Review Article

Modern Radiography Education: Clinical Competence, Simulation, and AI

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Received: 16 September 2025; Revised: 29 October 2025;
Accepted: 28 November 2025; Published: 16 December 2025

Abstract

Radiography education faces a clear pressure point. Clinical departments expect graduates who deliver safe examinations, justify imaging requests, optimise protocols, communicate with patients, and work with fast expanding digital systems. Placement capacity, supervision time, and assessment consistency still vary across sites. This review synthesises themes in clinical formation, competence assessment, technology enhanced learning, and curriculum renewal for artificial intelligence and digital professionalism. Evidence shows that clinical learning quality depends on supervision culture, structured feedback, and fair access to learning opportunities, not only on placement hours. Many assessment systems reward task completion more than judgement, patient safety, and adaptability. Simulation and virtual reality widen practice opportunities and protect patients, yet programme impact depends on design quality and alignment with clinical expectations. Digital transformation since the pandemic shapes curriculum delivery, assessment design, and student support. Artificial intelligence education has become a core requirement, yet outcome evidence remains limited. Many studies report confidence or perceived readiness, while fewer link educational change to clinical performance, patient safety, or early career transition.

Keywords: assessment, artificial intelligence, clinical learning environment, patient safety, radiography education, simulation

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Volume 1, Issue 1, December 2025

Similarity Index: 0%

1. Introduction

Radiography programmes train students for a role that carries immediate consequences for patients. Every examination involves radiation exposure decisions, positioning accuracy, image quality judgement, and communication with patients who may feel pain, anxiety, or confusion. These conditions make competence visible at the point of care, not only in written tests. Standards and education frameworks have therefore shifted toward explicit competence expectations that connect practice outcomes to training design (Health and Care Professions Council, 2023; International Society of Radiographers and Radiological Technologists, 2014).

A second pressure now shapes education with equal force. Digital systems change the work of radiographers at a pace that outstrips many curriculum cycles. Departments adopt workflow automation, dose monitoring tools, image reconstruction advances, and AI supported decision aids. Students also learn in a digital environment where online delivery, virtual resources, and AI tools influence study behaviour and assessment performance (Lewis et al., 2024). Programmes must therefore manage both clinical competence formation and digital professionalism within the same educational space.

A third pressure concerns the clinical training system itself. Placement time and placement quality do not match across hospitals. The differences often come from supervision capacity, patient volume, modality access, equipment age, and the teaching culture within departments. When these factors vary, student experience and competence development vary as well. Radiography education research has increasingly measured these differences and described their consequences for learning outcomes (Alipio, 2024; O'Connor & McNulty, 2024; Khine et al., 2024). This review focuses on themes that recur across the contemporary literature and that define the most important gaps for high impact education research and curriculum development.

2. Clinical Education and Professional Formation

Clinical placement forms the professional habits that define safe practice. Students learn to prepare and position patients, select protocols, manage movement and pain, and work within real workflow constraints. The placement also shapes identity. Students observe how radiographers speak to patients, how they negotiate with colleagues, how they respond to errors, and how they balance speed with safety. These experiences determine what students regard as normal practice.

Recent evidence confirms that placement quality depends on supervision culture and access to structured feedback. Students and clinical staff describe effective placements through shared expectations, inclusive team behaviour, and clear guidance during complex examinations (Khine et al., 2024). Where supervision is inconsistent, students rely on observation rather than coached practice. This reduces skill consolidation and increases variation in competence at graduation.

Measurement studies support targeted placement improvement. O'Connor and McNulty (2024) used a structured instrument to examine student views of the clinical learning environment. Their findings show that placement quality sits within measurable domains rather than vague impressions. Supervision quality, opportunities to practise, and the learning climate influence student experience. These results support a shift from broad claims such as "good placement" toward domain based quality assurance. It also supports a more strategic use of clinical partners. A programme can identify which sites excel in feedback, which sites provide high case volume, and which sites require structured support.

