Education Reform and Development, 2025, Volume 7, Issue 8
https://ojs.bbwpublisher.com/index.php/ERD
Online ISSN: 2652-5372
Print ISSN: 2652-5364

Discussion on the Transformation Mode of Clinical Diagnosis and Treatment Thinking in Medical Imaging

Lulu Li[1], Pengfei Liu[1]*, Yangyang Li[2]

[1]MR Department, The First Affiliated Hospital of Harbin Medical University, Heilongjiang, China
[2]Colorectal surgery, The third Affiliated Hospital of Harbin Medical University, Heilongjiang, China

**Author to whom correspondence should be addressed.*

Abstract: The low conversion rate of clinical diagnostic thinking in medical imaging is an important bottleneck in current medical education, manifested as a discontinuous connection from theory to practice for clinical medical students, specifically reflected in core issues such as the difficulty in image-pathology association, the lack of three-dimensional spatial positioning ability, and insufficient cognition of dynamic disease courses. This study breaks through the improvement ideas at the application level of traditional technologies, establishes a "three-dimensional ability matrix model", explores how to solve the problem of low conversion rate of clinical medical students, enables students to complete the efficient transformation from theoretical courses to clinical diagnosis and treatment thinking, and achieves remarkable results in improving the quality of medical imaging education and cultivating clinical diagnostic thinking. It provides a new idea for the efficient transformation of clinical medical students' thinking in future medical education.

Keywords: Medical imaging; Internship teaching; Clinical, diagnostic, thinking, and transformation; Educational innovation

Online publication: September 4, 2025

1. Introduction

As a branch of medical education, medical imaging bears the critical responsibility of interpreting and analyzing medical images. With advancements in healthcare technology, the importance of medical imaging education has become increasingly prominent. Students are required to master not only theoretical knowledge but also practical skills, clinical translation capabilities, and research innovation abilities [1]. Therefore, the transition from theoretical knowledge to clinical practice relies heavily on the bridging role of practical training courses. This is particularly challenging for clinical medicine students in translating imaging theory into clinical practice.

According to the RSNA 2022 Core Competency Assessment Report, 42% of radiology residents experience significant difficulties in complex image interpretation [2]. A recent *Radiology* study revealed that medical students' accuracy in interpreting chest X-rays is only 63.2%, far below clinical requirements [3]. Academic Radiology (2023) reported that medical students still struggle with "image-pathology" correlation three months post-internship, with an accuracy rate of merely 58.3%. Concurrently, WHO's 2023 Global Medical Education Monitoring Data shows that 83% of medical schools in developing countries still use traditional film-based teaching methods, lagging behind digital healthcare advancements [4]. These findings highlight significant gaps in clinical diagnosis training for medical imaging students, with clinical medicine students facing even more pronounced challenges.

Building on teaching experience with medical imaging students and considering clinicians' learning characteristics and needs, this paper proposes innovative reforms. The goal is to develop a teaching model better suited to clinicians' requirements through in-depth analysis. As technology progresses, digital and intelligent personalized teaching must integrate into traditional methods to enhance the efficacy of imaging practice conversion. Thus, effectively incorporating innovative teaching methods into clinical medical imaging internships to improve efficiency and quality represents an urgent challenge in medical imaging education.

2. The central role of medical imaging in clinical diagnosis and treatment

Diagnostic level: Provides visual information at anatomical, functional, and molecular levels (e.g., CT/MRI morphological diagnosis, PET metabolic assessment). Aids disease staging (e.g., tumor TNM staging), classification (e.g., TOAST stroke typing), and prognosis evaluation. Therapeutic level: Guides interventional procedures (e.g., image-guided biopsy, radiofrequency ablation) and monitors treatment efficacy (e.g., RECIST criteria for tumor response). Research translation: Radiomics and AI models support clinical decision-making (e.g., benign/malignant pulmonary nodule prediction), enabling quantitative imaging biomarker discovery. Forms the infrastructure for precision medicine implementation.

