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Exploration of an Innovative Training Model for "Excellent Forensic Medicine Postgraduates" in The Context of Intelligent Medicine

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Abstract: The rapid development of computer science and artificial intelligence has brought both challenges and opportunities to the training of forensic medicine graduate students. Traditional training models suffer from issues such as an overemphasis on theory, insufficient practical training, and inadequate outcomes translation. Against this backdrop, this forward-looking educational reform project explores an innovative talent cultivation model for "excellence forensic practitioners" within the context of intelligent medicine. The project first investigates the current application of virtual simulation and artificial intelligence in forensic education, and then, drawing on the "excellence engineering" training model, designs a pilot model that incorporates these technologies into the entire training process. The core objective is to establish a framework for the "excellence forensic practitioner" cultivation model, combining theory and practice, research and application, while strengthening practical skills and outcomes translation, as well as reforming the evaluation mechanism. The aim is to explore new approaches and effective methods for training forensic medicine graduate students in China.

Keywords: Forensic Science, Intelligent Medicine, Excellence Forensic Scientist, Talent Cultivation, Innovative Teaching Theory

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1. Challenges and intelligent pathways in the cultivation of excellence in forensic medicine talent

Forensic medicine serves as a crucial bridge between medicine and law, playing an irreplaceable role in upholding judicial fairness and establishing the foundations of social equity and justice [1]. As China enters a new era in the construction of a socialist rule of law, the reforms in the litigation system centered on trials have raised higher demands on the quality of evidence. Consequently, the scientific validity and authority of forensic expert opinions are undergoing unprecedented scrutiny. This profound transformation directly challenges the professional competence and practical abilities of forensic evaluators, thereby necessitating innovative reforms

in higher education, which bears the responsibility of cultivating talent in this field [2].

Although the forensic medicine education system in China has become increasingly refined, the graduate training process still faces multiple challenges, making it difficult to fully meet the new demands of rule of law development [3]. First, there is a significant disconnect between theoretical teaching and practical application. The traditional model places excessive emphasis on the delivery of theoretical knowledge, and graduate students have limited opportunities to engage with real cases or participate in complete forensic evaluations during their studies. This results in difficulties in translating acquired knowledge into the ability to solve complex real-world problems. Second, there is insufficient integration of cutting-edge technologies into education. Although the application of technologies such as virtual simulation and artificial intelligence in forensic medicine has yielded initial results [4], these efforts remain fragmented and have not been systematically incorporated into the entire graduate training process. Furthermore, there is a bias in the evaluation system, with current evaluations often focusing too heavily on the publication of academic papers while neglecting the assessment of students' practical skills in case analysis, technological innovation, and the translation of research outcomes. These challenges collectively hinder the development of high-quality, interdisciplinary "excellence forensic practitioners" and underscore the urgency for reform in the training model.

Currently, the wave of intelligent technologies represented by virtual simulation and artificial intelligence provides a historic opportunity to bridge the gap and reshape the forensic medicine education ecosystem [5]. In recent years, artificial intelligence (AI) technology has developed rapidly, and many scholars both domestically and internationally have begun exploring the application of AI in fields such as forensic pathology, forensic evidence, forensic anthropology, forensic clinical medicine, forensic toxicology, and forensic psychiatry [6]. Breakthroughs have been achieved in areas such as PMI (postmortem interval) estimation, individual identification, DNA profiling, diatom testing, injury recognition, toxicology testing, and the diagnosis and prevention of violent behavior in mental disorders, with some results already being applied and demonstrating superior model performance [7]. These technological applications not only effectively overcome the challenges of limited practical resources and the difficulty of replicating high-risk scenarios in traditional teaching but also systematically enhance students' practical skills and professional decision-making abilities through human-computer collaborative intelligent training models, providing crucial support for the reform of forensic medicine education. In the future, mastering artificial intelligence technology will be indispensable for cultivating excellence in forensic talent. To avoid being left behind by technological advancements, students must become both masters and users of these technologies [8]. Therefore, in the graduate training process for forensic medicine, it is essential to keep pace with the evolving demands of the era by incorporating AI technologies such as machine learning, deep learning, digital image processing, pattern recognition, and artificial neural networks into the curriculum. By imparting relevant knowledge, this approach will advance forensic medicine graduate students' progress in research, innovation, and solving traditional forensic challenges such as complex cause-of-death analysis, time-of-death estimation, individual identification, pattern analysis, and toxicological testing. This study emerged in response to the demands of the current era and aims to systematically explore and construct a future-oriented, innovative training model for "excellence forensic practitioners" under the domain of intelligent medicine.

