

Exploration and Practice of Approaches to Fostering the Innovative Capacity of Medical Undergraduates via Open Laboratories: Based on the “4215” Model

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Abstract: *Against the macro background of constructing a high-quality education system during the 15th Five-Year Plan period, further advancing the Healthy China Strategy, and realizing the integrated development of education, science and technology, and talents, strengthening the cultivation of high-level innovative medical talents serves as a strategic fulcrum for supporting the high-quality development of regional health undertakings and consolidating the foundation of building a great modern socialist country. Local medical universities generally face practical obstacles in cultivating students' innovative ability via open laboratories, including inadequate open sharing of resources, insufficient coordination of management systems, weak teachers' ability in innovative guidance, and insufficient internal motivation of students for active exploration. This paper constructs and systematically elaborates the “4215” operation mode for open laboratories. Centered on building one multi-level collaborative feedback platform, the mode focuses on four stakeholders: university administrators, laboratory managers, teachers and students. It promotes two-way reform between the resource supply side and student demand side, and carries out five core supporting measures: precise supply and optimized sharing of resources, improvement of teachers' innovative guidance capacity, reconstruction of institutional standards for laboratory opening, incentives for students' inquiry-based learning, as well as full-cycle digital supervision, evaluation, feedback and continuous improvement. Consistent with the policy orientation of innovative development of medical education led by the New Medicine Initiative and the open sharing of university laboratories, this mode provides a theoretically profound and operable action framework for local medical universities to systematically improve medical undergraduates' innovative practical ability relying on open laboratories.*

Keywords: Open laboratory, Medical undergraduates, Innovative ability, The 15th Five-Year Plan.

1. Introduction

The 15th Five-Year Plan clearly proposes to integrate the development of education, science and technology, and talents, and regards the cultivation of innovative talents as the core support for the strategy of building a strong country in education and Healthy China [1]. It requires medical education to focus on the construction of the “New Medicine” and comprehensively strengthen the cultivation of practical and innovative abilities of medical students. Under this policy orientation, as a key platform connecting theoretical teaching and practical innovation, the operational efficiency of open laboratories directly determines the quality of innovation ability training for medical undergraduates, and has become an important starting point for local medical colleges to implement national strategies [2].

Existing studies mostly focus on comprehensive universities or key medical colleges, with insufficient attention paid to local medical colleges that undertake the main task of cultivating clinical medical talents for regional development. Such colleges generally face practical dilemmas such as insufficient resource supply, imperfect management systems, and weak innovative guidance ability of teachers. The traditional closed laboratory management model has seriously restricted the development of students' innovative abilities. Meanwhile, the 15th Five-Year Plan puts forward new requirements for regional coordinated development and independent talent cultivation, setting higher standards for the operation mode of open laboratories in local colleges.

Previous fragmented and single reform measures can no longer meet the needs of innovative talent training in the new era.

Based on the positioning and actual conditions of local medical colleges, this study closely follows the requirements of the 15th Five-Year Plan and the “New Medicine” construction. By systematically sorting out policies and practical paths of medical education reform, it focuses on solving key problems such as insufficient resource supply and inefficient management mechanisms, and promotes the precise connection between laboratory open supply and students' innovative demands. This study aims to provide a replicable and promotable practical plan for the cultivation of innovative abilities of medical undergraduates, so as to support the high-quality development of regional health care.

2. Core Problems of Open Laboratories Empowering Innovation Training in Local Medical Colleges

Against the background of high-quality development and innovation-driven strategy during the 15th Five-Year Plan period, the construction of “New Medicine” emphasizes interdisciplinary integration, coordination of education and research, and digital transformation. It requires open laboratories to transform from a single teaching space to an innovation ecological hub, whose efficient operation depends on the coordination of university planning, management

support, teacher guidance and student participation [3]. However, local medical colleges generally face structural dilemmas including insufficient hardware support, weak institutional guarantee, inadequate human resources, and dislocated participation of multiple subjects [4]. These interwoven problems form a systematic bottleneck restricting innovative talent cultivation. This paper analyzes the problems from four dimensions: resource supply, management system, teaching staff, and student guidance [5].

