

Classroom Exploration of General Education in Emerging Medical Sciences from a Positivist Perspective

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Abstract: In the year 2021, the institution introduced The Logic of Discovery as a general education course in the medical sciences curriculum. The course adopts a positivist epistemology, tracing the historical development of pharmacological discoveries, starting with Shennong's investigation of plants for medicinal use and concluding with intelligent pharmaceutical development, with the objective of promoting the medical student's ability to integrate and innovate across disciplines. The chapter Evidence-based medicine: Transforming the black box of drug mechanisms into a white box, represents a pivotal point in the course structuring, allowing for conceptual continuity between preceding and subsequent modules. The training utilized the historical development of diagnosis and treatment of diabetes as an integrated case study, which linked the journey of traditional empirical medicine to modern evidence-based practice. Using an exploratory, evidence-seeking pedagogical orientation, elements of civic-ethical education and the medical humanities were integrated to construct problem-based learning (PBL) instructional pathway of historical tracing-logical deconstruction-competency immersion-translational application. This facilitated cultivation of core competencies among medical students through systematic classroom practice and inquiry.

Keywords: Positivism; Medical Education; Core Competencies; Classroom Teaching

1. Introduction

To support the national agenda of reforming medical education towards interdisciplinary integration ("new medical sciences"), the

institution started in 2021 a general education course entitled The Logic of Discovery. It is for first-year undergraduates of all medical and health-related majors. Using a positivist epistemological lens, the course examines pharmacological discovery from Shennong's empirical use of herbal medicines to intelligent drug development. A problem-based approach is adopted to promote students' capacity for innovative, multidisciplinary thinking [1]. The chapter of "Evidence-Based Medicine: From a Black Box to a White Box Explanation of Drug Action" is a crucial linking pin in a course that connects basic and advanced inquiry. They applied this approach in the classroom. The design of the instruction was consistent with the course objectives. We choose the historical evolution of the diagnosis and treatment of diabetes as a case integrator. The story arc incorporates educational elements into learning and experience. Logical reasoning, innovative inquiry, civic-ethical values and humanistic competencies can be these. Through systematic unification, a new educational model is born. This model aims to develop the professional qualities one expects of a physician in the era of new sciences.

2. Uncovering the Medical Philosophy and Core Values Embedded in Course Materials

This module revolves around the overall theme "From Black Box to White Box-Evidence-Based Medicine." The course uses the historical evolution of diabetes mellitus as a narrative framework. Through this framework, it systematically draws out the medical ethos and core values embedded in the field. These values reflect the transition from a "black box" to a "white box" model.

2.1 From Intuitive Observation to Scientific

Empiricism

The medical understanding of diabetes has evolved over millennia. Ancient civilizations left convergent observational records. The Ebers Papyrus (c. 1500 BCE) describes "flesh melting into urine." The Huangdi Neijing characterizes "xiao-ke" (wasting-thirst). These represent an era of intuitive disease characterization. The trajectory later advanced through key figures.

Wang Tao of the Tang Dynasty conducted empirical urine tasting. Eugene Opie elucidated islet pathology. Frederick Banting ultimately extracted insulin. These successive milestones gradually established an understanding of how diabetes is caused by lack of insulin, taking it to the cognitive leap between a "black box" and a "clear box".

Table 1. Lesson Plan Overview: "Evidence-Based Medicine: Transforming the Black Box of Drug Mechanisms into a White Box"