Preceptorship capacity remains a central constraint. Where departments carry heavy workloads, supervision competes with service delivery. Ofori-Manteaw et al. (2024) describe the roles and challenges of preceptors in clinical supervision, with barriers that include time constraints, limited resources, and unclear coordination between schools and sites. The implication is direct. A programme that relies on goodwill alone produces variable supervision and variable competence evidence. Preceptorship requires clear objectives, shared assessment language, and explicit support from both the academic institution and the clinical department.

A further issue concerns fairness. Students who enter high quality sites receive more coached practice and better feedback. Students in weaker sites often complete similar hours with less supervision. This produces inequity in competence development. High performing programmes treat placement equity as a quality obligation. They set minimum supervision and feedback expectations and support sites that struggle to meet those expectations.

3. Competence and Assessment in Radiography Education

Radiography competence includes technical skill, clinical reasoning, patient centred communication, radiation protection behaviour, and professionalism under pressure. These capabilities do not develop fully through observation. They require coached practice with feedback and structured assessment. Yet many systems still rely on task completion, logbooks, and end of rotation sign offs that vary by assessor and by site.

The education literature supports a shift toward defensible assessment programmes rather than isolated assessments. Miller (1990) distinguishes knowledge, competence, and performance in practice, which clarifies the need for assessment designs that capture more than recall. Workplace based assessment can support repeated observation, feedback, and progressive judgement of readiness (Norcini, 2003). In radiography, the need for defensible decisions is high because patient safety risk is high and competence gaps become visible on the first day of employment.

Peer supported approaches can also strengthen assessment literacy when the design includes clear criteria and staff calibration. Elshami and Abdalla (2017) report diagnostic radiography students' perceptions of formative peer assessment in technique education. Peer assessment supports criteria awareness and self-evaluation when students understand what competent performance looks like. This matters because graduates must continue to learn and self-correct in clinical practice.

A related development concerns the push toward aligned clinical assessment tools. The proposed Diagnostic Radiography Clinical Assessment Tool reflects a broader direction within professional education. It connects clinical assessment to professional standards and supports consistent judgement across sites (Harcus et al., 2023). This standardisation reduces the risk that students pass due to local custom rather than a shared competence threshold.

Radiation protection education also requires assessment that captures judgement, not only factual knowledge. Santos et al. (2022) describe the need for consistent radiation protection education and training in Europe. Their work supports a view of radiation protection as a longitudinal competence, reinforced through repeated decision tasks and reflection on optimisation. Programmes that treat radiation protection as a single module often produce students who can recite principles yet struggle to apply them under time pressure.

The major research gap across assessment studies remains outcome linkage. Many papers report confidence gains or positive student perceptions after assessment changes. Fewer studies link assessment reform to measurable clinical performance outcomes such as repeat rates, positioning error frequency, protocol compliance, or patient communication quality. High impact research will connect education interventions to observable workplace outcomes and will use multi site designs that account for placement variation.

4. Simulation and Virtual Reality in Radiography Education

Simulation has become a core educational resource because it protects patients while students develop skill and judgement. It also addresses a practical constraint. Not all placements provide the full range of cases that students need. Simulation allows deliberate practice of uncommon scenarios, high risk situations, and complex patient care tasks.

Bridge et al. (2021) provide an international audit of simulation use in pre-registration medical radiation science training. Their findings show wide variation in simulation implementation, with common reliance on low fidelity resources and limited involvement of service users. This matters because simulation quality determines transfer to practice. A simulation that focuses only on equipment manipulation without realistic patient interaction cannot fully prepare students for clinical conditions. Patient handling, consent communication, reassurance, and pain management shape examination success as much as technical factors.

The simulation literature supports targeted educational benefit when simulation aligns with authentic tasks and structured feedback. Hazell et al. (2020) synthesise evidence that simulation supports clinical readiness and confidence, with stronger effects when programmes embed simulation into a coherent progression rather than offering isolated sessions. Shanahan et al. (2016) also support the use of a simulated clinical environment in radiography education, with student perspectives that highlight the value of safe practice and immediate feedback.