2. Constructing a new paradigm for the cultivation of "excellence forensic practitioners"

This study aims to bridge the gap between theory and application, as well as research and practice, by

restructuring the curriculum, innovating practical pathways, and reforming the evaluation mechanism. The goal is to enhance students' practical skills and innovative competencies systematically, while establishing a replicable and scalable training model that provides new pathways and practical examples for cultivating high-end forensic talent in China, thereby contributing to the development of forensic medicine education.

The formation of this new paradigm is not a result of arbitrary design, but rather stems from a profound insight into existing challenges and a creative transformation of successful experiences. Its construction path is clear and specific:

2.1. Foundation of the new paradigm: Problem-driven approach and experience transfer

The construction of the new paradigm begins with two solid foundations: First, a thorough analysis of the existing challenges. We have recognized that the core contradiction in traditional training models lies in the disconnection between "academic training" and "professional competence." While graduate students may excel in writing academic papers, they often lack the adaptability needed to tackle complex and unconventional forensic tasks [9]. This underscores that the starting point of the reform must be practice. Second, the beneficial transfer of successful models. The "Excellence Engineer" program has provided significant conceptual references and methodological insights for the reform of forensic medicine graduate education. The core value of this program lies in its breaking of traditional disciplinary boundaries and establishing a training paradigm focused on "industry needs" and "strengthening practical engineering skills." By systematically integrating cutting-edge industry technologies and methods into the entire teaching process, it has created an evaluation system centered on solving complex engineering problems. This successful experience directly addresses the structural contradictions in current forensic medicine education, such as the disconnect between theoretical teaching and practical demands, as well as the insufficient technological empowerment.

2.2 Core solution of the new paradigm: Constructing a progressive training system of "human-computer collaboration and virtual-real integration

Based on the aforementioned understanding, our proposed solution focuses on bridging the gap between "learning" and "application," with the core concepts of "intelligent empowerment" and "competency-driven approach." The reform is integrated across three dimensions: curriculum structure, practical pathways, and evaluation mechanisms, aiming to create a cohesive and interconnected new paradigm for the cultivation of "Excellence Forensic Practitioners."

2.2.1. Curriculum restructuring: Embedding the "intelligent forensic medicine" gene

In traditional curricula, courses on intelligent technologies and forensic medicine are often disconnected, making it difficult for students to effectively apply new technologies within their professional field [10]. To address this, we have broken away from the conventional course structure, not simply by adding introductory courses on "Artificial Intelligence," but by embedding the "gene" of intelligent technologies deeply into the core forensic medicine courses, thereby restructuring the knowledge framework. For example, in the course "Forensic Pathology," we have introduced a module on the "Deep Learning-Based Death Time Inference Model," guiding students not only to understand traditional morphological inference methods but also to learn how to use convolutional neural networks to process large volumes of histological image data, thereby comprehending the principles, advantages, and limitations of model construction. In the course "Forensic Biology," we incorporated

a case study on "AI-Assisted Complex DNA Kinship Analysis," where students can experience firsthand how big data algorithms solve kinship identification challenges in complex scenarios such as child trafficking and disaster victim identification, which traditional methods struggle to address [11]. This curriculum restructuring aims to cultivate graduate students with an integrated "Forensic Medicine-AI" mindset, enabling them to consciously apply intelligent technologies to solve cutting-edge scientific problems in the field.

The curriculum restructuring has laid a solid "Forensic Medicine-AI" knowledge foundation for students. However, to transform this knowledge into the ability to solve real-world problems, it is essential to implement a systematic, practical training phase that facilitates the critical leap from theoretical understanding to practical skills.

2.2.2. Shift in training model: Constructing an "intelligent-augmented" forensic practical skills ladder

(1) Human-Computer Collaboration in Developing Diagnostic Thinking

In the practical training phase, the project innovatively integrates intelligent analytical methods, guiding students to apply cutting-edge technological tools to handle real-case data. A progressive "human-computer collaboration" training paradigm has been established. In forensic pathology and clinical training, students are required to operate intelligent analysis systems, inputting complete autopsy data from sudden death cases or clinical data from injured individuals to generate death cause inferences or disability level assessments based on big data. However, the core design of this project goes beyond the mere application of technology and aims to foster a critical human-computer collaborative diagnostic mindset. Students are encouraged to question, validate, and ultimately integrate AI outputs: they must combine professional knowledge to thoroughly analyze the validity and limitations of intelligent suggestions, understand the boundaries and uncertainties of the algorithms. This repetitive process of "questioning - validating - building" enables students to solidify the scientific understanding that technology should assist, not replace, human judgment, thereby shaping their cautious verification and scientific decision-making abilities, which are essential in the age of intelligent technologies [6].