Development Stage	Core Content	Key Figures /Events	Techniques /Methods	Breakthrough Points from Black Box to White Box	Logical Essence
Black-Box Exploration (Ancient Times-17th Century)	1. Observation of clinical manifestations; 2. Etiological speculation; 3. Attempts at symptomatic treatment	<i>Huangdi Neijing</i> ; Ebers Papyrus; Zhang Zhongjing; Sun Simiao; Wang Tao; Zhen Liyan	1. Sensory observation; 2. Empirical trial-and-error	1. Clarification of core symptoms of xiao-ke (wasting-thirst disorder) and the characteristic of sweet urine; 2. Establishment of a preliminary symptom-intervention association (e.g., sugar restriction, herbal formulas); 3. Elimination of the "sugar supplementation" misconception and establishment of dietary therapy as the treatment direction	Experience-based induction grounded in phenomenological observation, with effectiveness verified through trial-and-error, without penetrating the essential nature of the disease.
Black-Box Deconstruction (18th-19th Century)	1. Elucidation of the relationship between urinary glucose and blood glucose; 2. Anatomical localization of the affected organ (pancreas); 3. Exploration of functional pancreatic compartments	Matthew Dobson (1776); von Mering & Minkowski (1889); Eugene Opie (1901)	1. Willis's urine glucose detection; 2. Blood glucose measurement; 3. Animal experimentation (pancreatectomy); 4. Microscopic anatomical observation	1. Advancement beyond the understanding of "sugar solely in urine" to the discovery of the blood glucose-urinary glucose nexus; 2. Establishment of a direct causal link between the pancreas and diabetes mellitus; 3. Distinction between exocrine and endocrine (islet) pancreatic functions	Transition from "symptom correlation" to "organ localization," with causal relationships experimentally verified, and the scope of the black box progressively narrowed.
White-Box Foundation (Early 20th Century-1920s)	1. Extraction of insulin; 2. Validation of clinical insulin efficacy; 3. Scaled insulin production	Banting, Best, Macleod, and Collip (1921-1922); Eli Lilly & Company	1. Pancreatic extraction and purification techniques; 2. Clinical controlled trials; 3. Isoelectric precipitation (enhanced stability)	1. Definitive elucidation of the core etiology of diabetes: islet dysfunction leading to insulin deficiency; 2. Identification of a targeted therapeutic agent (insulin); 3. Achievement of a closed loop from "etiology" to "treatment"	Transition from "organ function" to "molecular substance" with key molecules isolated through experimentation, the essential nature of the disease clarified, therapeutic targets identified, and the black box fully opened

White-Box Deepening (Mid-20th Century-Present)	1. Elucidation of insulin molecular structure and mechanism of action; 2. Subclassification of diabetes mellitus; 3. Development of optimized therapeutics, such as human insulin and oral hypoglycemic agents; 4. Revelation of insulin resistance mechanisms	Frederick Sanger (1958 Nobel Prize); Chinese bovine insulin synthesis team (1960s); Harold Himsworth (1936); Metformin research team	1. X-ray diffraction (molecular structural analysis); 2. Genetic engineering (human insulin synthesis); 3. Molecular biology (receptor signaling pathway research)	1. Advancement from "knowing insulin exists" to "elucidating its structure and mechanism of action"; 2. Differentiation between "insulin deficiency" and "insulin resistance," enabling precision subclassification and targeted treatment; 3. Therapeutic development evolving from "extraction" to "rational design" (genetically engineered insulin, targeted hypoglycemic agents)	Transition from "substance identification" to "mechanistic clarity," with precision quantification and molecular technologies achieving full elucidation of the disease mechanism-therapeutic agent chain
White-Box Expansion (Modern Era)	1. Personalized precision treatment; 2. Exploration of curative regimens, such as stem cell therapy; 3. Scientific validation of traditional Chinese medicine theory, such as meridian channels	Frederick Sanger; Arnold Caplan; Semyon Kirlian	1. Genetic testing technologies; 2. Stem cell therapy technologies; 3. Functional magnetic resonance imaging, biophysical property detection, and Kirlian photography for meridian validation	1. Realization of individualized precision treatment; 2. Exploration of curative strategies targeting the root etiology (islet cell regeneration); 3. Integration of traditional medicine with modern technology, expanding the multi-dimensional explanatory scope of the white box	Transition from "universal treatment" to "precision cure," with interdisciplinary technological convergence continuously enriching the depth and breadth of the white box and progressively refining the disease diagnosis and treatment system

The historical development of medicine demonstrates that medical knowledge is achieved through an ongoing process of transformation. Furthermore, during this development, that which was observed led to hypothesis formation. These hypotheses were then tested through interaction with experimental evidence so that a form of verification could take place. (an outline of the lesson plan is given in Table 1). The most important driving force for medical discovery is an epistemology founded on positivism, along with a constantly accelerating technological development.

