Research on the Talent Cultivation Model of Medical-Engineering Integration in Critical Care Medicine Supported by Smart Teaching Platform

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Abstract: As a highly interdisciplinary and practical core discipline of clinical medicine, critical care medicine places high demands on interdisciplinary talent cultivation, clinical practical ability, and the application level of intelligent equipment. At present, however, there are still some problems to be solved in traditional critical care medicine teaching, which cannot meet the demand for cultivating compound talents in critical care diagnosis and treatment in the era of smart healthcare. To make up for this deficiency, this paper focuses on an in-depth exploration of the talent cultivation model of medical-engineering integration in critical care medicine supported by the smart teaching platform. It is hoped that new ideas and methods can be provided for the cultivation of innovative compound talents in critical care medicine in the new era.

Keywords: Smart teaching platform; Critical care medicine; Medical-engineering integration; Talent cultivation model

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Preface

Traditional critical care medicine teaching is mostly based on a single discipline, with insufficient consideration of the connections between medicine, engineering, and information. There are also situations where theory is emphasized over practice, diagnosis and treatment are emphasized over equipment, and results are emphasized over processes. Students' interdisciplinary thinking needs to be developed, and their practical abilities demonstrated are not satisfactory. In addition to the complexity and high risk of critical care medicine, which is highly practical, practitioners are required not only to have a solid grasp of medical theory but also to be familiar with engineering technologies such as the principles of equipment and the application of intelligent systems. Therefore, the integration of medicine and engineering has become an inevitable trend in the cultivation of innovative talents. The emergence of smart teaching platforms can not only solve the problems of traditional teaching, but also provide many new ideas for medical education reform.

1.The smart teaching platform supports the connotation and practical significance of medical-engineering integration talent cultivation

The core of medical-engineering integration is the deep integration of knowledge and capabilities in clinical medicine, biomedical engineering, intelligent equipment and information technology, with clinical needs as an important orientation and engineering technology as a strong support, to cultivate more compound talents who understand medicine, are proficient in equipment, are good at technology and can make decisions.

It is of great practical significance to carry out medical-engineering integration training in critical care medicine

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based on the smart teaching platform: It helps to break through teaching bottlenecks.

Use AI technology and virtual simulation technology to effectively address the pain points such as insufficient clinical training, disciplinary fragmentation, and the disconnection between medicine and engineering; Second, improve the quality of education, increase the training of clinical thinking, engineering literacy and intelligent application ability, and reasonably shorten the job adaptation period; Third, serve the development of the industry and supply more high-quality talents suitable for intelligent and engineered diagnosis and treatment scenarios to smart critical care medicine; Fourth, science leads teaching reform, providing replicable paradigms for digitalization of medical education and interdisciplinary[1] education.

2.Core issues to be addressed in traditional critical care medicine training

2.1 Prominent disciplinary barriers

Critical care medicine is characterized by its comprehensiveness and interdisciplinarity, and cannot do without the collaborative support of multiple disciplines such as medicine, engineering, and information. Traditional teaching follows a single-discipline framework, with independent courses and insufficient connections among contents, and most teachers have a single-discipline background, failing to conduct integrated teaching closely related to clinical practice. Students' knowledge is fragmented, which is not conducive to the construction of a systematic and interdisciplinary knowledge system and is difficult to meet the needs of intelligent diagnosis and treatment.

2.2 The integration of medicine and engineering is weak

Critical care is highly dependent on medical equipment, but most traditional teaching models have the phenomenon of "emphasizing medicine over engineering", with less engineering content such as equipment principles, parameter adjustment, and fault handling, and insufficient emphasis on medical-engineering integration training in practical links. Students also generally have the shortcoming of "being able to operate but not understand the principles", making it difficult for them to adjust the equipment and treatment plans in accordance with the condition, and unable to meet the various requirements put forward by the clinical practice for compound talents.

2.3 Limited practical scenarios

ICU clinical risks are high and scenarios are scarce, making it difficult to meet students' need for repeated practice. Traditional training has a low degree of simulation, and with a single case, it cannot reproduce complex critical conditions and sudden emergencies. Students' clinical thinking, emergency response and decision-making abilities are insufficient, and the efficiency of converting theory to practice is not ideal[2].

2.4 The evaluation system is rigid.

Traditional evaluation is mostly based on end-of-term theory and standardized operations, with a relatively single approach and limited dimensions. It pays insufficient attention to students' learning process, clinical thinking, and the assessment of medical-engineering integration ability, and provides less data-driven and personalized feedback. It is difficult to accurately identify shortcomings and to some extent restricts the improvement of students' comprehensive quality.

