



Construction of an online resource platform for anesthesiology postgraduates based on competency-based medical education concept

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Highlights

- A competency based medical education (CBME) online resource platform is developed to bridge gaps in post graduate anesthesiology education, enhancing both curriculum content and teaching approaches.
- Classical and dynamic knowledge modules are incorporated to support competency-based learning, fostering systematic, self-directed, and lifelong learning.
- Innovative hybrid teaching models and real-time access to updated resources have significant potential to improve clinical decision-making and practical skills.

Abstract

To bridge the gap between curriculum content and clinical needs, as well as address the insufficient quality of on-line educational resources in current postgraduate anesthesiology education, this study proposes a “library-style” network resource platform for anesthesia graduate students, grounded in the competency-based medical education framework. The platform’s primary focus is “classical knowledge module”, which covers six core domains in anesthesiology, such as clinical anesthesia management, anesthesia technical operation, and anesthesia pharmacology. The platform also integrates ‘Internet+’ technology, creating a multifunctional network resource to support comprehensive learning. The platform is characterized by modularized knowledge, diversified resources, dynamic updates, and universal accessibility, enabling postgraduate students to engage in independent and lifelong learning. This flexibility fosters the innovation of hybrid teaching models, combining both online and offline components. The study aims to strengthen the competency-oriented anesthesia training system, providing robust support for both clinical practice and academic research.

Keywords: Anesthesiology, postgraduate education, competency-oriented medical education, online resource construction, teaching reforms

Introduction

In 2020, the General Office of the State Council issued a document emphasizing the anticipated expansion for postgraduate enrollment in anesthesiology, highlighting the need for innovative approaches in medical education [1]. Among these approaches, Competency-Based

Medical Education (CBME) has emerged as a cornerstone in modern medical education. CBME shifts the focus from traditional knowledge-based teaching to an outcome-driven model, where the acquisition of measurable competencies is the primary educational objective [2, 3]. This model ensures that postgraduate students develop the critical skills, atti-

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tudes, and knowledge required to meet clinical demands and excel in professional practice. Addressing the specific challenges in anesthesiology education, this study seeks to integrate the CBME framework into the development of an online professional knowledge system. This system addresses gaps in curriculum content and resource quality, while enhancing competency-based training outcomes.

Theoretical foundations and research background

Concept of CBME

CBME is an educational approach that employs a structured core competency framework, focusing on designing, implementing, and evaluating education based on measurable outcomes [4]. In this context, competencies encompass a combination of motivation, traits, attitudes, knowledge, and values. Competency refers to any of these characteristics that can be reliably measured, distinguishing high-performing learners from average-performing students. Developing medical students' competencies has become the mainstream approach in modern medical education globally, with continuous evolution and refinement over time [5-10]. In 2018, the Ministry of Education issued a document advocating for competency-oriented education and teaching reform [11]. The CBME-based educational model begins by defining the essential competencies required for exceptional anesthesiologists and clinical scientists. It prioritizes the development of these competencies, establishes a well-structured educational system and assessment methods, and uses the achievement of these competencies as indicators of successful learning [11]. This process is dynamic, reflecting ongoing development and adaptation.

Prominent contradictions and problems in postgraduate anesthesiology education

In the United States, anesthesiology residency training begins only after obtaining an M.D. degree, marking the start of comprehensive professional education in anesthesiology [12]. This training spans four years, beginning with a foundational clinical year that includes rotations in internal medicine, surgery, and emergency medicine, followed by three years of core clinical anesthesia training (CA1-CA3) [13]. This curriculum emphasizes perioperative management, critical care, and pain medicine, incorporating simulation-based education to cultivate crisis management and teamwork skills. Assessment methods are structured around the

Milestones framework, which tracks residents' competency development through tools such as direct observation, Mini-CEX, simulation assessments, and standardized examinations like the American Board of Anesthesiology exams [10, 14]. Simulation-based education plays a vital role by providing opportunities for clinical decision-making and teamwork practice in a controlled environment [15].