2.2 From Empirical Induction to Scientific Critical Inquiry

The objective of both traditional empirical medicine and modern medicine is to make clear the essence of the disease. While traditional medicine relied on empiric induction from phenomenological observation, modern medicine demonstrates a verification from phenomenological correlation through

mechanistic explanation to technological application by establishing causal linkages between pancreatectomy and diabetes symptoms, precise anatomical localization of islet function via microscopy, and ultimately the obtaining, purifying, and genetic engineering of insulin. Similarly, the discovery of oral hypoglycemic agents—from goat's rue (*Galega officinalis*) to the "miracle drug" metformin, and from the fortuitous hypoglycemic side effects of sulfonamide antibiotics to the development of sulfonylurea agents—vividly illustrates the dialectical interplay between serendipity and inevitability in scientific discovery, guiding students to develop cognitive competencies in opportunity recognition, rational analysis, and principal extraction.

2.3 Humanistic Competencies and Cultural Confidence

The spirit of "the benevolent heart of the physician" (yi zhe ren xin) present in Sun Simiao's attitude in traditional Chinese medicine, is reminiscent of the nobility of Frederick

Banting and his colleagues, who gave away the patent of insulin for the good of man, helping millions of diabetes mellitus patients all over the world. The fact that insulin can restore life demonstrates that medical technology possesses an important humanistic value. In addition, the concepts of meridians and acupoints in traditional Chinese medicine were very often referred to as a black box. However, white box verification of these concepts has been achieved by Kirlian photography and MRI. To sum up, the historical progress of the diagnosis and treatment of diabetes is rich in the humanistic spirit and cultural value [2,3].

3 Classroom Practice of General Education Philosophy in Emerging Medical Sciences

The educational framework based on the inherent principles of medical education and the project authenticity professional development will help to realize the competence of a medical student through civic-ethical education, innovative thinking, logic and humane literacy. The educational route is aimed to enhance the imparting of knowledge while simultaneously forming competencies, bringing together scientific rigor and humanistic sentiment, historical view and contemporary relevance systematically cultivating the basic capabilities necessary for the subsequent professional evolution of medical students [4].

3.1 Integration of Civic-Ethical Education

Civic-ethical education is organically embedded in classroom instruction. It ensures the natural infusion of guidance about the value. An impressive example can be found in insulin extraction and production. Banting, along with his associates, gave up their patent rights. The decision universalized their insulin amongst diabetics all over the. This story showcases scientist's dedication to mankind. It also emphasizes their corporate social responsibility. In 1965, another milestone was achieved with the synthesis of bovine insulin by Chinese scientists. This strengthened China's confidence in scientific innovation. The nation's commitment to research was similarly demonstrated. The use of integrated Chinese and Western medicine has helped diabetes. This evidence-based confidence builds students' cultural capital. It also strengthens their mind inclusivity. Stem cell transplantation is an upcoming therapeutic frontier. Such initiatives

mobilize students towards the sustainability vision of medical research. A complete sense of responsibility supported by a forward-looking perspective and current actions.

3.2 Cultivation of Innovative Thinking

The program aims to raise the students' awareness of paradigm-shifting breakthroughs in the shift from empirical medicine to scientific medicine and provide a systematic framework to nurture innovative thinking. Students in the section on the empirical investigation of traditional Chinese medicine 'black boxes' are led to think about how Sun Simiao, confronted with an unknown etiology, invented dietary therapeutic strategies through an observational approach and trial and error, thereby cultivating experience-based open-mindedness. The work discusses the discovery of insulin from a case study perspective, the chance findings during pancreatectomy experiments, the repeated technical advances in insulin extraction, and the role of reverse thinking and cross-disciplinary thinking [5]. The discovery history of metformin and the sulfonylurea hypoglycemic agents guide students to identify deterministic patterns in random phenomena and cultivates an opportunity-oriented innovative mentality. The latest technologies such as genetically engineered insulin and stem cell transplantation are integrated into education to enhance student's vision of the unlimited future of all things medicine and also stimulate frontier-oriented innovative thinking [6].