2.1 Insufficient Resource Supply and Limited Opening Conditions

Adequate hardware facilities and supporting services are the foundation for the efficient operation of open laboratories. Restricted by school-running level and resource conditions, local medical colleges generally suffer from long-term insufficient funding. Most experimental equipment is limited to basic verification experiments, and the construction of design-oriented, innovative and cutting-edge experimental platforms lags behind. Informatization construction is also underfunded, making it difficult to establish a unified resource sharing and intelligent management platform. Equipment reservation and consumable management still rely mainly on manual methods [6].

Multi-campus operation further aggravates the contradiction of resource allocation: the lack of a cross-campus resource coordination mechanism leads to the concentration of high-end equipment, while other campuses suffer from serious shortage of available experimental resources, resulting in coexistence of idleness and shortage [7]. The decentralized resource layout increases the difficulty and maintenance cost of informatization integration, making it harder for limited funds to be invested in digital construction [8]. The superposition of the above problems seriously weakens the basic capacity of open laboratories to support innovative talent training.

2.2 Imperfect Management System and Weak Operational Support

The prominent shortcomings at the management level are fragmented safety governance and lack of incentive and restraint mechanisms. In terms of safety management, laboratory access standards and safety regulations are inconsistent between the university and secondary colleges, with unclear responsibility boundaries [9]. The management of hazardous chemicals and emergency disposal lack overall planning, which not only brings potential safety hazards but also restricts the development of high-level exploratory experiments.

In terms of incentives and constraints, the workload of teachers participating in open laboratory guidance is not effectively included in performance assessment and professional title evaluation. Students' innovative achievements lack standardized recognition and credit conversion channels. Insufficient two-way incentives for teachers and students weaken their motivation for sustained participation, making it difficult for open laboratories to form

a sustainable and self-operating innovative practice ecosystem.

2.3 Unbalanced Structure of Teaching Staff and Insufficient Guidance Ability

The teaching staff faces three structural contradictions: First, unbalanced disciplinary structure: teachers in traditional clinical medicine and medical technology are relatively sufficient, while reserves in cutting-edge "New Medicine" fields such as precision medicine, translational medicine and medical-industrial integration are weak, making it difficult to support interdisciplinary innovative experiments. Second, unbalanced ability structure: there is a shortage of compound teachers with scientific research innovation ability, laboratory management ability and digital teaching ability. Third, unbalanced echelon structure: young and middle-aged backbone teachers are in short supply, experience inheritance from senior teachers is insufficient, and young teachers lack systematic innovative teaching training [10].

These contradictions directly lead to insufficient innovative guidance ability of teachers. Most teachers have limited ability in operating new experimental technologies and digital platforms, and cannot effectively guide students to carry out design-oriented and inquiry-based experiments. Facing medical-industrial and medical-science interdisciplinary projects, disciplinary barriers are obvious, and guidance on experimental scheme demonstration and achievement transformation is insufficient. Innovative practice is often superficial, making it difficult to achieve in-depth improvement of innovative abilities.

2.4 Low Student Participation and Unfulfilled Subject Role

The core reason for insufficient student participation is the lack of hierarchical guidance and personalized support. In the innovation enlightenment stage, a grade-based and major-based cognitive guidance system has not been established: junior students lack understanding of laboratory resources and participation channels, making it difficult to form awareness of active exploration; senior students have willingness to participate but lack systematic guidance from clinical problem extraction to experimental design, resulting in unclear participation directions.

In the process guidance stage, students' independently designed experimental schemes lack scientific demonstration and optimization [11]. When encountering technical difficulties, data analysis and result interpretation obstacles during implementation, they cannot obtain timely and effective guidance, leading to project stagnation. Such a situation of "insufficient enlightenment and absent guidance", coupled with imperfect evaluation and incentive mechanisms for innovative achievements, not only dampens students' enthusiasm for sustained participation but also makes it impossible for them to temper innovative abilities in solving practical problems, deviating from the core educational goal of open laboratories.

Table 1: Key challenges of open laboratories in local medical colleges and corresponding measures of the “4215” model

Dilemma Dimension	Core Problem Manifestations	Corresponding Measures of the “4215” Model
Resource supply	Insufficient funding, equipment aging, fragmented resources across multiple campuses, lagging informatization	Establish dedicated funds and industry–university collaborative co-construction; build an interdisciplinary resource sharing and intelligent scheduling platform
Management system	Fragmented safety regulations, absence of incentive and constraint mechanisms	Unify university–college safety classification standards; incorporate faculty guidance into title evaluation and appointment; implement credit recognition for student achievements
Faculty team	Triple mismatch in disciplinary structure, competency structure, and echelon structure; weak interdisciplinary guidance capacity	Form interdisciplinary mentor teams; carry out targeted training; establish an assessment mechanism linked to guidance effectiveness
Student participation	Absence of tiered guidance, insufficient process support, inadequate incentive and transformation mechanisms	Construct a tiered progression experimental project system; implement whole-process mentorship and an achievement scholarship system