This tripartite role establishes medical imaging as the visual informatics backbone of contemporary healthcare, transforming raw data into clinically actionable knowledge. The field continues to evolve from passive documentation to active decision-support, with emerging technologies like molecular imaging and AI further expanding its clinical footprint.

3. Current state of medical imaging education for clinical students

Clinical students outside radiology specialties typically study systemic and regional anatomy but lack training in cross-sectional anatomy. This gap impedes their ability to map anatomical structures to imaging planes, resulting in poor spatial consistency. Without foundational imaging knowledge, students resort to rote memorization, struggling to master MRI, CT, and related diagnostic courses. Consequently, they face difficulties integrating imaging findings with clinical practice.

Moreover, non-radiology clinicians (undergraduates, graduates, and residents) have limited medical imaging training, with particularly rushed practical sessions. Since imaging internships are crucial for validating theoretical knowledge, improving their efficiency is vital for mastering common/multifocal disease presentations and understanding disease progression.

This challenging learning environment creates excessive cognitive load as students attempt to simultaneously integrate anatomical knowledge, pathophysiological principles, and technical imaging parameters, often resulting in cognitive overload and reliance on superficial pattern memorization rather than deep understanding. These systemic shortcomings collectively contribute to delayed development of imaging literacy, over-reliance on radiology consultations, suboptimal utilization of diagnostic imaging resources, and increased diagnostic errors in early clinical practice. The situation underscores the urgent need for comprehensive educational reforms that incorporate earlier and more frequent imaging exposure, integration of cross-sectional anatomy, competency-based training models, and advanced simulation technologies to better prepare future clinicians for the imaging-intensive reality of modern medical practice.

4. Establishment of a clinical competency model

To address these educational challenges, our institution has developed an innovative competency framework that systematically bridges the gap between theoretical knowledge and clinical application in medical imaging. This multidimensional model emphasizes progressive skill acquisition through three critical axes of development.

Our department developed a "Three-Dimensional Competency Matrix" (**Figure 1**) to clarify the objectives of internship reform. Our competency framework represents a paradigm shift in medical imaging education, systematically addressing current limitations while preparing students for future advancements in this rapidly evolving field. By integrating technical, cognitive, and professional development within a structured, progressive curriculum, we are establishing new standards for clinical imaging education.

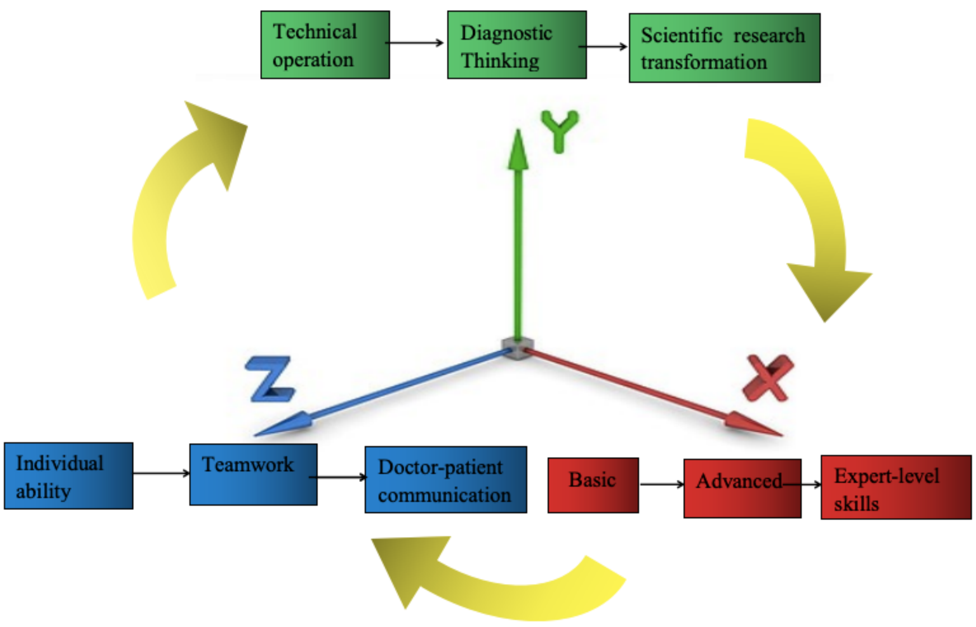

Figure 1. Three-dimensional competency matrix model.