3.3 Construction of Rational Logic

In the cognitive transformation section from "black box" to "white box", students are guided to articulate the empirical logical chain from "symptom observation-hypothesis formulation-experimental verification-conclusion modification", thereby mastering the fundamental methodological logic of scientific inquiry. In relation to core questions like the relationship between glycosuria and diabetes mellitus, and blood glucose and insulin, the question 'Which experimental designs were important in the discovery of insulin?' is discussed in class [7]. Through the inquiry into the empirical validation of traditional Chinese medicine theory, students are guided to dialectically analyze "scientific validity of traditional medical experience" and "limitedness of modern medicine," which prevents them from

developing an absolutist or reductive cognitive worldview, thus constructing a dialectically unified logical structure. By means of the historical case involving repeated early failures in the extraction of insulin, students develop an evidence-based, rationally founded, and persevering scientific habit of mind.

3.4 Nourishment of Humanistic Competencies

The curriculum deepens intertwining of professional education and humanistic education to cultivate the reverent attitude of life and benevolent heart of physician. Due to the commitment of ancient physicians who felt the pulse, tasted urine and personally tried medicines in the interest of learnt medicine, students are guided to develop the professional quality of “benevolent heart of the physician” (yi zhe ren xin). The striking contrast between the quality of life of patients before and after insulin therapy makes you understand the value of life and purpose of medicine. Therefore, students easily start loving humanity. The stark difference in patients’ quality of life after the introduction of insulin therapy makes students appreciate the value of life and the mission of medicine, at the same time, develops reverence for life. As to the humanistic connotation of medicine, the humanistic spirit of traditional Chinese medicine theory of holism and the pattern-differentiation treatment, and the humanistic care of modern precise and individualized medicine cultivate students’ humanistic clinical sensibility, so that the progress of medical science and technology is illuminated by humanistic spirit. By analyzing the relationship between technological progress and ethical standards like the limits of genetic manipulation applications, students are encouraged to internalize the developmental principle of technology oriented toward the common good so that the furthering of medicine remains in the service of humanity [8].

3.5 Fostering Cognitive Relativity in Science

Students will formulate a dialectical and evolutionary conception of science. The evolution of diabetes treatment illustrates this. It has progressed from dietary therapy and insulin injection to genetically engineered therapeutics and stem cell transplantation. The journey represents the continuous pursuit of improvement in medicine. Ingraining this paradigm, students readied to lifelong learning

to address changing medical horizons. Traditional Chinese medicine itself has become evidence based from its empirical tradition. Insulin has limited uses that clarifies relativity of science. For example, Type 2 diabetes is a complex condition affecting two organ systems that must be careful not to medicalize things too quickly. Acknowledging a persistent “knowledge gaps”, students should also develop intellectual humility, epistemic curiosity and interdisciplinary thinking. Essentially, critical thinking is the development of an adaptive mindset. They ought to consider divergent viewpoints, such as interpretations of diabetes in traditional Chinese and Western medicine, remaining analytically neutral for weighing the critiques of and contributions to insulin. The fundamental principle of medical literacy is the balanced excitability of skepticism and reasoning. Research has shown that a foundation for this is provided by an undergraduate degree that progressively builds cognitive flexibility. Above all, this teaching methodology frames the intellectual character of future clinicians in terms of science’s dynamic nature and inquiry.