3 Specific implementation measures for medical-engineering integration talent cultivation supported by smart teaching platforms

3.1 Platform construction: Building an AI-enabled interdisciplinary critical care medicine smart teaching platform

①Build an interdisciplinary structured knowledge graph. With the help of artificial intelligence technologies such as natural language processing and knowledge mining, organically integrate the core knowledge resources of multiple disciplines including critical care medicine, intelligent information technology, and biomedical engineering, break through the traditional disciplinary boundaries, and build a systematic and visualized interdisciplinary knowledge graph of critical care medicine. The knowledge graph takes critical clinical diagnosis and treatment scenarios as the core thread, completes the sorting of related knowledge such as the diagnosis and treatment processes of various critical diseases, the logic of intelligent monitoring technology, and parameter regulation standards, and provides assistance for the subsequent construction of an integrated knowledge framework of "disease diagnosis and treatment - equipment application - technical principles - engineering adaptation". The platform can enhance the intelligent association of knowledge, provide visual display and precise retrieval, so that students can quickly query single knowledge points and related interdisciplinary extended content around the learning needs of different periods, properly solve the problem of fragmented disciplinary knowledge, help students build a systematic medical-engineering integration knowledge system, and achieve the integration of multi-disciplinary knowledge[3].

②Develop a core module for 3D virtual simulation teaching. Upgrade the 3D virtual simulation system based on the team's visualized diagnosis and treatment and the existing hardware equipment of the artificial intelligence laboratory, and develop specialized virtual simulation teaching modules that are compatible with medical-engineering integration teaching around real critical clinical scenarios to effectively make up for the deficiencies of traditional practical teaching. The module is built around the core skills of critical care medicine and involves core training contents such as comprehensive assessment of critically ill patients, dynamic electrocardiogram monitoring, critical ultrasound examination, and application of intelligent diagnosis and treatment systems. Through 3D modeling technology, the ICU, operating room treatment environment and various precision medical equipment are replicated one-to-one to achieve precise replication of the internal structure, operation process, operating principle and parameter adjustment logic of the equipment. Students can organize practical operation activities such as equipment disassembly, standardized operation, and fault simulation handling based on virtual scenes to avoid the risks of real clinical operations as much as possible, break through the limitations of the number of practical training sessions, consumables and scenarios, help students master the engineering principles and clinical application skills of critical care medical equipment proficiently, and lay a solid foundation[4] for the practical operation of medical-engineering integration.

③ Improve the construction of intelligent and personalized learning systems. Flexibly introduce machine learning algorithms and use the platform's big data collection function to complete the full recording of students' learning data in all dimensions, including the duration of theoretical study, mastery of knowledge points, and correct answer rate. Use algorithms to intelligently analyze learning data to accurately identify students' learning characteristics, practical weaknesses, thinking loopholes, and knowledge weaknesses. Based on the data analysis results, the system can automatically plan personalized learning paths for students, complete explanations of weak points, targeted practical training cases, and targeted push of extended medical-engineering integration teaching resources. Furthermore, the platform can quickly generate overall class situation reports for teachers, visually presenting the overall teaching shortcomings and common problems, helping teachers to precisely adjust the teaching focus, improve the teaching content, smoothly implement individualized teaching, and promote the overall improvement of teaching efficiency and learning effect.

3.2 Model innovation: Building a 3D virtual simulation-enabled medical-engineering combined practice teaching model

①Develop clinical-oriented virtual simulation cases of medical-engineering integration. Develop a series of medical-engineering integration virtual simulation teaching cases for shock, acute respiratory distress syndrome, and severe trauma and critical illness based on clinical high-incidence, difficult and critical diagnosis and treatment scenarios, as well as real clinical cases. All cases should break free from the logical constraints of pure medical teaching and combine the two core elements of "clinical diagnosis and treatment needs + engineering technology application" to fully reproduce the evolution of patients' conditions, equipment selection, parameter adjustment and optimization of diagnosis and treatment plans. In the case practice, students are required not only to make judgments about the patient's condition and formulate a complete and feasible treatment plan, but also to analyze the compatibility of the equipment in connection with engineering knowledge, optimize the operating parameters of the equipment, make appropriate adjustments to the treatment strategy based on intelligent monitoring data, complete the full training of students' clinical diagnosis and treatment thinking and engineering application ability, and contribute[5] to the deep integration of medical knowledge and engineering technology.