3. Implementation Path of Open Laboratories Empowering Innovation Ability Under the “4215” Model

3.1 Connotation of the Model

The “4215” model is designed to systematically resolve the structural contradictions of open laboratories in local medical colleges concerning resources, management, teaching staff and student participation. Its framework can be summarized as follows: one multi-level collaborative feedback platform connecting four stakeholders including university authorities, management staff, teachers and students; two-way reforms promoting standardization on the supply side and precision on the demand side; supported by five measures covering optimization of resource supply, construction of teaching staff, improvement of institutional systems, incentives for student participation, and supervision, evaluation and guarantee [12]. Following the logic of “problem diagnosis – stakeholder linkage – supply-demand matching – iterative optimization”, the model aims to tackle practical dilemmas such as scattered resources, fragmented management, inadequate guidance and insufficient participation, so as to build an operable and sustainable innovative education system based on open laboratories.

3.2 Implementation Paths

3.2.1 Four Core Dimensions: Whole-chain Collaborative Education

To address separated management powers and insufficient coordination, the model carries out targeted governance from four dimensions: university, management, teachers and students. At the university level, focusing on cutting-edge fields such as precision medicine and intelligent medicine, the university coordinates the allocation of interdisciplinary sharing platforms and large-scale instruments to break resource barriers. At the management level, one-stop online approval and inter-departmental linkage among academic affairs, scientific research departments and experimental centers are implemented. A supervision system oriented by resource utilization rate and transformation rate of innovative achievements is established to guarantee smooth operation of the whole chain. At the teacher level, interdisciplinary guidance teams are set up to build an experimental project database connecting clinical demands and research frontiers [13]. The tutorial system is adopted to realize scheme demonstration, technical guidance and data interpretation. At

the student level, students conduct experiments independently following the procedure of “independent topic selection – interdisciplinary team formation – scheme demonstration – practical verification”, so as to realize coordinated improvement of innovative thinking and research literacy.

3.2.2 Two Reforms: Precise Matching Between Supply and Demand

In response to the dual contradictions of insufficient resource supply and mismatched demands, simultaneous reforms are advanced to realize standardization on the supply side and hierarchical adaptation on the demand side. On the supply side, interdisciplinary instruments and consumable resources are integrated; full-process specifications for reservation, utilization and maintenance are formulated; systems for safety management and quality control of innovative experiments are improved. Visualized allocation of resources is realized relying on the digital platform. On the demand side, in accordance with the progressive development law of innovation ability, freshmen and sophomores receive innovation enlightenment, juniors strengthen design practice, and seniors focus on tackling innovative problems [14]. Characteristic experimental modules are customized for different majors including clinical medicine, public health and medical technology. Standardized supply guarantees basic operational conditions, while demand precision provides directions for supply optimization, breaking the low efficiency of traditional one-way matching mode.

3.2.3 One Feedback Platform: Closed-loop Dynamic Optimization

To solve the problem of delayed operation information, a multi-level collaborative feedback platform is constructed to form a closed loop of “collection – processing – optimization – evaluation”. At the collection terminal, online modules, regular surveys, teaching research forums and special interviews are adopted to continuously collect information on the adaptability of experiments for students, accessibility of teachers’ guidance, bottlenecks in interdisciplinary collaboration and clinical innovation demands. At the processing terminal, a special group consisting of teaching administrators, academic leaders and technical backbones sorts out collected information by category and sets priority levels [15]. Routine problems are required to be responded within a time limit, while complex issues are solved through inter-departmental joint consultation. At the optimization terminal, dynamic adjustments are carried out accordingly: additional tutors or special training are arranged to make up

insufficient guidance; experimental projects are updated based on clinical feedback; resource allocation is restructured according to usage data. At the evaluation terminal, follow-up surveys and monitoring are used to verify optimization effects,

and evaluation results are incorporated into the next round of iteration to continuously improve the matching degree between the open laboratory system and talent training demands.