3.6 Advancing Multidisciplinary Integration

The study of insulin's molecular structure and 3D conformation is grounded in biochemistry and structural biology. This case highlights the incorporation of natural sciences into medicine [9]. The meridians and acupoints are now being scientifically validated with modern imaging and physics technologies. This shows cross-disciplinary innovation at the intersection of medicine and engineering. Epidemiological investigations of diabetes mellitus and cost-effectiveness analyses of treatment regimens rely on public health and health economics. These reflect the convergence of "medicine and management." The scientific elucidation of traditional Chinese medicine theory and the modern development of traditional pharmacological agents fully embody the "inheritance and innovation" paradigm of integrated Chinese and Western medicine. Moreover, emerging technologies such as artificial intelligence and big data analytics are now being incorporated into diabetes diagnosis and treatment. This exemplifies the deep collaborative integration of medicine with computer science, biology, statistics, and public health. Such integration facilitates the cultivation of compound medical talents capable

of advancing with the times [10,11]. Furthermore, the systematic cultivation of research and innovation competencies among medical professionals requires a structured curricular design as its foundational support. This becomes especially important at the graduate level after the completion of this seminar-style gen-ed course. As an example, one study fused two core courses, Clinical Research Design and Statistical Analysis and Biomedical Research Strategies and Experimental Skills, with the former corresponding to the clinical big data analysis and the latter corresponding to building fundamental experimental skills, thus forming a clearly defined “innovation chain” training path. This research-process-oriented curricular design is conceptually continuous with the logical reasoning cultivated at the undergraduate level by deconstructing “black boxes” through historical case studies, collectively supporting the stepwise development of students’ research and innovation competencies [12].

4 Teaching Effectiveness Assessment

To systematically evaluate the instructional efficacy of this course and validate the

pedagogical pathway of ‘historical tracing-logical deconstruction-competency immersion-practical application’, a self-developed course effectiveness questionnaire was administered to students enrolled in Chapter 4 of The Logic of Discovery, titled ‘Evidence-Based Medicine: Transforming the Black Box of Drug Mechanisms into a White Box’, to conduct a systematic survey. Concurrently, to investigate the deeper impact of the course on critical thinking competencies, a correlational study was conducted to examine the relationship between course participation and university students’ critical thinking dispositions.

The course effectiveness questionnaire encompassed four dimensions-civic-ethical education, innovative thinking, logical reasoning, and humanistic literacy-comprising 32 items scored on a 5-point Likert scale. A total of 168 valid questionnaires were retrieved (from an initial sample of 171, with 3 outliers excluded). As shown through the data in Table 2, all dimensional mean scores were rather high, scoring above 95% (maximum score), thus indicating an overall exceptionally high student endorsement of the course content.

Table 2. Descriptive Statistics of Course Effectiveness Questionnaire Scores by Dimension (N = 168)

Dimension	M	SD	Maximum Score	Score Rate
Civic-Ethical Education	38.38	3.07	40	96.0%
Innovative Thinking	38.25	3.23	40	95.6%
Logical Reasoning	38.14	3.20	40	95.3%
Humanistic Literacy	38.45	2.92	40	96.1%
Total Score	153.21	11.83	160	95.8%

5. Teaching Challenges and Responses

As elucidated above, the classroom practice of medical general education which is discussed here, is not merely the teaching of separate medical knowledge points, but rather that which is directed towards the construction of the competencies of a medical doctor. Using the past of diabetes diagnosis and treatment as a curriculum material the course connects medical history, the methodology of science, and clinical practice, the latter of traditional and modern medical content. The organ unity of the knowledge transmission and competency capacity is done through multi-dimensional integrative pedagogical practice. This course is the first of its kind in general education in medicine at the university for students from

2021 to 2025. Student feedback on the initiative has been positive but pedagogical practice faces numerous challenges. The teaching team has held repeated discussions about the highlighted teaching issues, made use of feedback from students to revise curricular content and improve pedagogy. The problems are being addressed through the three strategies.