② Create a highly realistic and immersive practical teaching environment. With the help of 3D virtual simulation and virtual reality technology, highly replicate the real ICU, intensive care operating room, and intensive care treatment scenarios, replicate many scene details such as the real clinical emergency treatment atmosphere, equipment operation status, and sudden changes in patients' conditions, and improve the construction of immersive and interactive practical teaching environments. Compared with traditional static training scenarios, the construction of immersive virtual environments can simulate various sudden critical situations such as sudden drops in patient blood oxygen, circulatory failure, and minor equipment failures, thereby helping students to respond quickly, handle accurately, and conduct repeated training in clinical emergency ability, on-the-spot adaptability, and comprehensive decision-making ability. Highly realistic scenarios can minimize the gap between classroom practice and clinical practice, allowing students to accumulate practical experience in critical care treatment in a risk-free and repeatable environment and promoting the overall improvement[6] of job fit capabilities.

③Focus on the implementation of the blended teaching model that integrates online and offline. Integrate the advantages of online smart platform resources, offline classrooms and practical training teaching organically to build a blended teaching model of online self-study + offline precise teaching + virtual and real combined practical training, and complete the reconstruction of the teaching process of critical care medicine. In the online part, students can complete cross-disciplinary theoretical knowledge learning, personalized resource learning, as well as pre-class preview and post-class consolidation with the help of the smart teaching platform, achieving self-mastery of basic medical knowledge, equipment engineering principles and basic operation procedures. Offline classes should be structured around key and difficult points. Teachers can precisely explain the common problems in online learning, analyze the key and difficult points of medical-engineering integration based on real cases, and have students conduct discussion activities, practical operation Q&A, and offline physical equipment practical operation training[7] in groups. It is also important to have a deep connection between the results of online virtual simulation training and offline practical assessment, to build a closed-loop teaching model of virtual previewing, offline practical operation, and complementary virtual and real, which not only helps to significantly enhance students' learning enthusiasm and teaching effectiveness, but also effectively breaks through the problems of low efficiency and shallow integration in traditional teaching.

3.3 Evaluation Reform: Building an AI-enabled intelligent evaluation system for critical care medicine in all aspects

① Improve the AI intelligent automated evaluation system. With the help of technologies such as natural language processing, big data analysis and image recognition, an intelligent evaluation system dedicated to critical care medicine will be developed to comprehensively, automatically and precisely assess students' comprehensive abilities. The system can conduct intelligent assessment and evaluation around three core competencies of students: First, the ability to master theoretical knowledge. With an intelligent question bank, test papers are generated to assess students' cross-disciplinary theoretical knowledge reserves and achieve precise screening of knowledge gaps; Second, practical operation skills. Record and analyze the entire process of students' virtual simulation training operations, complete the comparison of standardized operation norms, so as to automatically evaluate the standardization, proficiency and accuracy of operations, and ensure that operational errors and technical shortcomings can be identified in a timely manner; Third, clinical thinking and decision-making ability. Intelligent assessment of students' medical-engineering integration thinking and clinical decision-making level through analysis of complex case handling procedures, equipment parameter optimization logic, and treatment plan selection for students. After the evaluation is completed, the system can automatically generate personalized evaluation reports, clearly identify strengths and weaknesses, and push targeted improvement plans to students, providing more precise data support[8] for subsequent teaching optimization by teachers.

②Build a multi-dimensional and diversified comprehensive evaluation system. Process evaluation should be effectively integrated throughout the entire teaching process, covering aspects such as online learning progress, mastery of knowledge points, classroom interaction performance, participation in group discussions, etc., to complete key assessments of students' learning attitudes, phased growth, etc. Result-oriented assessment is based on the final comprehensive assessment, focusing on interdisciplinary theoretical tests, comprehensive diagnosis and treatment analysis of complex cases, and virtual combined practical assessment, to comprehensively assess students' application of knowledge and practical abilities. In addition, by integrating teacher professional evaluation, student self-review evaluation and group peer evaluation, students' diagnostic thinking, teamwork ability and other aspects can be scientifically evaluated to facilitate the continuous improvement of comprehensive ability and cultivate more compound talents.

4.Conclusion

To sum up, in the context of smart healthcare and digitalization of education, the training of critical care medicine talents has shifted from a single medical ability to a compound model of coordinated development of medicine, engineering, and intelligent technology. With the support of smart teaching platforms, by improving interdisciplinary teaching systems, innovating medical-engineering integration practice models, and improving intelligent multi-evaluation to address teaching pain points, achieve deep integration of theory, training and practice, facilitate the coordinated development of students' clinical thinking, equipment operation, emergency response, and medical-engineering integration capabilities, and contribute to the healthy and sustainable development of critical care medicine.

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