements are iteratively integrated into the practical teaching resource bank of foundational medical AI courses, further consolidating the sustainable iterative closed-loop educational mechanism of the talent cultivation framework.

3.7. Achievements in Teaching Reform Demonstrations and Faculty Development

The principal investigator of this study has presided over one provincial teaching reform project and two industry-university collaborative talent cultivation projects approved by the Ministry of Education. The six-dimensional closed-loop talent cultivation model proposed in this research has been fully implemented and piloted across four undergraduate majors, namely Intelligent Medical Engineering, Biomedical Engineering, Medical Imaging, and Medical Information Engineering. In addition, the standardized curriculum resources and systematic cultivation framework are planned for open sharing with peer higher education institutions in Hubei Province, including Hubei University of Medicine and Three Gorges University, which verifies the excellent regional promotion value and practical applicability of the proposed reform model.

4. Conclusion

4.1. Research Summary

This study constructs a full-cycle six-dimensional closed-loop talent cultivation framework covering six core progressive modules: fundamental AI mathematics and programming literacy, systematic robot and AI competition training, research empowerment via provincial and ministerial-level projects, large-scale innovative project incubation, clinical translational validation of technical outcomes, and the cultivation of high-quality provincial-level undergraduate dissertations. The proposed framework achieves seamless integration of the entire undergraduate cultivation chain from basic knowledge acquisition to graduation project completion. All cultivation stages feature interconnected resource allocation and mutually reinforcing outcome iteration, effectively resolving three core bottlenecks in conventional medical engineering teaching: stage-wise fragmentation of teaching content, insufficient transformation efficiency of innovative research achievements, and inadequate output of high-quality academic theses. Two-year practical implementation of the educational reform verifies that this closed-loop framework is capable of standardized and systematic cultivation of high-caliber interdisciplinary talents specialized in medical artificial intelligence and imaging engineering.

4.2. Core Innovation Points

4.2.1. Full Closed-Loop Integrated Education Innovation

This innovative educational paradigm integrates six originally isolated and fragmented educational modules, including AI mathematical programming literacy, robot and AI competition training, provincial and ministerial-level research empowerment, large-scale innovative project incubation, clinical translational verification, and high-quality undergraduate dissertation cultivation, into an organic cyclic linkage system. In this framework, early-stage cultivation links provide sufficient innovative foundations and practical resources for subsequent progressive training, while final-stage academic and practical outcomes realize effective backward feeding into fundamental teaching sessions. Such bidirectional interactive logic supports the sustainable iteration and dynamic optimization of the whole medical AI talent cultivation model.

4.2.2. High-Level Undergraduate Research-Driven Innovation

This educational initiative breaks the long-standing institutional barrier of graduate-dominated high-level research resource access. By fully opening self-developed original algorithms and standardized clinical imaging datasets from national, provincial and ministerial-level research projects to undergraduates, this reform fundamentally resolves the core bottleneck that restricts undergraduate innovative practice, namely the inadequate access to frontier research resources and technical supports.

4.2.3. Clinical Application-Oriented Outcome Validation Mechanism

This reform establishes a clinical practice-oriented outcome evaluation system, which takes real-world clinical and industrial application scenarios as the core validation criterion for innovative achievements. By assessing the practical applicability and translational value of competition works and large-scale innovative projects through authentic practical scenarios, this mechanism effectively eliminates the prevalent drawback of isolated theoretical simulation research, preventing innovative outputs from deviating from actual clinical demands and practical application scenarios.

4.2.4. Thesis-Driven Closed-Loop Sustainable Education Mechanism

This study takes high-quality undergraduate dissertations as the comprehensive integration and output platform of the full-cycle cultivation system. It systematically integrates whole-process theoretical learning, competitive practice, and scientific research outcomes to support the completion of high-standard graduation theses. Meanwhile, excellent thesis achievements realize the iterative renewal and cyclic optimization of core teaching resources, ultimately constructing a stable, long-term and sustainable medical AI talent cultivation mechanism.

4.3. Existing Shortcomings and Optimization Directions

Despite the promising performance of the proposed full-cycle closed-loop cultivation framework, this study still has several inherent limitations. First, the reserve and accumulation of multimodal imaging datasets targeting rare medical diseases are insufficient, restricting the generalized training and robust verification of medical AI algorithms. Second, emerging cutting-edge teaching modules covering medical large language models and photon-counting CT technology remain incomplete and require systematic expansion and iteration. Third, the team of full-time interdisciplinary teaching faculty is relatively understaffed, and the long-term normalized teaching mechanism with joint participation of clinical physicians and industrial engineers lacks standardized institutional constraints and systematic refinement.

To compensate for the above limitations and further improve the sustainability and comprehensiveness of the cultivation system, this study proposes a systematic subsequent optimization and development roadmap. First, expand the scale of multi-category desensitized clinical imaging databases and enrich rare disease dataset resources to support generalized algorithm training and verification. Second, develop and launch specialized advanced courses focusing on multimodal medical large models and frontier CT imaging technologies to update the existing curriculum system. Third, further construct university-enterprise-medical integrated joint laboratories and standardize the long-term three-mentor guidance mechanism composed of full-time teachers, clinical physicians, and industrial engineers. Fourth, establish a provincial medical-engineering interdisciplinary teaching alliance to popularize and promote the innovative closed-loop cultivation model proposed in this research. Fifth, optimize the process-oriented multi-dimensional talent evaluation system by integrating multiple assessment indicators, including academic competition achievements, undergraduate innovation and entrepreneurship training projects, and clinical practical performance, into the comprehensive curriculum evaluation framework.

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