The Future of Radiology Education: Adaptation to Technological Advances and Evolving Roles

Introduction

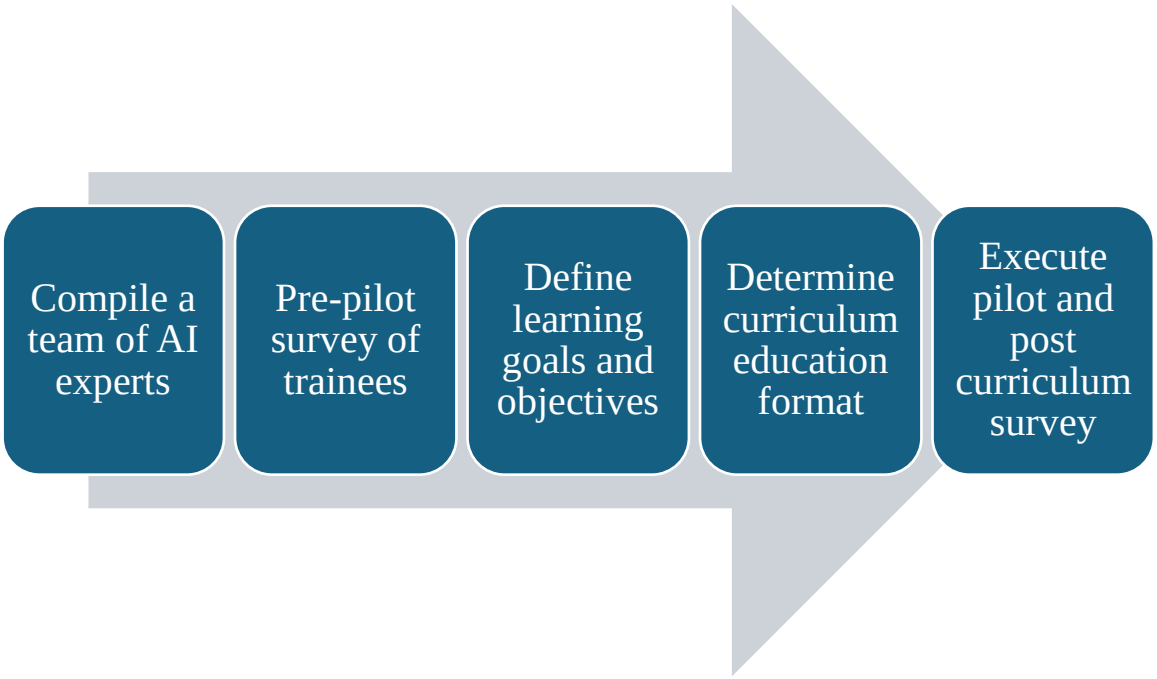
Radiology education is at a crossroads, with rapid advancements in technology poised to significantly change the role of the future radiologist in clinical practice and evolve the current training landscape. Radiologists will rely on artificial intelligence to assist in image analysis, allowing them to focus more on complex diagnostic challenges and patient interactions. (1)Additionally, they may take on expanded roles in multidisciplinary teams, providing insights that integrate imaging with other clinical data. This shift will necessitate new skills and training in data interpretation and technology management. (2)The 2023 RCR Clinical Radiology Curriculum highlighted the need for trainees to be adept at this changing landscape, with trainees expected to have a substantial up-to-date knowledge of artificial intelligence, deep learning and radiomics. As the radiologist's role also expands, the curriculum also highlights the need for trainees to be fully independent at the end of training in image-guided biopsies which is a key to the NHS England National Cancer Strategy. (3)Potential challenges in adapting to these changes are ensuring that radiology training programs keep pace with technological advancements, resistance from trainers accustomed to traditional methods, and lack of funding.

This essay will explore the future of radiology education, highlighting the impact of recent technological advances and the evolving role of radiologists in modern clinical practice by looking at Artificial intelligence (AI) and machine learning (ML) in radiology education, Simulation in radiology training, Use of handheld devices, Online learning platforms and digital resources as well as examples of successful implementations.

Artificial intelligence and machine learning.

Artificial intelligence (AI) enables machines to mimic human learning, comprehension, problem-solving, creativity and decision-making. (1) Recent advancements in generative AI have garnered attention in medical imaging and integrating AI into workflows can improve efficiency, reduce errors, and streamline processes. (1,4) The primary driver behind the emergence of AI in medical imaging has been the desire for increased efficacy and efficiency in clinical care. (2)With the growing volume of radiological imaging data and a shortage of consultants, AI is poised to serve as an adjunct to daily radiology practice. (2) It could enhance the overall work experience ultimately improve retention and reduce burnout. A recent UK trainee survey on AI in radiology by RADIANT, a trainee-led research collaborative network shows that over 80% of respondents were interested in AI in radiology but 71.4% had no experience of working with AI, with only one training programme implementing AI-based teaching. (5)

A recently published paper on a framework for integrating AI training within a residency programme has shown that a focused course which involves AI experts and radiologists could be a starting point in providing trainees with the knowledge required to understand the role of AI in radiology including its daily applications and limitations. (6)The framework is customisable, and an adaptation is highlighted below.



Adapted from: van Kooten, M., et al. (2024). A framework to integrate artificial intelligence training into radiology residency programs: preparing the future radiologist. (6)

Simulation training.