In contrast, postgraduate anesthesiology education in China integrates master's-level academic training with standardized residency training, leading to differences in curriculum structure, focus, and assessment strategies [16]. The U.S. system places greater emphasis on integrating basic sciences with clinical practice, while the Chinese system more emphasizes fundamental theories and technical skills, with relatively less focus on team collaboration and crisis management. Existing study reveals that postgraduate anesthesiology students in China are still constrained by traditional medical education models [17]. Besides, under the "Double Tracks" practical educational mode, the curriculum lacks distinctive teaching characteristics and sufficient class hours. This highlights the need for innovative technological measures and reforms in curriculum structure and teaching methods to cultivate the competency of clinically-oriented postgraduate anesthesiology students [18].

To address this gap, our department has conducted an exploration to strengthen the competency-oriented anesthesia talent training system. In 2022, we conducted a survey of nearly 600 graduates from our university, 18 local colleges and universities, and eight grassroots units [16]. The survey results on the professional competencies of graduates during their undergraduate years revealed that the top three self-evaluated dimensions were work ethics and perseverance, psychological quality, and professional ethics. The score for solid professional theoretical knowledge closely followed these, with over 85% of respondents rating these aspects as "very satisfied" or "generally satisfied." In the competency training needs survey, the top three areas identified for further development were clinical skills, anesthesia-related procedural skills, and oral and written communication skills. Based on these findings, alongside both domestic and international research on graduate education in anesthesiology, two prominent contradictions emerge in this field.

Firstly, the content of postgraduate courses does not align with the clinical anesthesia prac-

tices required by postgraduate students' knowledge systems, nor does it meet the demand for core competencies in knowledge and skills. Anesthesiology, due to its unique disciplinary nature, has a distinct technical system and knowledge framework. It focuses not only on the local body but also on the entire body. Anesthesiologists must understand the interconnections among various fields of professional knowledge, earning them the nickname "internists in the field of surgery." However, the current structure of graduate professional courses tends to be monotonous, making it difficult to build a comprehensive professional knowledge system through limited in-class teaching hours [19]. Furthermore, undergraduates majoring in clinical medicine constitute a significant portion of postgraduate students in anesthesiology, and they often lack sufficient exposure to anesthesiology courses [20]. This gap in foundational knowledge makes it challenging to meet the differentiated teaching requirements of postgraduate education. Additionally, some professional courses and teaching materials are overly theoretical, lacking practical relevance to clinical scenarios. For example, the course of anesthetic pharmacology introduces the mechanisms of action and pharmacological properties of drugs, but it does not offer guidance on how to use these drugs effectively in clinical situations. This disconnect prevents students from bridging basic knowledge with real-world applications. The slow pace of content updates further exacerbates this issue. Hence, it is essential to improve the knowledge system of postgraduate students through diverse means, such as self-directed learning both within and outside the classroom, to support competency-based education. Nevertheless, the current textbooks of subdisciplines are fragmented, and the knowledge within each subdiscipline is vast. This leads to an overall deficiency in students' understanding of the anesthesiology discipline as a whole [21, 22]. To address this, there is an urgent need to construct an integrated, systematic professional knowledge that facilitates independent learning and optimizes the content to better guide clinical practice.

Secondly, the scarcity and poor quality of online educational resources in anesthesiology hinder the effectiveness of postgraduate classroom teaching, autonomous learning, and lifelong learning in the digital age. We conducted surveys to assess graduates' evaluations and suggestions on various aspects of professional anesthesia education and curriculum planning. Among these, 10.03% of the graduating students expressed significant dissatisfaction with the "information-based teaching" aspect,

which ranked second to last among the nine survey items. High-quality online educational resources for anesthesia are generally scarce. Although some anesthesia knowledge resources are available on non-specialized platforms, they often suffer from issues such as disorganization, incomplete content, lack of peer review, high error rates, outdated information, complex retrieval processes, and low relevance to practical needs.

