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Artificial intelligence learning objectives in radiography education: A document analysis

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ABSTRACT

Introduction: Artificial Intelligence (AI) is rapidly changing healthcare delivery and radiography, impacting both practice and education. Despite its significance, there is limited agreement on educational priorities and curriculum organisation for radiographers. This study gathered relevant Learning Outcomes (LOs) for AI education in radiography from existing literature, structuring them according to the European Qualifications Framework (EQF) model of Knowledge, Skills and Competences (KSCs).
Methods: A literature review was conducted systematically utilising PRISMA reporting guidelines, and thematic analysis was applied using Saldaña's coding framework. Data were coded deductively with the EQF and open-coded to highlight further important aspects of AI education for radiographers.
Results: Three major themes emerged: Knowledge, Skills, Competencies, with 15 subthemes. The recommended LOs for radiographers range from fundamental practice, such as patient safety, to advanced tasks like coding AI.
Conclusion: The variety of LOs identified suggests that AI education in radiography cannot be presented as one unified framework. Instead, educational approaches should reflect the different roles radiographers may have in relation to AI, ensuring practitioners at all levels gain the most relevant AI-KSCs.
Implications for practice: AI education should be embedded in existing educational structures, with tailored outcomes for specific AI-related roles. Ongoing research is needed to determine which LOs should be prioritised for roles and educational stages.

Introduction

AI applications in healthcare, such as data analysis, decision support, process automation, and predictive analytics,[1,2] are vital for radiographers, whose work increasingly relies on digital data. AI offers crucial tools for managing escalating data volume, and is also being used in image processing and radiation dose management, thereby improving efficiency and patient outcomes.[1,3–5] Furthermore, AI's capability in predictive analysis enhances personalised patient care, supporting better clinical decisions.[6,7]

Despite the growing use of AI in clinical radiography, a standardised educational framework is currently absent, thus contributing to a lack of standardisation in radiographer KSCs,[8,9] which can compromise patient safety and hinder the effectiveness of AI tools. Moreover, the lack of consensus on essential AI-KSCs creates barriers to workforce mobility and practice standardisation across Europe.[10,11]

This study primarily aims to identify and synthesise educational LOs for AI in radiography reported in existing literature.

Methods

This study employed a qualitative, descriptive design utilising a systematically conducted literature review to identify AI-KSCs relevant to radiography education. The search and selection process followed PRISMA reporting guidelines to ensure transparency and reproducibility, though the review did not incorporate formal

Abbreviations: AI, Artificial Intelligence; CPD, Continuous Professional Development; EQF, European Qualifications Framework; LOs, Learning Outcomes; KSCs, Knowledge, Skills and Competencies; MI, Medical Imaging.

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quality appraisal tools and is therefore characterised as a literature review conducted systematically rather than a full systematic literature review.

Data collection involved qualitative document analysis of peer-reviewed and grey literature, including regulatory and professional frameworks. Non-radiography-specific sources were included where their AI-KSCs demonstrably overlapped with radiography practice and education.

Searches were conducted across MEDLINE, CINAHL (via EBSCOhost), Scopus, ScienceDirect, the British Medical Journal (BMJ), and Web of Science using the query: ("AI" OR "Artificial Intelligence") AND ("Radiographer" OR "Radiation Therapist" OR "Nuclear Medicine Technologist") AND ("Knowledge" OR "skills" OR "competencies" OR "training" OR "education"). These databases were selected to ensure broad and complementary coverage across health science education literature.

Publications were restricted to the most recent five years for relevance, with continuous database alerts configured. Grey literature was incorporated via targeted searches of official sources (e.g., professional and regulatory bodies) and screened using the same criteria (Table 1). Considering the European context, the EQF[12] definition for KSCs was adopted. Inclusion focused on publicly available documents discussing AI-KSCs relevant to European radiography practice.

Screening was conducted by the primary researcher across all identified records. A list of included, excluded and uncertain records was reviewed by the supervisory team, with disputed or uncertain inclusions resolved through discussion and consensus.

Thematic coding

An inductive thematic analysis approach was employed to identify and organise AI-KSCs from the included literature using NVivo software v15.1. First-cycle coding employed provisional, holistic, process, and descriptive approaches to efficiently analyse large text segments.[13] A subsequent second cycle round refined the initial code set to consolidate categories and clarify relationships, yielding a systematic structure.[13] Double coding was performed by three independent researchers, distinct from the primary researcher, to enhance rigour and credibility.[13] Each double-coder was randomly assigned two sources for thematic coding. Any inconsistencies between coders were resolved through collaborative discussion, with any unresolved issues referred to the supervisory team for adjunction.

