

THE ART AND SCIENCE OF CLINICAL PEDAGOGY: ENHANCING MEDICAL EDUCATION FOR THE FUTURE

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ABSTRACT

Clinical medicine represents the practical application of science to diagnose and treat illness, requiring a critical transition from classroom learning to complex patient interactions. This article examines the evolution of medical education from early apprenticeships to the scientifically rigorous standards established by the Flexner Report and the subsequent calls for reform in the 21st century. It provides a comprehensive analysis of diverse clinical teaching methodologies, including bedside teaching, ward rounds, case-based learning (CBL), and simulation-based training. While these traditional methods are essential for developing clinical reasoning, professional empathy, and the integration of theory and practice, they are often hindered by persistent challenges such as time constraints, patient privacy concerns, and a lack of standardized assessment.

Central to this discussion is the transformative potential of Artificial Intelligence (AI) in modernizing clinical pedagogy. AI-driven tools—such as virtual patients, intelligent tutoring systems, and predictive analytics—offer personalized, scalable, and safe environments for students to master high-stakes procedures and complex diagnostics. These technologies provide objective, real-time feedback and allow for data-driven curriculum optimization. However, the integration of AI necessitates careful consideration of ethical challenges, including data privacy risks, algorithmic bias, and the potential for over-reliance. The article concludes that the future of medical education depends on a judicious blend of trusted traditional methods and smart technology. This hybrid approach ensures that AI augments, rather than replaces, the essential human touch and mentorship required to produce skillful, compassionate healthcare professionals.

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Introduction

Clinical medicine is the practical use of science to diagnose, treat, and prevent illness. Unlike classroom learning, it requires a deep understanding of diseases along with skills in patient interaction, critical thinking, ethical choice-making, and teamwork. Moving from

lectures to a busy clinic is a major step that builds a student's professional identity. Good clinical teaching is not just about giving out facts; it is about helping students become smart doctors who handle human suffering with both kindness and expertise. This article looks at the different ways of clinical teaching for both old and new and

discusses how Artificial Intelligence (AI) is changing the future of medical education.

The history of medical education has moved from simple apprenticeships to organized study plans. In the past, students simply followed experienced doctors to learn by watching. While helpful, this lacked consistency. The Flexner Report of 1910 was a major turning point, arguing that medical practice should be based on science, focusing on lab work and a set curriculum (Flexner, 1910). Even with these changes, clinical teaching often remained informal. Recently, there has been a new focus on teaching principles in clinics, realizing that being a good teacher is a skill that can be studied and improved. This change is part of a larger conversation about fixing medical education, as seen in the 2010 Carnegie Foundation report (Cooke, Irby, & O'Brien, 2010; Irby & Cooke, 2010). Clinical teaching faces many hurdles, such as busy schedules, balancing patient care with teaching, and the fast growth of medical knowledge. Solving these problems requires a careful and planned approach to how we teach in clinical settings.

Methods of Clinical Teaching

Clinical teaching uses many different methods to help students learn in various situations. Bedside teaching is often considered the best method because it occurs right next to the patient. It allows students to practice talking to patients and performing physical exams while getting immediate feedback, which helps build empathy and professional skills (Ramani, 2003; Aldeen & Gisoni, 2006). However, it can be time-consuming and sometimes difficult if a patient is too ill or wants privacy. Another common method is Ward Rounds, where a team of doctors and students walk through the hospital to review patient cases. Students present their findings and discuss treatment plans, which helps them learn clinical reasoning and teamwork (Gonzalo et al., 2009). While this covers many cases, the busy hospital environment can sometimes limit the extent to which each student can participate.

Outpatient Clinic Teaching happens in a clinic rather than a hospital room, focusing on common illnesses and long-term health management. It teaches students how to care for patients over a long period, though the fast pace of a clinic can sometimes feel rushed. For a more structured classroom approach, Case-Based Learning (CBL) and Problem-Based Learning (PBL) are used. In CBL, students work together to solve realistic medical cases (Burgess & Mellis, 2015). PBL goes further by using a complex medical problem as the starting point for all learning, helping students connect basic science with clinical practice (Walton & Matthews, 1989). These methods are great for critical thinking but require very good teachers to guide the discussion.