4.1. X-axis: Basic → Advanced → Expert-level skills

The medical imaging internship course should provide relatively comprehensive internship opportunities within a limited time. The college will divide each group of students participating in the clinical internship into a group of 10–15 people. After arriving at the internship department, the department will further divide the college into sub-groups of about 3–5 people. The internship teachers will be divided into main instructors and auxiliary instructors, and will be integrated into each sub-group to lead the trainees to complete the process of familiarizing themselves with the machines, the imaging principles, and the basic operation principles. The dry and obscure imaging principles will be integrated into the functions of each component and the actual operation steps. The performance of different imaging equipment and the indications for different imaging examinations will be mastered. The best examination methods for different diseases will be fully grasped by clinical physicians, which is also an important aspect that most clinical physicians lack in their clinical practical work. Gradually complete various tasks, including the operation of imaging equipment (such as CT and MR parameter settings), the processing after imaging (such as three-dimensional reconstruction), and the advanced training in imaging diagnosis. Start to truly complete the verification from theoretical textbooks to practice, from the basic skills.

Meanwhile, the Imaging Department of our hospital has established a "university-clinical" joint teaching base to implement the concept of "early and extensive clinical exposure". During their academic tenure, clinical students are required to complete three iterative and progressive cycles of practical training: in-class internships, pre-employment internships, and graduation internships.

Distinct training programs are designed for different stages, mimicking the hierarchical and progressive teaching model of standardized residency training. Our goal is to cultivate comprehensive imaging professionals, minimize the adaptation period from theory to clinical practice, and continuously refine and validate theoretical knowledge through hands-on experience.

This approach allows non-clinical physicians to engage with imaging medicine intermittently, thereby reactivating situational memories and facilitating the conversion of theory into practice.

4.2. Y-axis: Technical operation → Diagnostic thinking → Research translation

The internship course of medical imaging should provide relatively comprehensive internship opportunities within a limited time, allowing students to operate medical imaging equipment under supervision, conduct image acquisition, processing and analysis, understand the reasons for setting basic examination parameters, the purpose of each basic examination sequence, and the information that can be obtained from the images produced by this sequence. It should also enable students to deeply understand the reasons for using each examination image and the examination results represented by different examination images. Based on mastering the basic knowledge, the operation of actual cases should be started, making a preliminary diagnosis based on the patient's medical history, examination site, and imaging manifestations, and conducting a preliminary diagnosis and treatment assessment process. While making a diagnosis, the ability of diagnose and treat should be improved. However, due to the time limit, clinical interns cannot complete the learning of all common diseases through actual operation cases within a limited time. Therefore, the use of our hospital's Picture Archiving and Communication System (PACS) has accelerated the teaching process.

The emergence of the PACS system has changed the traditional image storage and reading methods in hospitals, and has also provided strong technical support and equipment foundation for the development and reform of medical imaging education. Digital medical imaging education was established on this basis, and it has cultivated a large number of professional talents for medical imaging through up-to-date teaching methods [5,6]. Smart teaching is a teaching mode that utilizes modern information technology and artificial intelligence means to build personalized and interactive teaching environments, promoting in-depth participation and interaction in the teaching process, and optimizing learning outcomes [7]. Therefore, in the internship teaching process, digital learning resources, smart teaching tools, and artificial intelligence technology should be integrated into the courses, allowing students to truly achieve the goals of the imaging practice courses. With the introduction of our hospital's AI system, including the AI diagnosis system for CT pulmonary nodules and coronary artery angiography (CTA), and the AI diagnosis system for magnetic resonance liver, the application of artificial intelligence in imaging diagnosis has been further strengthened.