(2) Virtual Simulation Training

To achieve a risk-free transition from theory to practice, this project systematically designs a training module based on virtual simulation technology. We comprehensively integrate existing digital resources, such as 3D modeling, human-computer interaction, and case databases [12], to create highly realistic forensic work scenarios for students. In this environment, students are required to follow standard operating procedures and independently complete the full workflow, from the three-dimensional examination of the crime scene, trace evidence identification and collection, laboratory analysis, to the final formation of forensic conclusions. The core objective of this systematic training is to go beyond single-skill operations, thoroughly honing students' abilities in constructing evidence chain logic, making comprehensive decisions in complex situations, and fostering awareness of standardized practices. During the training process, we introduce structured assessment metrics to provide real-time feedback and debriefing on students' operational paths, evidence handling logic, and the rationality of their forensic conclusions, helping them identify potential gaps in professional judgment. Moreover, we simulate various complex situational variables, such as contradictory evidence, time pressure for forensic analysis, or case background interference, to guide students in

adjusting their strategies and responding flexibly to the uncertainties encountered in real forensic work. This highly immersive, repeatable, and error-tolerant training model effectively promotes the deep internalization of professional knowledge and skills, significantly shortening the cycle from knowledge acquisition to the development of professional competence [13].

(3) Real Case Practical Training

The ultimate goal of virtual simulation is to serve real-world scenarios. After completing the systematic virtual training, students will enter collaborative forensic institutions, where, under the guidance of experienced forensic experts, they will participate in handling real cases. This phase is not only an application of skills but also a process of shaping professional identity and a sense of responsibility. Students are no longer merely learners; as members of the forensic team, they are tasked with specific forensic duties, and their analytical results will directly enter the judicial process.

2.2.3. Reform of the training evaluation mechanism: Implementing a "practice empowerment and multi-dimensional verification" result evaluation system

To fundamentally change the singular evaluation tendency of "publication-oriented" assessment, this project establishes a multi-dimensional, comprehensive evaluation system centered on "competency output [14]." This system spans the entire training process and covers various dimensions, including knowledge integration, technical application, and innovative practice. In terms of process evaluation, we have designed a "Training Ability Portfolio," which thoroughly records students' performance in both virtual simulation and real case investigations. Key indicators, such as the completeness of the evidence chain construction, proficiency in using intelligent tools, and the reliability of forensic conclusions, are meticulously documented. Additionally, an industry expert blind review mechanism is introduced to ensure the objectivity and professionalism of the evaluation. At the results evaluation level, students' assessments follow a "choose one of three" model:

(1) An academic paper presenting innovative insights in the field of forensic justice.

(2) A high-level virtual case investigation report and defense, which must demonstrate the ability to conduct systematic analysis of complex cases and include a critical evaluation of AI-assisted diagnostic results.

(3) A technology patent or software copyright applied to forensic practice, such as a self-developed image recognition algorithm or intelligent diagnostic model [15], which must have a clear application scenario and practical value.

This reform has fundamentally reversed the previous evaluation bias, which emphasized theory over practice and outcomes over process, shifting the focus from "what is known" to "what can be done." For instance, students who choose the virtual case report option must defend their work before a joint committee of experienced forensic experts, who will question them on forensic logic, technical approaches, and innovative points. Students who select patent achievements, on the other hand, are required to demonstrate how their inventions improve solutions and effectiveness in real forensic scenarios. This "competency-based" evaluation approach effectively guides graduate students to shift their focus from pursuing the quantity of academic papers to enhancing their practical abilities and innovative capabilities, ultimately aligning talent development with industry needs.

3. Conclusion

This study actively explores a new training paradigm of "intelligent empowerment and competency-oriented" in

the field of forensic medicine graduate education reform. Drawing on the concept of "excellence engineering" education, we have restructured the curriculum, established a progressive training system, and implemented a multi-dimensional evaluation mechanism. These efforts have led to the preliminary formation of a "forensic excellence" training pathway that integrates theory and practice, and combines research and application. This model effectively enhances graduate students' practical response abilities in complex cases and their capability to translate research outcomes into practical applications, offering a viable solution to the traditional dilemma in forensic medicine education, which tends to prioritize theory over practice. Looking ahead, we will continue to refine this training system and expect it to make a positive contribution to the overall improvement of high-end talent cultivation in forensic medicine, thereby providing stronger human resource support for the construction of a rule-of-law society in China.

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