Open Journal of Applied Sciences, 2026, 16(1), 9-15
https://www.scirp.org/journal/ojapps
ISSN Online: 2165-3925
ISSN Print: 2165-3917

Innovative Experimental Teaching in Medical Education: Integrating Inquiry-Based Learning and Value Education

Jiawei Guo[1,2]

[1]Department of Vascular and Endovascular Surgery, The First Affiliated Hospital of Yangtze University, Jingzhou, China
[2]Department of Pharmacology, Medical Center, Yangtze University, Jingzhou, China
Email: guojw9@alumni.sysu.edu.cn

How to cite this paper: Guo, J.W. (2026) Innovative Experimental Teaching in Medical Education: Integrating Inquiry-Based Learning and Value Education. *Open Journal of Applied Sciences*, **16**, 9-15.
https://doi.org/10.4236/ojapps.2026.161002

Received: November 10, 2025
Accepted: January 1, 2026
Published: January 4, 2026

Abstract

With the continuous advancement of modern medical education, the cultivation of innovative, reflective, and socially responsible medical professionals has become a key educational objective. Experimental teaching, serving as a crucial bridge between theoretical knowledge and clinical practice, plays a pivotal role in achieving this goal. By integrating inquiry-based learning with value-oriented education, experimental teaching not only fosters students' ability to investigate medical phenomena through scientific reasoning, but also nurtures their professional ethics and humanistic awareness. In pharmacology and related medical experiments, students are encouraged to formulate questions, design experimental procedures, and interpret data independently. This transition from passive recipients to active participants enhances their experimental competence, critical thinking, and problem-solving skills. Moreover, it reinforces a strong sense of responsibility, ethical consciousness, and innovative spirit. Educational practice has demonstrated that inquiry- and value-integrated experimental teaching significantly contributes to the all-round development of medical students. It offers a practical and effective approach for cultivating high-quality healthcare professionals suited to the evolving demands of 21st-century medical education.

Keywords

Inquiry-Based Learning, Value-Oriented Teaching, Experimental Teaching, Medical Education, Pharmacology Education, Professionalism, Ethics Education

1. Introduction

The landscape of medical education is undergoing significant transformation as emerging medical sciences increasingly emphasize interdisciplinary integration, innovation, and the cultivation of value-oriented talent. Within this evolving framework, experimental teaching serves as a vital bridge between theoretical instruction and clinical application. Traditional models of experimental teaching often focus primarily on the verification of knowledge, with students playing passive roles in the learning process. However, the growing complexity of contemporary medical practice and societal needs calls for medical professionals who possess not only a solid foundation in scientific knowledge but also strong innovative thinking, problem-solving skills, and strong humanistic and ethical awareness.

To address these demands, this study proposes an inquiry-based and value-oriented experimental teaching model. In this model, "value-oriented education" is defined as the intentional cultivation of core professional values essential to modern medical practice, including integrity, empathy, professionalism, teamwork, and social responsibility. These values are operationalized through specific instructional strategies, such as embedding ethical considerations into experimental design, integrating patient-centered or public-health-related scenarios into inquiry tasks, encouraging students to justify experimental decisions from moral and social perspectives, and incorporating structured reflection sessions that link scientific findings to broader societal well-being.

While the proposed model shares some features with established approaches such as Problem-Based Learning (PBL), it differs in its explicit integration of professional values and ethical reasoning into the experimental process [1]. Unlike traditional PBL, which emphasizes problem-solving and self-directed learning, our model systematically embeds core professional values through contextualized scenarios, reflective exercises, and ethical decision-making tasks. This integration allows students not only to develop scientific inquiry skills but also to cultivate moral awareness and social responsibility, providing a more holistic preparation for contemporary medical practice.

By linking pharmacological mechanisms or physiological phenomena to real-world health challenges, students develop both scientific inquiry skills and ethical reasoning. This pedagogical model can be implemented through contextualized experimental problems, staged ethical decision-making exercises, reflective writing, peer feedback, and assessment frameworks incorporating value-oriented competencies. Such an approach transforms students from passive recipients of information into active, reflective, and morally grounded learners.

In summary, the exploration of inquiry-based and value-oriented experimental teaching represents a meaningful response to ongoing reforms in medical education. It provides a feasible pathway for cultivating high-quality medical professionals who possess both scientific competence and strong professional values, enabling them to meet the complex demands of healthcare in the 21st century. The following sections detail the design, implementation, and evaluation of this pedagogical model.