Virtual reality extends this approach through immersive practice environments that allow repetition without radiation exposure. Student experience studies in radiography describe VR as a tool that supports practice of positioning and workflow, especially when the system provides feedback and when faculty integrate VR tasks into course outcomes (O'Connor et al., 2020; Sapkaroski et al., 2020). A more recent radiography focused systematic review supports the educational potential of VR while also reinforcing the need for stronger study designs and consistent outcomes (Gårdling et al., 2025).

The most important issue for programmes is not whether simulation or VR feels modern. The issue concerns transfer to clinical performance. Many studies report satisfaction or confidence improvements. Those results do not guarantee safer practice. High impact education work will measure transfer through objective skill checks, image quality outcomes, and clinical supervisor ratings that use standard criteria. It will also examine retention. Skills that fade after a few weeks do not protect patients. Programmes should therefore treat simulation and VR as part of a longitudinal skill pathway, with defined performance criteria and planned refreshers.

5. Digital Transformation, AI Literacy, and Digital Professionalism

Digital transformation now shapes radiography education in two ways. It changes clinical practice, and it changes student learning behaviour. Programmes have adopted online delivery, digital resources, and new assessment designs since the pandemic. Tay and McNulty (2023) describe radiography education after this shift and highlight how digital delivery has become part of the educational baseline rather than an emergency strategy.

Artificial intelligence adds a further requirement. AI affects image acquisition, reconstruction, workflow prioritisation, and decision support. Departments therefore expect graduates who understand what AI can do, what it cannot do, and how to evaluate outputs within clinical governance. Studies also show that radiographers and students often report limited formal AI education and call for structured training (Doherty et al., 2024).

Crotty et al. (2024) propose curriculum recommendations for undergraduate medical imaging education that treat AI literacy as a structured module set rather than a single lecture. Their recommendations focus on data literacy, ethics, governance, evaluation, and clinical integration. This aligns with broader radiology education commentary that emphasises evaluation skills and patient safety consequences when AI tools enter practice (Tejani et al., 2022).

AI also influences academic work. Students use AI tools for writing support, summarisation, and study tasks. Lewis et al. (2024) report patterns of AI use among medical imaging and radiation science students, which makes guidance and assessment design urgent. Programmes must define acceptable use, disclosure rules, and assessment formats that measure clinical reasoning rather than polished text output. This is not an optional policy discussion. It is part of professional formation. Graduates will work in an environment where digital tools shape both clinical practice and professional accountability.

The key research gap concerns validated AI competence outcomes for entry level radiographers. Many programmes now include AI lectures, yet few evaluate competence through authentic tasks such as tool appraisal, bias identification, governance reasoning, and safe escalation decisions. High impact studies will test longitudinal AI curricula with objective assessments and will examine whether graduates use AI outputs safely within defined clinical protocols.

6. Conclusion

Radiography education must now deliver consistent clinical competence and digital capability within a training system that varies across placement sites. The literature converges on a clear set of priorities. Clinical learning quality depends on supervision culture, structured feedback, and fair access to coached practice. Competence assessment requires defensible standards that measure judgement, patient safety behaviours, and adaptability, not only task completion. Simulation and VR expand safe practice opportunities, yet programme benefit depends on design quality, facilitation, and deliberate linkage to clinical performance. Digital transformation has reshaped delivery and assessment, while AI has become a core curriculum requirement that demands longitudinal structure, ethics, governance, evaluation skills, and clear rules for academic integrity.

The main research gap across these themes concerns outcomes. Radiography education research must link educational change to clinical performance and patient safety indicators. Programmes that align competency standards, clinical assessment, supervision development, simulation pathways, and AI literacy will produce safer graduates and stronger evidence for accreditation and workforce trust.

Acknowledgment

The quality of this paper was greatly improved by the reviewers' valuable comments, for which sincere thanks are acknowledged.

Conflict of Interest Statement

The author declares no conflict of interest.

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Author Contributions: Alipio, M.; Study design, method conception, data collection, data analysis and manuscript writing