Modern technology has introduced Simulation-Based Learning, where students practice on high-tech mannequins or virtual reality. This creates a safe space to master difficult procedures without any risk to real patients (Lateef, 2010). While it is very effective, it can be expensive and does not always feel as "real" as a human encounter. More traditional methods like Grand Rounds and Didactic Lectures are still used to share new research and expert knowledge with large groups, though they are less interactive. Finally, Near-Peer Teaching involves senior students or junior doctors teaching those who are just starting. This is often less intimidating for new students and helps the older students reinforce their own knowledge.

Clinical teaching encompasses a wide array of methods, each with its unique strengths and optimal applications. A comprehensive approach often involves a judicious blend of these techniques to cater to diverse learning styles and clinical scenarios (Karkera et al., 2024).

1. Bedside Teaching: Often considered the gold standard of clinical teaching, bedside teaching involves direct interaction with patients in their presence. This method allows students to observe the clinical encounter firsthand, practice history taking and physical examination skills under supervision, and witness the nuances of patient-

physician communication. The immediate feedback loop and the opportunity to connect theoretical knowledge with real-life presentations are unparalleled, fostering empathy and professionalism (Ramani, 2003; Aldeen & Gisoni, 2006).

- **Advantages:** Direct patient interaction, real-time feedback, integration of theory and practice, development of communication and empathy, authentic assessment of clinical skills.
- **Disadvantages:** Time-consuming, may be disruptive to patient care if not managed well, patient privacy concerns, requires willing patients, limited by patient availability and clinical conditions.

2. Ward Rounds: Ward rounds are a cornerstone of inpatient clinical teaching. These structured discussions typically involve a team of healthcare professionals (physicians, residents, medical students) reviewing patient cases, discussing diagnoses, treatment plans, and progress. Students present cases, formulate differential diagnoses, and propose management strategies, receiving feedback from senior clinicians (Gonzalo et al., 2009). Ward rounds provide a rich environment for learning clinical reasoning, teamwork, and an understanding of the multidisciplinary nature of patient care.

- **Advantages:** Comprehensive case discussions, promotes clinical reasoning, fosters teamwork, exposure to multiple cases, demonstrates the continuum of care.
- **Disadvantages:** Can be didactic and less interactive for some students, time pressure, large group size may limit individual participation, less direct patient interaction for all students.

3. Outpatient Clinic Teaching: Similar to bedside teaching but in an ambulatory setting, outpatient clinic teaching exposes students to a wide variety of common conditions and chronic disease management. Students learn to conduct focused histories and physicals, formulate

management plans for non-acute conditions, and understand the importance of continuity of care and health promotion.

- **Advantages:** Exposure to common conditions, focus on chronic disease management, emphasizes preventive care, allows for follow-up of patients.
- **Disadvantages:** Time constraints, rapid patient turnover, may be less exposure to complex or acute conditions compared to inpatient settings.

4. Case-Based Learning (CBL): CBL involves presenting students with realistic clinical cases (often anonymized and fictionalized for teaching purposes) that require them to apply their knowledge to solve clinical problems. Students work collaboratively to analyze the case, identify learning objectives, research relevant information, and propose solutions. This method promotes self-directed learning, critical thinking, and problem-solving skills, with facilitators guiding the discussion rather than lecturing (Burgess & Mellis, 2015).

- **Advantages:** Promotes active learning and critical thinking, encourages self-directed learning, enhances problem-solving skills, can be tailored to specific learning objectives, flexible format.
- **Disadvantages:** Requires well-structured cases and skilled facilitators, can be time-consuming, less direct patient interaction, may not fully replicate the pressure of real clinical decision-making.

5. Problem-Based Learning (PBL): PBL takes CBL a step further, where a clinical problem is the starting point for learning. Students, in small groups, identify what they know, what they need to know, and how they will acquire that knowledge. The facilitator acts as a guide, encouraging inquiry and critical thinking. PBL emphasizes self-directed learning and the integration of basic science with clinical application (Walton & Matthews, 1989).

- **Advantages:** Deepens understanding of concepts, fosters critical thinking and problem-solving, enhances collaborative skills, promotes self-directed learning, integrates basic and clinical sciences.
- **Disadvantages:** Requires significant faculty training and commitment, can be resource-intensive, may not cover all essential content systematically, students may struggle with self-direction initially.