Supporting role of network resources of professional knowledge systems based on CBME in anesthesiology postgraduate talent cultivation

A "library-style" network resource platform for anesthesia graduate students, based on the CBME framework, provides multifaceted support for postgraduate education and training of anesthesiology talents. First, this practice-oriented, hierarchically structured, specialized, and integrated knowledge system compensates for shortcomings in classroom teaching, curricula, and existing teaching materials by providing novel and differentiated learning resources. Second, the platform supports a hybrid online-offline teaching mode, allowing students to learn flexibly in diverse circumstances and fostering the innovation and development of teaching models. In addition, the integrated resource network helps postgraduate anesthesiology students develop a holistic view of knowledge and independently build a comprehensive knowledge framework that spans interdisciplinary subjects. This enables them to better comprehend the discipline's intrinsic connections and evolving trends. The user-friendly interface and clear structure render knowledge accessible and searchable, providing students with convenient opportunities for autonomous and lifelong learning. Most importantly, this CBME-based online resource platform refines the competency-oriented talent cultivation system, promoting the overall development of students' theoretical knowledge and practical skills, thereby laying a solid foundation for their future clinical practice and academic research.

Resource content and construction methodology

Leveraging the features of 'Internet+' in the digital age and meeting the requirements of clinical anesthesia practice, course resources based on the CBME concept support the reform of the graduate curriculum and teaching approaches. The primary goal is to build a clinical practice-oriented professional knowledge system for postgraduate anesthesia students. Simultaneously, a multifunctional professional

Table 1. Overview of the classical knowledge module's structure

Primary Directory	Secondary Directory
Clinical anesthesia management	Preoperative evaluation and preoperative preparation Basic anesthesia management strategy Perioperative management of special crowd Perioperative management of patients with special diseases Special surgery perioperative management Perioperative management in outpatient and day-care wards Severe complications during anesthesia emergence and recovery from anesthesia
Clinical anesthesia techniques	Endotracheal intubation Neuraxial anesthesia technique Nerve block technique Vascular puncture and catheterization Mechanical ventilation techniques Heart, lung, and brain recovery technology
Clinical anesthesia pharmacology	Intravenous anesthetics Narcotic analgesics and antagonists Gas anesthetics Local anesthetics Skeletal muscle relaxants and their antagonists Anti-heart failure and anti-arrhythmia Drugs acting on the autonomic nervous system Other medications
Perioperative monitoring	Hemodynamic monitoring Respiratory function monitoring Brain function monitoring Liver and kidney function monitoring Internal environment monitoring Neurological monitoring
First aid and organ function protection	Cardiovascular function and protection Nervous system Respiratory function and protection Digestive system Urinary system Infection with sepsis Multiple organ dysfunction syndrome Trauma and hemorrhagic shock Neonatal first aid
Diagnosis and treatment of acute and chronic pain	Fundamentals of clinical assessment and treatment of pain Postoperative pain management Labor analgesia Chronic pain treatment Cancer pain treatment

network resource platform is established. By integrating these two modules, the platform adopts the characteristics of an open, systematic, easy-to-search, and dynamic 'library-type' resource. Finally, this model network resource platform is built through promotion, exploration, application, and continuous optimization.

During the construction process, a professional team reviewed relevant literature, expert consultations, and research on postgraduate anesthesiology students. The basic knowledge framework of anesthesiology was constructed by linking clinic requirements with anesthesia practice. The framework's content was further

enriched and refined to form a comprehensive knowledge network, which is finally embedded in the network resource platform. The construction of this platform was primarily led by the School of Anesthesiology at the Naval Medical University, with the support from invited experts across various academic disciplines.