Results and discussion

Search results

The initial literature search, conducted between December 2024 and March 2025, yielded **2430** records. After removing duplicates and retracted articles, **1945** unique records underwent title and abstract screening. Most documents (1,833) were excluded for lacking focus on both AI and radiography education, or for evaluating specific technologies without educational relevance. From the initial 2430 records, only **seven** peer-reviewed articles[7,11,14–18] met the full inclusion criteria.

Targeted grey literature searches in March 2025 identified seven documents, **five** of which were included.[19–23] To ensure the review captured the most current literature, automated database alerts were maintained beyond the formal search window. This mechanism identified one additional highly relevant, eligible study published in late April 2025.[24] (Fig. 1 - Prisma Framework). Following supervisory consultation, and noting that formal data extraction from the previous pool had not yet commenced, this April 2025 record was officially included due to its direct and significant relevance to the review topic, bringing the final count of peer-reviewed articles to **eight**[7,11,14–18,24] with **five** grey literature sources[19–23].

Thematic framework

The thematic analysis yielded three overarching themes (Fig. 2), each encompassing distinct yet intersecting facets of AI education for radiographers. These themes emerged were organised around curricular content (KSCs). The themes and subthemes derived from this analysis are presented in Fig. 2.

A single, general educational framework incorporating all identified AI-KSCs is neither feasible nor desirable for two reasons: 1) different KSCs apply to different AI-related roles of the radiographer, and 2) the list of KSCs is also too extensive to be covered in one single educational programme, exceeding current curricular capacity. This aligns with the tiered educational model proposed by Topol[25] and the NHS report for AI-enabled healthcare work,[26] suggesting that while digital literacy is a universal requirement, high-level technical competencies should be reserved for specialist roles. Thus, not all tasks identified in the literature are a core competency of radiographers; some are only required if radiographers take specific roles (e.g. implementation of AI systems). Therefore, the profession requires a differentiated approach featuring clear, role-specific profiles and tiered proficiency levels, reflecting the depth of interaction with AI systems as proposed by EFRS.[10]

Literature was often unclear whether the presented AI-related KSCs were **core LOs** for all radiographers (at EQF6[21,22]) or **advanced practice-level LOs** (post-graduate). Consequently, organising the LOs by academic level was unfeasible during this study and further research is necessary. This role-based stance also aligns partially with the recent NHS report[26] proposing archetypes for AI-enabled healthcare work. However, given the diversity of LOs in this study, we argue radiography requires its own dedicated mapping. Different radiographer roles will necessitate **distinct educational interventions.**

Table 1
Inclusion and exclusion criteria.

Inclusion criteria	**AI-related knowledge, skills and competencies (AI-KSCs)** directly involving radiography practice in Europe. Statements in literature were considered 'knowledge', 'skill' or 'competency' when:
	
	• referred to as such in literature or
	• identified in literature as[12]:
	  ○ **theoretical or factual knowledge** ('knowledge')
	  ○ **A practical or cognitive proficiency** ('skills') or
	  ○ A task that falls under the radiographer's **responsibility** or **autonomy** ('competency').

Exclusion criteria	• KSCs not relevant to radiography education or AI • Non-English publications • Publications not representative of European radiography practice • Conference abstracts, editorials, commentary papers