2. Integrating Inquiry-Based Learning with Professional Values

The integration of inquiry-based learning with professional values forms the foundation of a holistic and competency-oriented approach to undergraduate pharmacology education. Within this pedagogical framework, students actively formulate research questions, develop hypotheses, design experiments, and critically analyze data, cultivating curiosity, analytical thinking, and problem-solving abilities—essential competencies for future medical professionals.

Undergraduate pharmacology laboratories offer rich opportunities to blend technical skill development with ethical reflection. For instance, in cardiovascular pharmacology experiments, students may explore the effects of acetylcholine or epinephrine on isolated frog hearts, investigating how variations in dosage or route of administration influence physiological responses. In behavioral pharmacology simulations, students examine the analgesic effects of medications using animal models while considering issues related to animal welfare and ethical treatment. Similarly, experiments involving autonomic drugs on rabbit blood pressure or the simulation of acute toxicity (e.g., LD50) provide practical contexts to emphasize the importance of safe and responsible experimental design [2].

These learning activities foster students' ability to link laboratory observations with broader ethical and societal implications. Beyond mastering experimental techniques, students are guided to reflect on key questions such as: How might improper drug use compromise patient safety? In what ways can experimental findings be translated into clinical practice? What ethical and societal considerations should influence pharmacological research? By embedding professional values—including ethical reasoning, scientific integrity, and social responsibility—into laboratory instruction, educators cultivate a culture of accountability and conscientious decision-making. This approach ensures that students not only acquire technical competence but also internalize the ethical dimensions of medical practice. To effectively implement this educational model, experimental courses are intentionally designed to provide hands-on learning experiences that promote hypothesis generation, critical analysis, and ethical reflection. In doing so, abstract concepts are meaningfully connected to real-world laboratory contexts, reinforcing the idea that professional values should consistently inform both experimental design and execution.

3. Integrating Inquiry-Based Learning and Professional Values in Experimental Medical Education

Medical education is increasingly recognizing the need to cultivate professionals who are not only scientifically competent but also ethically grounded and socially responsible [3]. Transformative experimental courses aim to address this demand by integrating inquiry-based learning with professional value education, structuring laboratory experiences that foster independent thinking, methodological flexibility, and critical interpretation of results. The curriculum emphasizes open-ended experimental design that encourages students to explore creative hypotheses while adhering to rigorous scientific standards and reproducibility. Core modules span cardiovascular, neurological, renal, and behavioral pharmacology, where students investigate the effects of pharmacological agents on physiological systems through both hands-on experiments and virtual simulations, enabling exploration of scenarios that may be unsafe, impractical, or ethically restricted in real-life settings. These courses are carefully designed to embed professional values from the outset, prompting students to consider patient safety, societal impact, and responsible reporting, while structured reflection sessions and case-based exercises reinforce the connection between scientific inquiry and moral reasoning, integrity, empathy, teamwork, and social responsibility.

Within this framework, students actively engage in inquiry-driven and value-oriented activities that cultivate critical thinking, innovation, and ethical awareness. They design experiments, analyze unexpected results, propose alternative hypotheses, and iteratively refine experimental plans [4]. Collaborative projects, oral presentations, peer discussions, and reflective journals strengthen teamwork, communication, leadership, and ethical reasoning. In pharmacokinetics simulations, students optimize drug absorption and metabolism studies in liver and kidney models while considering sources of variability and error. In cardiovascular pharmacology experiments, they examine drug interactions and vascular tissue responses, discussing safety, clinical implications, and ethical concerns. Neuropharmacology experiments involve studying neurotransmitter receptor responses, isolating pathways, and interpreting unexpected cellular outcomes, linking experimental results to potential clinical applications. Herbal pharmacology studies challenge students to evaluate efficacy and safety, reflecting on patient use and broader societal consequences. Across all these activities, students internalize professional values, integrate ethical reflection with scientific inquiry, and cultivate analytical and social competencies essential for navigating complex challenges in research and clinical practice.