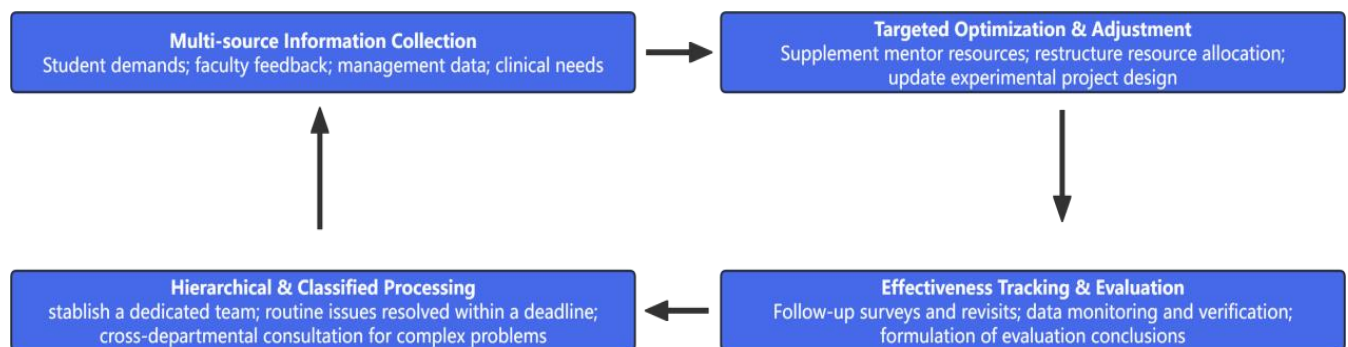


Figure 2: Closed-loop operation mechanism of open laboratory empowering innovation cultivation

3.2.4 Five Guarantee Measures: Foundation for Long-term Operation

The five measures provide systematic support for the operation of the model. Resource supply guarantee: set up special funds, expand university-enterprise collaborative construction, integrate interdisciplinary resources and build an intelligent scheduling platform to realize precise allocation of resources. Teaching staff guarantee: organize interdisciplinary training and teaching seminars, incorporate the effectiveness of innovative guidance into assessment and incentive mechanisms to stimulate teachers' initiative. Institutional system guarantee: improve regulations covering laboratory safety management, open operation and recognition of innovative achievements, clarify power and responsibilities between the university and colleges, and formulate norms for inter-departmental collaboration. Student participation guarantee: implement procedural credit recognition and scholarships for innovative achievements to provide developmental support and form a virtuous cycle of "participation – incentive – growth". Supervision and evaluation guarantee: establish a full-process and multi-dimensional evaluation system. Periodic evaluation is carried out based on comprehensive feedback from teachers, students and clinical practice. Evaluation results are linked to resource allocation and faculty assessment to ensure continuous improvement of the model.

4. Conclusion

The core objective of the "4215" open laboratory operation model is to respond to the overlapping demands for medical education reform raised by the training of top-notch innovative talents proposed in the 15th Five-Year Plan and the construction of the New Medicine initiative. It aims to tackle structural problems including scattered resources, fragile mechanisms and low efficiency existing when traditional open laboratories are used to foster undergraduates' innovative ability. Theoretically, the model breaks the limitation of single-dimensional support in previous studies. Taking the whole-chain coordination of resources, faculty, institutions, incentives and evaluation as the logical thread, it expands the analytical framework for guarantee mechanisms of innovative talent cultivation in medical education. Practically, designs such as university-enterprise collaborative resource supply, faculty incentives linked with

professional title evaluation, and student participation channels supported by credit conversion offer transferable operational schemes for universities to implement innovative training via open laboratories, highlighting the education orientation featuring interdisciplinary integration, emphasis on practice and achievement transformation. Further exploration can be carried out in three directions in the future. First, technological empowerment: construct an intelligent monitoring platform for open laboratories based on artificial intelligence and big data, so as to promote precise iteration of resource allocation, demand matching and efficiency evaluation. Second, cross-regional collaboration: boost the co-construction and sharing of innovative training resource pools among universities, research institutes and pharmaceutical enterprises to alleviate regional resource imbalance and expand the model's radiation scope. Third, optimization of long-term mechanisms: keep track of the implementation of the 15th Five-Year Plan and trends of medical education reform, continuously improve the dynamic adjustment mechanism of supporting measures, strengthen the transformation of innovative achievements into clinical applications, and realize deeper alignment between the cultivation of medical undergraduates' innovative ability and the Healthy China Strategy.