The platform's primary focus is "classical knowledge module", which covers fundamental areas of clinical anesthesia practice that are relatively stable over time, including clinical anesthesia management, clinical anesthesia techniques, clinical anesthesia pharmacology, perioperative monitoring technology, first aid

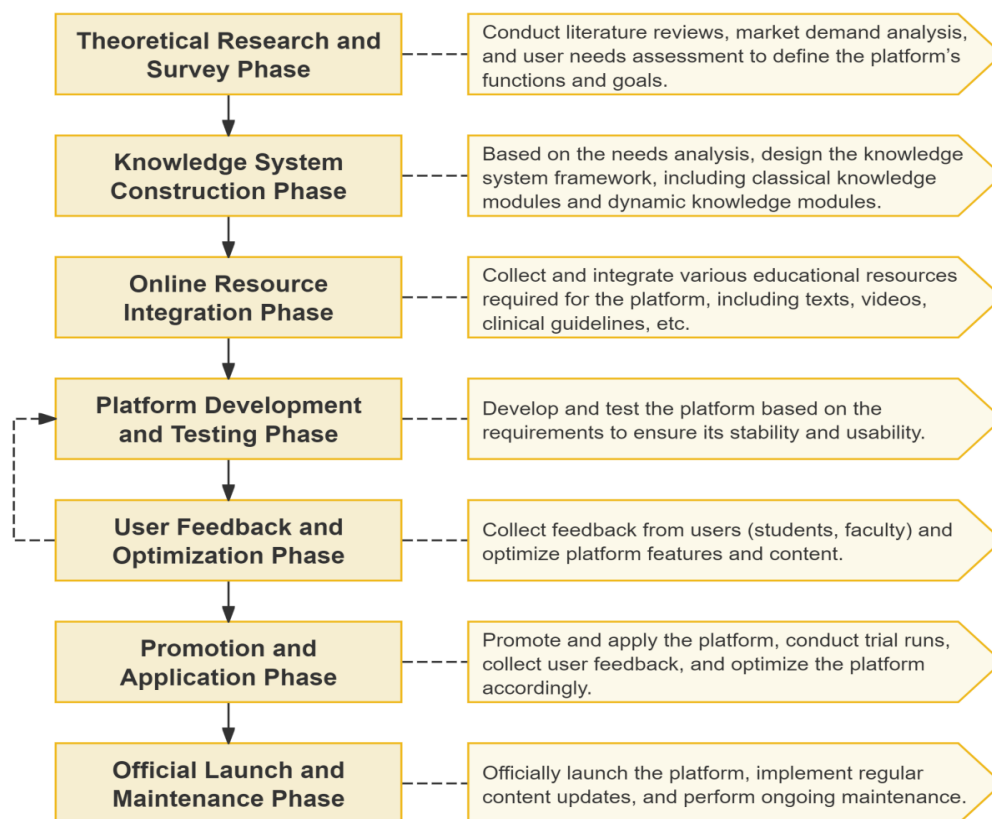


Figure 1. Flowchart of the construction process for the online resource platform. The diagram outlines the seven main stages of the platform development, from theoretical research and survey to official launch and maintenance.

and organ function protection, and acute and chronic pain diagnosis and treatment. Classical knowledge provides a comprehensive and systematic overview of the essential information required for clinical anesthesia practice (Table 1). The knowledge content is presented in various forms, such as articles, pictures, and videos. In addition, the content can be further screened and optimized to better meet the practical needs of clinical anesthesia practice.

Dynamic knowledge module, such as those addressing medical frontiers, can be added later as the field evolves. This module addresses the continuously changing nature of medical education and clinical practices. It is updated based on advancements in clinical guidelines, significant publications in peer-reviewed journals, emerging technologies, and user feedback, through a systematic monitoring process.

The frequency of updates is typically semi-annual, ensuring the platform stays current and meets the latest clinical and educational needs. However, immediate updates are prioritized to address critical advancements or urgent clinical requirements. The content for updates is sourced from authoritative guidelines, high-impact research, and validated online repositories. To ensure the accuracy and

relevance of these updates, a multidisciplinary expert panel—comprising educators, clinicians, and technical specialists—reviews and validates the contents before it is incorporated into the platform.