With the continuous advancement of technology, students need to master the cutting-edge AI technologies and their relevance to medicine. The concept of Radiomics was introduced to teach students how to extract high-throughput features from images and correlate them with clinical prognosis. Large-scale data analysis practices were conducted using open-source databases (such as TCIA, BraTS), learning the standardized processing and mining methods of image data. Connecting to the forefront of research, the ability to conduct data-driven imaging analysis was cultivated. The impact of interdisciplinary course design on medical imaging education is profound. In modern medical education, medical imaging is no longer an isolated discipline but is closely linked with computer science, data science, engineering, and other disciplines. Through interdisciplinary course design, students cannot only acquire professional knowledge of medical imaging but also understand the principles of AI algorithms, methods of big data analysis, and engineering technologies of imaging equipment. This integration of interdisciplinary knowledge helps to cultivate students' innovative thinking and comprehensive problem-solving abilities [8].

4.3. *Z-axis:* Individual Competency → Teamwork → Patient Communication

Gamification enhances engagement:

During the teaching process, the monotonous input of theoretical knowledge often fails to achieve the desired teaching results and cannot enhance students' intrinsic motivation. Therefore, in the internship process, a gamified teaching model is introduced to enable students to complete their learning through games and solidify their theoretical knowledge through practice. For instance, with the support of an image database, a game against AI intelligence is played. For the same case, one group of students competes against the AI for the analysis of lung nodules. During the game, students deepen their understanding of lung nodules and improve their diagnostic ability; simulate emergency scenarios, conduct group competitions, requiring students to complete image interpretation within a limited time and formulate treatment plans, mastering the diagnosis process of common diseases; for difficult diseases, design an "image treasure hunt" task, using image features to find hidden pathological clues, comparing step by step, analyzing the disease components, and completing the analysis and discussion of the disease. At the same time, mechanisms such as points and leaderboards are introduced to enhance the learning fun. Through gamification, learning motivation is stimulated, learning fatigue is reduced, and personal abilities are improved. Teamwork is strengthened through mutual encouragement and competition, and continuous progress is made.

Under the digital and intelligent teaching model, the significance of humanistic education in teaching should also be emphasized. Therefore, an imaging ethics module (such as radiation protection, patient privacy protection, etc.) should be added to the teaching. Through role-playing to simulate doctor-patient communication scenarios, humanistic education is incorporated into the gamified teaching process to train students on how to explain imaging results to patients and handle ethical-related issues that may arise during the process. Cultivate empathetic and responsible imaging physicians, forming a "technology-ethics" double helix structure.

5. Construction and training of the teaching staff

During the application of the above matrix model, innovative teaching methods such as digitization and gamification can be well accepted by students. They can solve the problem of fully interpreting theoretical knowledge in practice, rather than simply repeating the theoretical content in the traditional sense. It is difficult for clinical medical students to absorb and master it well within a short period and achieve the purpose of flexible transformation. Moreover, the biggest challenge lies in the cultivation of the teaching staff, especially for clinical practice teachers, as fully mastering new teaching skills is also a challenge. Therefore, our hospital continuously strengthens the training of the teaching staff, conducts collective lesson preparation, and each lecturer should fully express their teaching ideas and processes during the lesson preparation. The members of the teaching group will continuously refine and discuss the teaching process. During the teaching process, the role of teaching supervision is also fully exerted. From a third-person perspective, observe the teaching process of the teachers and the teaching effect of students in class, and communicate and provide feedback with the teachers promptly after class to continuously improve the quality and level of the instructors. Based on this, our department assigns 1 to 2 assistant teaching teachers to each teaching instructor. While maximizing the efficiency in training clinical doctors, this also provides sufficient preparation for cultivating reserve teaching staff. Teaching staff need to be continuously cultivated with care, passed on and connected continuously, and infused with new vitality. Based on the constantly changing technological development, we strive to ensure that teaching can also continuously improve, providing the most suitable teaching model for students.