5.1 Balancing Knowledge Depth and Instructional Efficiency

First-year students from various majors at the medical college do not possess systematic prior training in medicine. Moreover, their mastery and understanding of terms like “islet function”, “receptor bound”, “genetic engineering” and others lack depth. It may be the case where mere accumulation of knowledge points may lead to

comprehension difficulties and reduction in teaching efficiency. On the contrary, the complete non-use of core knowledge will undermine the initial support for “evidence-based medical logic”. A critical balance must be achieved where the logical development takes place from “black box” to “white box”. Furthermore, it must carry out the “popularized translation” of specialized knowledge while carefully eliminating the unrelated details. This is to ensure that the teaching process will not be impeded by the details of excessively low-level case analysis. In classroom teaching, students will be trained from the phenomenology to the mechanism of diabetes mellitus with a focus on the hierarchy of the core logic. This will help them to understand that the essence of evidence-based medicine is to “unpack the black box”. In the future, there is much hope that AI technology will open up a more deeply personalized balance. Through the use of intelligent analysis of learning behavior data, the speed and depth of presentation of educational content can be dynamically adjusted. Intelligent education platforms can extend knowledge graphs and extra materials for students who have deficiencies in different foundational knowledge to strike a better balance between efficiency and depth [13]. Accordingly, medical education should research new technology-assisted education modalities at the same logical level.

5.2 Balancing Individual Stimulation and Collective Advancement

Students differ significantly in their knowledge bases and cognitive engagement. Medical history is a point of interest for some. Some are good at reasoning. Some have fragile footing and shun discussion. The instructional design uses a layered way of thinking to realize logical reasoning at different levels. The design fits Vygotskian theory since it brings together low-threshold participation with high dimensional challenge. The learner’s Zone of Proximal Development must be where computer-supported collaborative learning takes place. Proper teaching must tackle the discrepancy between what a student can do now and what he can do with the teacher’s assistance. Interactions with a low threshold promote collectivity. These activities help cement the basic elements of logical reasoning. Problems with Many Dimensions Boost Individual

Creativity. Moreover, they extend the limits of learners’ cognitive capacity. The design ensures the advancement of every pupil within his or her ZPD. Consequently, the overall group benefits broadly from cognitive ability [14].

5.3 Bridging Classroom Instruction and Post-Class Extension

The goal of classroom teaching is the development of logical reasoning. Post-Class Extension depends on developing a culture of innovation with the help of these measures. The connection between in-class activities and out-of-class activities is through well-designed assignments which should be cognitively appropriate for students. They should also represent classroom contents. By adopting a task-driven approach, educators establish a bridge. This bridge promotes the consistent development of logical reasoning skills [15]. For instance, to strengthen the classroom logic and further enhance students’ ability to apply methodological logic, students could be asked to take a medical phenomenon of their choice and to propose an initial observation-hypothesis-verification protocol based on the drug-discovery logic of the class. During the next class, about 10–15 minutes is set aside for students to share their post-class outcomes. Thus, this feedback loop of “classroom learning-post-class practice-results sharing-collective advancement” reinforces the transfer of competencies and motivates the search for more knowledge and ways to apply them [16]. Interestingly, the key focus of the course is to cultivate the comprehensive capabilities and professional qualities of medical men through an implicit infusion process. The above-mentioned qualities and abilities not only apply in the medical profession but also more generally in many areas of social life.

The responsive strategies totally reflect a student-centered competency oriented educational philosophy that enables students to comprehend content, achieve mastery, get engaged, attain meaningful learning, apply and transfer competencies. Ultimately, this educational approach has transformed “evidence-based medicine” from classroom knowledge into a capacity for lifelong professions. This laid the foundation for the growing high-quality medical talent of new medical sciences. This philosophical approach to education has received additional extensions and

enrichments in specialized courses at the graduate level. For instance, dealing with huge data and complex problems in the information age characteristics, the evidence-based medicine courses systematically integrate frontier content such as artificial intelligence, real-world research, and so on in a "lecture-discussion-practice" format with project-based assessment models emphasizing on the cultivation of advanced research thinking and innovative capacity to solve practical problems [17]. These developments indicate that, within the overarching framework of "new medical sciences" construction, educational reforms at all stages of medical training are converging toward the systematic shaping of students' core competencies and innovative capacities.