The integration process not only involves incorporating validated content into the platform but also adding annotations and metadata to enhance traceability and usability. Users are notified of updates via the platform interface, supplemented by periodic newsletters summarizing key changes. This structured approach guarantees the operability and sustainability of the dynamic knowledge modules, enabling the platform to continuously support the competency development of postgraduate anesthesiology students. The development of the online resource platform follows a systematic process, comprising seven main stages, from theoretical research and surveys to official launch and ongoing maintenance. A detailed overview of this process is shown in Figure 1.

To demonstrate the practicality of the online resource platform, a teaching cases have been integrated into its design and evaluation. For instance, in the clinical anesthesiology course, students are guided to use the platform for pre-class preparation, such as reviewing multi-

media materials on perioperative management and studying case scenarios of severe complications. During class, the platform facilitates interactive discussions, with students referencing dynamic modules containing the latest clinical guidelines and engaging in real-time case simulations. After class, the platform supports review and self-assessment through quizzes and annotated video tutorials, reinforcing key concepts. Preliminary feedback from teaching practice suggests that the platform significantly enhances students' ability to independently analyze clinical scenarios, understand complex pharmacological mechanisms, and integrate interdisciplinary knowledge, thereby providing strong support for competency-based learning.

Meaning and value of resource building

From a theoretical perspective, the construction of the resource system can bridge the gap within the CBME-oriented integrated knowledge system for clinical anesthesia practice. It addresses issues such as fragmented professional knowledge, the isolation of subdisciplines, and students' lack of a holistic understanding of the knowledge system.

From a practical standpoint, the specialized network resource platform contributes to the transformation and innovation of the postgraduate education teaching models, offering a platform and resources to support hybrid online-offline teaching modes. The knowledge system is closely aligned with clinical practice, emphasizing the practical knowledge needed to tackle real-world clinical problems, thereby enhancing its practical value. It enables students to independently and quickly construct their own professional knowledge system.

At the level of social value, the network resource platform, along with its integrated knowledge system and expanded content, is characterized with openness, systematization, searchability, and dynamics, providing diverse services such as self-directed learning and continuing education, not only for postgraduate students but also for professionals at large. By leveraging internet technology and a CBME-based professional knowledge system, the platform facilitates the transformation of graduate education models, aids in the competency development of graduate students majoring in anesthesiology, and ultimately enhances the quality of anesthesia talent cultivation.

Discussion

The construction of the online resource plat-

form for anesthesiology postgraduate education marks a significant advancement in integrating technology into the education. This platform addresses key challenges in traditional education, such as fragmented knowledge and limited access to clinical training resources. By integrating classical and dynamic knowledge modules, the platform offers a more systematic, easy-to-search, and continuously updated learning experience for students.

Compared to traditional educational models, our platform enables students to interact with dynamic learning materials, conduct self-assessments, and access the latest clinical guidelines in real time. This approach is consistent with international trends in medical education, where competency-based models and online resources are increasingly used to enhance learning outcomes.

Despite its strengths, the platform faces several challenges, such as the need for ongoing content updates and integration with other educational systems. While early feedback from students has been positive, further research is required to evaluate its long-term impact on clinical competencies and critical thinking skills. Future developments could involve expanding the platform's content offerings and enhancing user engagement through advanced simulation tools.

Conclusion

In conclusion, the development of the online resource platform for anesthesiology postgraduate education represents a significant advancement in modernizing teaching methods and enhancing clinical training. The platform provides a flexible, accessible, and comprehensive learning environment that supports competency-based education. As the platform continues to evolve, it holds great potential to improve the quality of anesthesiology education, both within our institution and across broader medical education contexts. Future efforts will focus on expanding the platform's capabilities, incorporating user feedback, and exploring its potential applications in other medical disciplines.