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References

- [1] Ministry of Education of the People's Republic of China. Launch Conference of "Six Excellence and One Top-Tier Program 2.0" Held: Sparking a Quality Revolution in Higher Education to Support the Building of Quality China [EB/OL]. (2019-04-29) http://www.moe.gov.cn/jyb_zzjg/huodong/201904/t20190429_380009.html.

- [2] Ministry of Education, National Health Commission of the People's Republic of China, National Administration of Traditional Chinese Medicine. Opinions on Strengthening the Integration of Medical Education and Clinical Practice to Implement the Outstanding Doctor Education and Training Program 2.0 [J]. Gazette of the Ministry of Education of the People's Republic of China, 2018(10):16-19.
- [3] Guo Rui, Kou Mingzhen, Wei Yihan, et al. Building a New Medical Science Innovation and Entrepreneurship Education System under the "Trinity" Model: A Case Study of Tianjin Medical University [J]. Theory Research and Practice of Innovation and Entrepreneurship, 2022, 5(17):75-79+94.
- [4] Zhang X, Wang XL, Qi CJ, et al. Research on Teaching Methods of Sanitary Microbiology Experiment Course under the Background of New Medical Disciplines [J]. Health Vocational Education, 2022, 40(10): 81-83.
- [5] Wang, H. Y., Sun, H. T., & Zhu, B. L. (2021). Exploration on the application of "progressive open laboratory project" in scientific research and innovation training of medical students. Medical Education Research and Practice, 29(5), 667-671. <https://doi.org/10.13555/j.cnki.c.m.e.2021.05.005>
- [6] Li N, Xiao YL, Xu HY, et al. Professional-oriented, interdisciplinary integration, industry-education and ideological-political empowerment: Student-centered smart teaching reform and practice of basic medical courses—A case study of Zhengzhou College of Health [J]. China Educational Technology & Equipment, 2026, (10): 63-69+73.
- [7] Li X, Sun HY, Du ZW, et al. Exploration on the Reform Direction of Traditional Teaching Concepts in the Era of Medical Big Data [J]. International Journal of Geriatric Medicine, 2026, 47(3): 389-392.
- [8] Li ZX, Wu JR, Zhuang Q, et al. Exploration and Reflection on Evidence-Based Medicine Teaching for Practical Training of Scientific Research Ability of Medical Undergraduates under Five-Dimensional Paradigm [J]. New Medical Knowledge, 2026, 36(4): 479-486.
- [9] Gao XM, Xu DJ, Zhu Y, et al. Teaching Reform and Practice of Integrating the Collaborative Training Concept of Innovative Talents into Medical Experiment Courses [J]. Disease Prevention, Treatment and Rehabilitation, 2026, 27(4): 290-294.
- [10] Liu C, Lu FG, Hu J. Strategies and Reflections on Intelligent Upgrade of National First-Class Online Courses Empowered by AI: A Case Study of Basic Immunology and Pathogenic Biology [J/OL]. Chinese Journal of Immunology, 1-11 [2026-08-11]. <https://link.cnki.net/urlid/22.1126.R.20260416.0907.002>.
- [11] Wu R, Peng N. Current Situation Analysis and Reform Exploration of Career Planning and Employment Guidance Courses in Medical Colleges — A Case Study of Medical College A in Shanghai [J]. Scientific Consult, 2026, (8): 95-99.
- [12] Zhu YN, Wang G, Feng Y, et al. Discussion on Open Sharing Management of University Laboratories under the Background of Emerging Engineering Education [J]. Laboratory Testing, 2026, 4(10): 136-138.
- [13] Shi Y, Yang WZ, Huang QG, et al. Research on Educational Effectiveness of Laboratory Open Sharing Mechanism [J]. Research and Exploration in Laboratory, 2026, 45(5): 211-217. DOI:10.19927/j.cnki.syyt.2026.05.034.
- [14] Zhao SQ, Feng LS, Bi DM, et al. Current Situation and Countermeasures of the Construction of University Laboratory Open Platform [J]. Western Quality Education, 2026, 12(1): 182-185. DOI:10.16681/j.cnki.wcqe.202601041.
- [15] Dai JH, Wang X, Su ZH, et al. Research on Innovative Paradigm of University Laboratory Opening and Sharing Empowered by Digital Twin [J]. Technology Wind, 2026, (1): 143-145+155. DOI:10.19392/j.cnki.1671-7341.202601046.

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