6. Simulation-Based Learning: Simulation utilizes high-fidelity mannequins, standardized patients (actors trained to portray patients), or virtual reality environments to replicate clinical scenarios. Students can practice a wide range of skills, from basic physical examination maneuvers to complex resuscitation efforts, in a safe and controlled environment without risk to real patients (Lateef, 2010). Debriefing after the simulation is crucial for learning and reflection.

- **Advantages:** Safe environment for practice, allows for repetition and mastery of skills, provides immediate feedback, excellent for practicing high-stakes or rare events, no risk to patients.
- **Disadvantages:** Can be expensive to set up and maintain, requires trained facilitators, may not fully capture the complexity and unpredictability of real clinical encounters, "suspension of disbelief" can be challenging.

7. Grand Rounds and Didactic Lectures: While less interactive than other methods, grand rounds and didactic lectures still play a role in clinical teaching, particularly for disseminating new knowledge, discussing complex cases, or presenting updates on specific diseases. They can provide a broad overview of a topic and expose students to expert opinions.

- **Advantages:** Efficient way to transmit information to a large group, can provide updates on current research and guidelines, exposure to expert speakers.

- **Disadvantages:** Passive learning, limited interaction, may not cater to diverse learning styles, less emphasis on clinical reasoning in real-time.

8. Near-Peer Teaching: Involving senior medical students or junior residents in teaching more junior students can be highly effective. Near-peer teachers can relate more closely to the struggles of their mentees, offer practical advice, and reinforce their own understanding through teaching.

- **Advantages:** Relatable and accessible for junior students, reinforces learning for the teacher, fosters a supportive learning environment, often more practical and less intimidating.
- **Disadvantages:** May lack the depth of experience of senior faculty, requires training for near-peer teachers, quality can vary.

Advantages and Disadvantages of Clinical Teaching in General

Advantages:

- **Integration of Theory and Practice:** Clinical teaching bridges the gap between theoretical knowledge learned in classrooms and its practical application in real-world patient scenarios. This integration is crucial for deep learning and retention.
- **Development of Clinical Reasoning:** Students learn to gather information, synthesize data, formulate hypotheses, and make decisions under uncertainty, mirroring the cognitive processes of expert clinicians (Khani et al., 2023).
- **Enhancement of Communication Skills:** Direct patient interaction and team discussions hone verbal and non-verbal communication skills, including active listening, empathy, explanation of complex medical concepts, and breaking bad news.

- **Cultivation of Professionalism and Ethics:** Students observe and internalize professional behavior, ethical considerations in patient care, teamwork, and accountability. They learn the importance of patient autonomy, confidentiality, and beneficence (Cooke, Irby, & O'Brien, 2010).
- **Exposure to Diverse Patient Populations and Diseases:** Clinical environments expose students to a wide spectrum of diseases, varying patient demographics, and the social determinants of health, providing a rich learning experience.
- **Real-time Feedback and Assessment:** Clinical teachers can provide immediate, formative feedback on students' performance, allowing for rapid correction and improvement of skills. Direct observation is a powerful assessment tool.
- **Motivation and Engagement:** The opportunity to interact with patients and contribute to their care is highly motivating for medical students, fostering a sense of purpose and engagement in their learning.
- **Mentorship and Role Modeling:** Clinical teachers serve as role models, demonstrating not only clinical expertise but also professionalism, compassion, and resilience. Mentorship relationships can be profoundly influential.
- **Patient Privacy and Comfort:** Balancing educational goals with patient privacy and comfort can be challenging. Some patients may be unwilling or unable to participate in teaching encounters.
- **Lack of Standardization:** The quality and consistency of clinical teaching can vary significantly depending on the individual teacher's skills, enthusiasm, and pedagogical training.
- **Assessment Challenges:** Objectively assessing complex clinical skills, professionalism, and clinical reasoning in a busy clinical environment can be difficult and time-consuming.
- **Student Preparedness and Anxiety:** Students may arrive at clinical rotations with varying levels of foundational knowledge and experience, leading to anxiety and difficulty in applying concepts.
- **Faculty Burnout:** The demands of patient care combined with teaching responsibilities can lead to faculty burnout if not adequately supported and recognized.
- **Limited Opportunities for Repetition:** Unlike simulation, real clinical scenarios offer limited opportunities for students to repeatedly practice complex procedures or interactions until mastery is achieved.