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References

- [1] General Office of the State Council [2020] No. 34 Guiding Opinions of the General Office of the State Council on Accelerating the Innovative Development of Medical Education. Available at: https://www.gov.cn/zhengce/content/2020-09/23/content_5546373.htm
- [2] Li H. Analysis of the Relationship between the Second-generation Medical Education Reform and Competency-based Medical Education. *Chin J Med Educ* 2019; 39: 801-806.
- [3] Frenk J, Chen L, Bhutta ZA, et al. Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. *Lancet* (London, England) 2010; 376: 1923-1958.
- [4] Frank JR, Snell LS, Cate OT, et al. Competency-based medical education: theory to practice. *Med Teach* 2010; 32: 638-645.
- [5] Zheng X, Peng H. A Brief Discussion on the Quality Education of Medical Students. *J Guangdong Med Univ* 2005; 339-340.
- [6] Education CCoETHfR. Consensus on Core Competency Framework for Residency Education Among China Consortium of Elite Teaching Hospitals for Residency Education. *Med J Peking Union Med Coll Hosp* 2022; 13: 17-23.
- [7] Hospitals CCoET. Establishment of the esident Core Competency Milestone Evaluation System in China Consortium of Elite Teaching Hospitals. *Med J Peking Union Med Coll Hosp* 2023; 14: 978-982.
- [8] Englander R, Cameron T, Ballard AJ, et al. Toward a common taxonomy of competency domains for the health professions and competencies for physicians. *Acad Med* 2013; 88: 1088-1094.
- [9] Frank JR, Langer B. Collaboration, communication, management, and advocacy: teaching surgeons new skills through the CanMEDS Project. *World J Surg* 2003; 27: 972-978.
- [10] Swing SR. The ACGME outcome project: retrospective and prospective. *Med Teach* 2007; 29: 648-654.
- [11] Jiao Gao [2018] No. 4 Opinions on Strengthening the Coordination between Medical Education and Implementing the Excellent Doctor Education and Training Program 2.0. Available at: http://www.moe.gov.cn/srcsite/A08/moe_740/s7952/201810/t20181017_351901.html
- [12] Kang W. The Development of Anesthesiology Education in the United States. Hebei Medical University 2023.
- [13] Program Requirements for Graduate Medical Education in Anesthesiology. Available at: https://www.acgme.org/globalassets/pfassets/programrequirements/040_anesthesiology_2023.pdf
- [14] INITIAL CERTIFICATION IN ANESTHESIOLOGY. Available at: https://www.theaba.org/wp-content/uploads/2023/01/Initial_Certification_Content_Outline-4.pdf
- [15] Ziv A, Wolpe PR, Small SD, Glick S. Simulation-based medical education: an ethical imperative. *Acad Med* 2003; 78: 783-788.
- [16] Yang F, Liu Y, Hu P, et al. Investigation on the Undergraduate Training of Anesthesiology Professionals and Competency-Oriented Optimization Strategies - Taking the Naval Medical University as an Example. *J Navy Med* 2023; 44: 1226-1231.
- [17] Yu J. Discussion on the Teaching Reform of Improving the Clinical Practical Ability of Anesthesiology Postgraduate Students. *Acta Med Sin* 2018; 31: 140-141.
- [18] Liang Y, Zhang Z, Jun Z, Zhang R. Cultivation of Non-technical Skills for Postgraduate Students Majoring in Anesthesiology. *Acta Acad Med Weifang* 2021; 43: 302-304.
- [19] WeiPing C. A Brief Discussion on the Cultivation of the Comprehensive Abilities of Research-oriented Anesthesiology Postgraduates. *Hosp Dir Forum* 2011; 342-343.
- [20] National Health Commission [2018] No. 21 Notice on Printing and Issuing the Opinions on Strengthening and Improving Anesthesia Medical Services Available at: https://www.gov.cn/zhengce/zhengceku/2018-12/31/content_5435335.htm
- [21] Jia S, Zhang N, Tian G. Exploration on Integrating the Cultivation of Scientific Research Ability into the Construction of Professional Courses for Postgraduate Students with Academic Degrees in Anesthesiology. *Med Innov China* 2021; 18: 159-163.
- [22] Setlur R, Jahan N, Gupta N, Sheshadri K. Competency-based undergraduate curriculum implementation in anesthesiology-A survey-based comparison of two models of training. *J Anaesthesiol Clin Pharmacol* 2021; 37: 196-202.