Medical education is not just about imparting knowledge and techniques. Rather, it is primarily about shaping ways of thinking and a system of value. Rooted in the evolution of evidence-based medicine, and in the methodical unearthing of educational worth embedded in curricular materials, the course, in part, has developed a multi-dimensional pathway to the development of competencies, realizing the integration of scientific, ethical, intellectual and philosophical values. Through this new cross-general education course of medicine, the shift from a "knowledge-based" to a "competency-based" education system has been realized, thus producing quality medical professionals for Healthy China, who have sound professional ability, firm ideological conviction, scientific method capability and solid humanistic quality.

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References

- [1] Park YS, Konge L, Artino AR Jr. The positivism paradigm of research. *Academic medicine*, 2020, 95(5): 690-694.
- [2] Runzhi Huang, Zhitong Zhou, Yifan Liu, et

- al. Empathy in undergraduate medical students: a multi-center cross-sectional study in China. *BMC Psychiatry*, 2024, 24(1): 414.
- [3] Zhiguang Duan, Chen Wang, Yan Shi. Construction of the Medical and Health Humanities System in China. *Medicine & Philosophy*, 2025, 46(18): 27-32.
- [4] Xinyao Wang, Youlin Long, Yating Zeng, et al. The impact of medical humanities literacy on job competency. *Chinese Journal of Evidence-Based Medicine*, 2023, 23(3):286-291.
- [5] Fengqiong Liu, Shuming Qu, Yi Fan, et al. Scientific creativity and innovation ability and its determinants among medical postgraduate students in Fujian province of China: a cross sectional study. *BMC Medical Education*, 2023, 23(1): 444.
- [6] Kathryn Parker, Allia Karim, Risa Freeman. Developmental Evaluation: six ways to get a grip on the potential of education scholarship to serve innovation. *Canadian Medical Education Journal*, 2021 Nov 1;12(5): 54-58.
- [7] Fadous MC, Zeeny C, Cheiban K, et al. Critical thinking gamification in medical education. *BMC Medical Education*, 2025, 26(90).
- [8] Tiefang Liu, Luwei Ran. Reassessing the Fundamental Purpose of Humanities Education. *Journal of Higher Education*, 2025, 46(02): 1-10.
- [9] Xiaobao Zhang, Baocun Liu. From Separation to Integration: Foreign Experience on Interdisciplinary Education and Its Localization. *Heilongjiang Higher Education Research*, 2025, 43 (02): 62-67.
- [10] Masters K, Mac Neil H, Benjamin J, et al. Artificial intelligence in health professions education assessment: AMEE Guide No. 178. *Medical Teacher*, 2025, 47(9): 1410-1424.
- [11] Jennifer Simoni, Judith Urtubia-Fernandez, Elisa Mengual, et al. Artificial intelligence in undergraduate medical education: an updated scoping review. *BMC Medical Education*, 2025, 25(1): 1609.
- [12] Haitao Tang, Ji Bao, Fan Chen, et al. Exploration and practice in constructing a curriculum system for cultivating scientific research innovation capabilities in clinical medicine postgraduates. *Chinese Journal of Evidence-Based Medicine*, 2025,

- 25(12):1440-1444.
- [13]Ying Qiu, Yi Li. Exploration of How Artificial Intelligence Promotes the Digital Transformation of Medical Education. China Higher Medical Education, 2025, (11):26-28
- [14]Xinyu Wang, Pengxin Geng, Xingyue Chen, et al. A study on the academic innovation ability and influencing factors of public health graduate students based on nomograms: a cross-sectional survey from Shandong, China. Front Public Health, 2024, 23: 12: 1429939: 1-10.
- [15]Zehua Shi, Chunqing Li, Hongbin Wu, et al. Effects of the education and training programme for excellent physicians in China on medical students' academic performance: a cross-sectional study. BMJ Open, 2023, 13(9): e072940.
- [16]Girishwar Misra, Raghubir Singh Pirta, Indiwar Misra, et al. The game of science and puzzles of paradigm. Integrative Psychological and Behavioral Science, 2021, 55(1): 167-180.
- [17]Jiayue Xu, Yuning Wang, Xin Sun, et al. Exploration of evidence-based medicine curriculum reform in the information age. Chinese Journal of Evidence-Based Medicine, 2024, 24(5):612-616.