Disadvantages:

- **Time Constraints:** Clinical environments are inherently busy, with patient care often taking precedence. This can limit the time available for dedicated teaching and one-on-one interaction (Deza et al., 2009).
- **Variability in Patient Cases:** The availability of specific patient cases cannot be guaranteed, meaning students may not encounter certain conditions or presentations during their rotations.

How to Incorporate Artificial Intelligence in Clinical Teaching

Artificial intelligence (AI) holds immense potential to revolutionize clinical teaching, addressing many of the traditional challenges and creating innovative learning opportunities. AI can act as a powerful tool to augment, rather than replace, human educators, providing personalized learning experiences, enhancing efficiency, and expanding access to resources (Narayanan et al., 2023).

1. AI-Powered Virtual Patients and Simulations: Sophisticated AI algorithms can power highly realistic virtual patients that respond dynamically to student inputs. These virtual patients can simulate a vast array of clinical conditions, including rare diseases and complex comorbidities, offering students unlimited opportunities for practice in history taking, physical examination (through haptic feedback devices), diagnosis, and treatment planning. AI can track student performance, identify areas of weakness, and provide immediate, personalized feedback.

- Example: An AI-driven virtual patient could present with atypical chest pain. Students would interact by asking questions, performing virtual physical exams, and ordering diagnostic tests. The AI would then simulate the patient's physiological responses and provide feedback on the student's diagnostic accuracy and treatment choices.
- Benefits: Scalability, standardized learning experiences, safe environment for high-stakes procedures, access to rare cases, personalized feedback, objective performance tracking.

2. Intelligent Tutoring Systems (ITS) and Adaptive Learning Platforms: AI can analyze a student's learning patterns, strengths, and weaknesses to create highly personalized learning paths. ITS can recommend specific resources, practice questions, or clinical scenarios based on a student's individual needs. These systems can adapt the difficulty and content of material in real-time, ensuring optimal challenge and engagement (Tapalova & Zhiyenbayeva, 2022).

- Example: An AI platform could identify that a student consistently struggles with understanding cardiac murmurs. It would then provide targeted tutorials, interactive diagrams, and simulated auscultation exercises until mastery is achieved.

- Benefits: Personalized learning, addresses diverse learning styles, efficient knowledge acquisition, continuous assessment, reduces the burden on human instructors for repetitive explanations.

3. AI for Clinical Reasoning and Diagnostic Support: While not replacing human judgment, AI can assist students in developing their clinical reasoning skills. AI-powered diagnostic tools, often used in clinical practice, can be integrated into teaching to show students how complex data points are analyzed to arrive at a diagnosis. Students can compare their differential diagnoses with those generated by AI, promoting critical reflection (Ramoni et al., 2024).

- Example: After a student completes a virtual patient encounter, an AI could provide a suggested differential diagnosis based on the collected data, alongside a detailed explanation of the reasoning. The student could then compare this with their own reasoning.
- Benefits: Exposure to advanced diagnostic reasoning, highlights potential biases, encourages evidence-based decision-making, supplements human teaching.

4. Natural Language Processing (NLP) for Feedback on Documentation and Communication: NLP can analyze student-written progress notes, discharge summaries, or patient communication transcripts (from simulated encounters). AI can identify grammatical errors, omissions, clarity issues, and even assess empathy in written communication. This provides scalable and objective feedback on crucial documentation and communication skills.

- Example: A student submits a mock patient note. An NLP tool flags missing elements, unclear phrasing, or jargon, providing suggestions for improvement based on established medical documentation standards.

- Benefits: Objective and consistent feedback, improved documentation quality, enhanced communication skills, reduced faculty workload in reviewing written assignments.

5. AI-Enhanced Image and Pattern Recognition Training: In specialties like radiology, pathology, and dermatology, AI can be used to train students in recognizing subtle patterns and abnormalities in medical images. AI algorithms can highlight areas of interest, provide immediate feedback on diagnostic accuracy, and curate vast libraries of images for diverse learning experiences.