Balancing skill acquisition with patient safety in radiology education is challenging, given the technical complexity of certain skills. To address this, simulation-based training has become essential to enhancing trainee competence while maximising patient safety. (7) This approach boosts confidence and provides access to real-life cases in a risk-free environment, improving communication and teamwork. Simulation training is used in several aspects of radiology education, including interventional radiology, diagnostic and procedural ultrasound and is particularly pertinent in image-guided procedures as the RCR expects a level 4 (entrusted to act unsupervised) competency level from trainees at the end of training regardless of subspecialty interest. (3)

As clinical skills training evolves, the traditional Master-Apprentice model faces scrutiny due to its limitations, such as relying on real patients, time constraints on training because of changes in trainee working hours, and the lack of uniformity in training as trainees are limited to only learning about the clinical cases that their patients present with. (7) However, medical

simulation addresses these issues by ensuring trainees can observe and manage a wide range of cases in a controlled environment, making its widespread adoption crucial to radiology education.

In 2020, radiology trainees at Imperial College London utilised interactive holograms and augmented reality headsets for innovative training in image-guided needle biopsy, led by Professor Mohamad Hamady. (8)Additionally, advancements in virtual reality (VR) and augmented reality (AR) allow students to practice interpreting medical images and performing procedures in controlled environments. Platforms like Osso VR and ImmersiveTouch offer realistic 3D models, enhancing understanding and retention while enabling remote learning, which is particularly valuable during times of social distancing or limited clinical access and is well-established in surgical specialities. (9,10)

Handheld Devices

Since their emergence in the early 1990s, handheld computers, commonly known as personal digital assistants (PDAs), have gained significant traction in the medical field. These devices provide numerous advantages, including the ability to view radiology examinations, access radiology reports remotely and manipulate images. (7)

These devices come equipped with internet connectivity, email, spreadsheet and database applications, word processing capabilities, and digital media functions, making them invaluable tools for training. (7)While handheld computers are not yet fully reliable for image interpretation, they offer a range of features that can significantly enhance workflow and efficiency for radiologists. These features include improved personal information management, decision support through access to educational resources, and remote

connectivity to radiology information systems. This is true as remote and virtual working is now part of most radiologists' job plans and is predicted to rise in the coming years.

Handheld devices are also changing the landscape of ultrasound training. Several medical universities in the UK now provide free portable ultrasound (US) to their graduating students, which allows them to learn and practice independently, before entering formal clinical practice. (11) Ultrasound-guided venous cannulation, for example, can improve inpatient experience if a junior doctor can perform this procedure without needing a trained practitioner. This innovation has empowered the next generation of skilled ultrasound users, enhancing their educational experience and practical skills.

Online learning platforms and digital resources

Radiology education has primarily been based on either academy-styled teaching or a traditional training model which predominantly involved interactive or didactic lectures, case-based small group discussions and informal tutorials during reporting sessions. (12,13)The introduction of Picture and Archiving Communication Systems (PACS) drove the shift from film-based to digital reporting and image storage which has led to a rapid increase in the use of the internet for teaching and virtual presentations. (14)

Easy access to information online has transformed radiology education. Resources like the Internet2 connect hundreds of academic institutions, enabling the development of advanced network applications that support high-quality video conferencing, serving as an effective alternative to traditional lectures and tutorials. (15) Applications such as Zoom, MS Teams and Webex have changed the online education environment and now form a key part of training in the post-COVID-19 pandemic era. (16)Teaching and research resources from large radiology organisations such as the RCR, the Radiological Society of North America and the European Society of Radiology are now widely available to radiology trainees globally.

Additionally, websites like Radiopaedia play a role in radiology education and beyond by providing a comprehensive repository of radiology cases, articles, and educational resources. This platform allows learners to access a wealth of information and has recently introduced a virtual conference which offers lectures, workshops and poster presentations and has garnered a significant number of attendees globally. (17)

The rise of social media has also had a significant impact, with platforms like YouTube offering tutorials from diverse educators and X (formerly Twitter) fostering a vibrant community among radiology organisations, consultants and trainees. Together, these resources create a dynamic learning environment, making radiology education more accessible and engaging for trainees. (18)

Case study

NHS England - Midlands provided funding to develop a new training model at the Midlands Imaging Training Academy (MITA). The new electronics and picture archiving suite (EPACS) is being piloted as a platform to develop AI learning and cooperation in imaging academies. The Academy Director reports the new simulation facilities will provide excellent learning practices to get trainees work-ready in a fast-paced clinical environment. (19)

This case highlights that investing in emerging technology should be part of the NHS long-term workforce plan, as harnessing new digital technology will allow staff to focus on patient care which will benefit patients, clinicians and the health service.

Conclusion

The future of radiology education is undeniably intertwined with rapid technology advancements, particularly in areas like artificial intelligence, simulation-based training, and

web-based learning. These innovations are reshaping how radiologists are trained, offering new opportunities for skill development, efficiency, and diagnostic accuracy. Artificial intelligence promises to enhance clinical workflows, while simulation training ensures patient safety and trainee competence in a risk-free environment. Internet-based resources democratise access to educational materials, making learning more flexible and widespread.

As these technologies continue to advance, radiology trainers and trainees must adapt to maintain the highest standards of education which will invariably translate to better patient care and improved satisfaction. The integration of AI into the curriculum, and the widespread availability of digital learning tools are essential in preparing future radiologists for a tech-driven world. To stay at the forefront of these advancements, medical education systems must embrace these changes, ensuring that trainees are equipped with the necessary skills and knowledge to thrive in this evolving field.

Word Count: 1500

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