6. Future prospects and challenges: The Extended Reality (XR) teaching paradigm

The implementation of Virtual Reality (VR) and Augmented Reality (AR) technologies in medical education continues to face several challenges, including high hardware costs, digital ethics considerations, and varying levels of digital literacy among teaching faculty. However, significant progress is anticipated shortly with the accelerated development of 3D virtual imaging anatomy laboratories. These advanced facilities will enable students to utilize VR devices for immersive exploration of human anatomical structures and their radiological representations, facilitating dynamic comparisons between pathological and normal tissues.

Through AR technology, medical imaging data such as CT and MRI scans can be digitally superimposed onto physical anatomical models or a patient simulator, achieving real-time "image-anatomy" correlation. This technological approach effectively overcomes the limitations inherent in traditional two-dimensional imaging, significantly enhancing spatial perception while reducing the cognitive abstraction of complex anatomical relationships.

Within medical imaging education, this paradigm shift accomplishes more than just transitioning from 2D slice interpretation to 3D spatial cognition. More importantly, it systematically cultivates two critical competencies demanded by contemporary medical practice: "spatial diagnostic reasoning" and "dynamic clinical decision-making" capabilities. Future research directions should focus on integrating neuroconstructivist learning principles with extended reality (XR) technologies, with the ultimate goal of optimizing educational environments at the level of synaptic plasticity to maximize learning outcomes.

The application of virtual reality (VR) and augmented reality (AR) technologies currently faces challenges such as high hardware costs, digital ethics issues, and teachers' digital literacy. It is expected that soon, a 3D virtual imaging anatomy laboratory can be rapidly constructed. Students can immerse themselves in observing the human anatomy structure and imaging manifestations through VR devices, and dynamically understand the differences between diseased and normal tissues. Using AR technology, CT, MRI, etc. images can be superimposed onto human models or patient simulation bodies to achieve real-time comparison of "images and anatomy". This breaks through the limitations of traditional two-dimensional images, enhances spatial perception ability, and reduces the abstractness of learning. In medical imaging education, this design not only realizes the cognitive upgrade from two-dimensional slices to three-dimensional reality but also cultivates “spatial diagnostic thinking” and “dynamic decision-making ability” that meet the needs of modern medicine. In the future, it is necessary to further explore the integration of neuroconstructivism and extended reality technology to optimize the design of the learning environment at the synaptic plasticity level.

7. Conclusion

Medical imaging education must center on students, leveraging technology, clinical integration, and interdisciplinary approaches to cultivate competent, empathetic professionals. The shift from “image description” to “clinical solutions” requires breaking disciplinary barriers and embracing innovation. In the AI era, teaching must evolve to produce multidimensional, socially responsible talent.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Huang J, Qi Z, Lu J, et al., 2019, Application of T-PACS System Combined with MDT Model in Medical Imaging Diagnosis Teaching. Journal of Medical Imaging, 29(7): 1213–1216.

[2] RSNA Education Committee, 2022, Core Competency Gap Analysis in Radiology Residency Programs: A Nationwide Cross-Sectional Survey. RSNA Annual Meeting, Chicago, IL, United States.

[3] Smith J, Doe R, Lee K, 2021, Competency Gaps in Chest X-Ray Interpretation Among Medical Students. Radiology, 301(2): 398–406.

[4] WHO, 2023, Global Standards for Digital Health Education. World Health Organization, Geneva: 45–48.

[5] Zhang M, Su Z, Du X, et al., 2019, Application of Case Discussion-Based PBL Teaching Method Based on WeChat Platform in Medical Imaging Teaching. Chinese Medical Equipment, 16(10): 127–130.

[6] Qin J, 2021, Research on Implementation Strategies of Smart Teaching Mode in Universities Under the Background of Educational Informatization. Journal of Qilu Normal University, 36(6): 29–34.

[7] Zhang P, Feng C, 2024, Thoughts on the Application of Artificial Intelligence Technology in Medical Imaging Course Practical Teaching. Smart Health, 10(8): 1–4 + 8.

[8] Hu F, Sun Z, Zhou J, 2024, Application and Evaluation of Artificial Intelligence Technology in Medical Imaging Teaching. Chinese Health Industry, 21(12): 152–155.