- Example: Students could use an AI-powered platform to analyze thousands of chest X-rays, with the AI identifying normal vs. abnormal findings and providing immediate feedback on their interpretations.
- Benefits: Accelerated learning in visual diagnostics, exposure to a wide range of cases, objective performance measurement, reduced need for expert supervision for initial training.

6. Predictive Analytics for Student Performance and Remediation: AI can analyze large datasets of student performance, identifying students who are at risk of struggling early on. This allows educators to intervene with targeted remediation programs before significant difficulties arise.

- Example: An AI model predicts that a student's performance on recent quizzes and simulated cases indicates a potential struggle in understanding renal physiology. The system then alerts faculty, who can offer additional support or resources.
- Benefits: Proactive intervention, personalized support, improved student outcomes, efficient resource allocation.

7. AI for Curriculum Development and Optimization: AI can analyze learning outcomes, student feedback, and performance

data to identify gaps or inefficiencies in the curriculum. It can suggest optimal sequencing of topics, recommend relevant resources, and help educators tailor content to meet evolving healthcare needs.

- Example: AI could analyze student performance on various clinical competencies and identify that students consistently perform poorly in managing acute asthma exacerbations. This insight could prompt a curriculum review to strengthen teaching in that area.
- Benefits: Data-driven curriculum improvements, efficient resource allocation, continuous refinement of educational programs.

Challenges in Incorporating AI:

Despite the immense potential, incorporating AI into clinical teaching presents several challenges:

- Cost and Infrastructure: Developing and deploying sophisticated AI systems requires significant investment in technology, data infrastructure, and specialized personnel.
- Data Privacy and Security: AI systems rely on large datasets, raising concerns about patient and student data privacy and security. Robust ethical guidelines and secure systems are essential (Alam, Lim, & Zulkipli, 2023).
- Bias in Algorithms: AI algorithms are trained on existing data, which may contain biases (e.g., related to patient demographics or historical diagnoses). If unchecked, these biases can be perpetuated or even amplified, leading to inequitable learning experiences or skewed diagnostic reasoning (Alam, Lim, & Zulkipli, 2023).
- Faculty Training and Acceptance: Educators need to be trained not only in using AI tools but also in understanding their capabilities and limitations. Resistance to change or a lack of understanding can hinder adoption.

- **Maintaining Human Touch:** While AI can enhance efficiency, the human element of empathy, ethical judgment, and complex patient interaction remains paramount. AI should augment, not replace, the mentor-mentee relationship.
- **Regulatory and Ethical Frameworks:** As AI in medical education evolves, clear regulatory and ethical frameworks are needed to ensure responsible development and deployment.
- **Over-reliance and Deskilling:** There is a risk that students might over-rely on AI tools, potentially leading to a deskilling in fundamental clinical skills if not carefully managed (Alkhaaldi, 2023).

Conclusion

Clinical teaching is a vital part of medical education that turns students into skilled and kind healthcare professionals. It uses many different ways to teach, combining old methods like bedside teaching and ward rounds with new ones like simulation and problem-based learning. Each method helps in its own way, from teaching students how to talk to patients to helping them think critically and work as a team. However, there are still difficulties, such as a lack of time, differences in the types of patients students see, and the need for fair ways to test their skills.

The arrival of Artificial Intelligence (AI) offers a great chance to solve these problems and improve teaching. AI tools, such as virtual patients and smart tutoring systems, can provide personalized and fair learning experiences that support human teachers. AI can help students improve their diagnosis skills, read medical images better, and even help schools plan better lessons (Narayanan et al., 2023). This technology can make learning more efficient and fair for everyone.

However, using AI must be done carefully and ethically. We must protect data privacy, prevent bias in computer programs, and make sure the human side of medicine stays at the center of care

(Alam, Lim, & Zulkipli, 2023). AI should be a tool that helps both teachers and students, not something that replaces the human bond and mentorship that are so important in medical training. The future of clinical teaching depends on a mix of trusted traditional methods and smart new technology. This will prepare future doctors to be skillful, kind, and ready for the changes in 21st-century healthcare.

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