Laboratory learning further serves as a bridge between technical competence and professional practice by immersing students in variability, uncertainty, and real-world problem-solving [5]. Exposure to experiments such as drug-induced physiological responses, organophosphate toxicity, and behavioral pharmacology simulations challenges students to adapt protocols, anticipate clinical outcomes, and balance innovation with ethical judgment. Ethical reasoning is systematically incorporated, encouraging reflection on responsible handling of experimental animals, patient-centered safety considerations, and societal impacts of pharmacological interventions. Guided discussions, peer debates, and case studies cultivate accountability, integrity, empathy, and conscientious practice, while fostering creativity through alternative experimental designs and critical evaluation of limitations. By integrating analytical reasoning, innovation, and moral reflection, students develop holistic competencies that prepare them to confront the technical, ethical, and societal complexities of modern medicine.

This integrated model ensures that laboratory experiences cultivate not only technical proficiency but also professional values, critical thinking, and social consciousness. Students emerge as well-rounded medical professionals capable of combining scientific rigor with ethical reasoning, creative problem-solving, and social responsibility. By connecting curriculum design, active student engagement, and professional practice, this pedagogical framework provides a cohesive pathway for nurturing future medical practitioners who are both competent and morally grounded, ready to meet the multidimensional challenges of 21^{st}-century healthcare.

4. Implementation Challenges and Assessment Strategies

While the integrated experimental model provides a comprehensive framework for cultivating scientific competence and professional values, its practical implementation presents several challenges that must be carefully addressed. One major consideration is the need for specialized faculty training, as instructors must be capable of guiding students through inquiry-based and value-oriented activities while fostering critical thinking, creativity, and ethical reflection. Additionally, individualized guidance and supervision for each student can require significant time commitment, particularly in courses involving open-ended experiments and collaborative projects. Standardizing assessment across diverse experimental modules also poses challenges, as evaluating both technical proficiency and ethical reasoning involves nuanced judgment. Furthermore, adequate laboratory resources, flexible scheduling, and institutional support are essential to ensure successful implementation and maintain high-quality learning experiences.

To evaluate learning outcomes and ensure alignment with course objectives, a combination of assessment strategies can be employed. Rubric-based laboratory reports provide structured criteria for assessing experimental design, data interpretation, and ethical reflection. Reflective journals allow students to articulate moral reasoning, connect experimental findings to societal impact, and demonstrate personal engagement with professional values. Group presentations, peer feedback, and case discussion exercises further cultivate collaborative skills, ethical judgment, and communication abilities. In certain contexts, scenario-based quizzes or objective tests may complement these methods to evaluate knowledge acquisition and critical thinking. By combining multiple assessment approaches, instructors can monitor the development of both inquiry skills and ethical reasoning, thereby ensuring that students achieve the intended educational outcomes.

Despite these potential challenges, careful planning, targeted faculty development, and thoughtfully designed assessment strategies can ensure that this integrated pedagogical model successfully nurtures technically proficient, ethically grounded, and socially responsible medical professionals. By addressing practical implementation issues and systematically evaluating learning gains, the model strengthens the connection between curriculum design, student engagement, and professional practice, reinforcing the objectives described in the previous sections.

5. Conclusion: Transformative Impacts of Inquiry-Based and Value-Oriented Experimental Teaching

Integrating inquiry-based learning, ethical reflection, and hands-on experimentation provides a holistic educational experience. Students acquire technical skills, critical thinking, and ethical awareness necessary for responsible contributions to medical science and patient care. Laboratory courses become spaces for exploration, reflection, and collaborative problem-solving rather than rote repetition of predetermined procedures.

Students demonstrate improved critical thinking, creativity, and practical skills. They can design experiments independently, analyze complex results, and propose innovative solutions. Ethical awareness and social responsibility are reinforced consistently, as students consider the implications of experiments for patient care, public health, and society. Collaborative projects mirror real-world professional environments, strengthening teamwork, communication, and leadership.

Overall, the combination of inquiry-based learning and value integration transforms both students and the educational process. Students emerge as reflective, innovative, and ethically conscious professionals, prepared to tackle challenges in medical research and clinical practice. This model offers a replicable framework for experimental teaching and guidance for curriculum development, fostering medical professionals who are technically competent and socially responsible. Future work may explore adaptation of this model across other medical disciplines and larger cohorts to evaluate broader applicability.

Acknowledgements

This study was supported by National Natural Science Foundation of China (grant nos. 82300526); Health commission of Hubei Province Scientific Research Project (grant nos. WJ2025M003).

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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