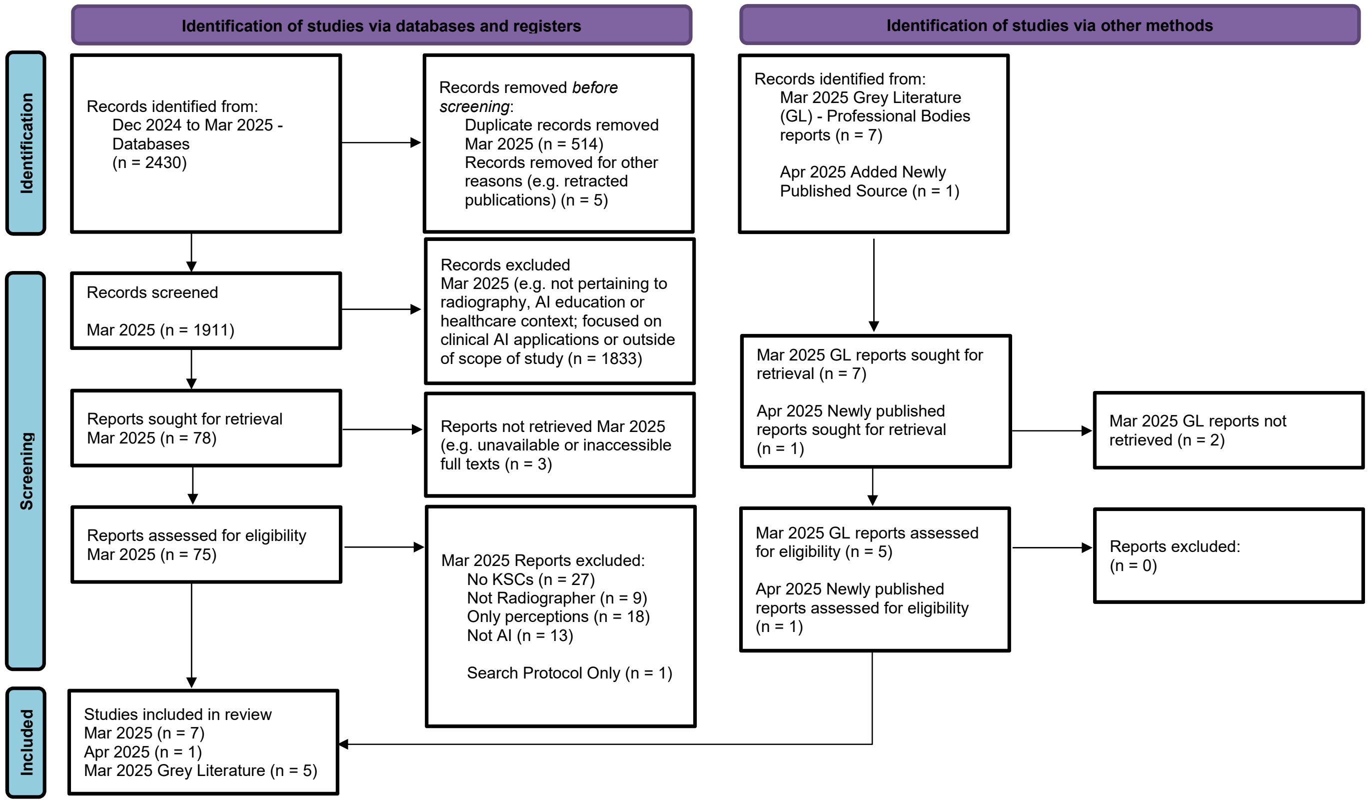

Figure 1. Prisma framework.

Practically, this implies that an ideal framework (i) defines **radiography-specific roles**, (ii) maps each role to a **targeted subset of AI-KSCs**, and (iii) specifies **proficiency levels** (e.g. awareness, working, advanced) per competency.

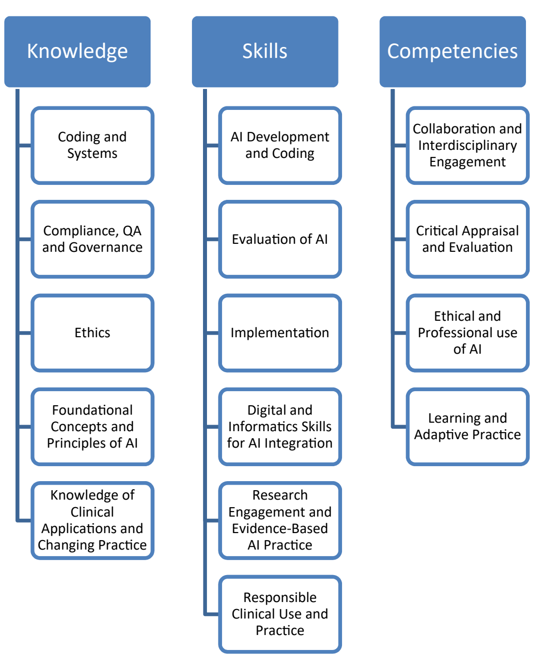

Figure 2. Thematic analysis overview.

Themes

Three major themes emerged: Knowledge, Skills, Competencies. LOs coded under Knowledge were Identified in literature as the foundational theoretical and conceptual understanding required for radiographers engaging with AI. Thematic analysis revealed **five** subthemes. Skills were applied abilities that enable radiographers to employ AI tools effectively in clinical practice, consistent with the EQF[12] definition. **Six** subthemes emerged from the analysis. Finally, competencies were coded as the integrated application of knowledge, skills, and professional judgement required for radiographers to use AI safely and effectively in practice, and is related to professional autonomy and responsibility.[12] **Four** subthemes emerged. A full description of the above themes may be found in the Supplementary Materials Tables 1–3.

Prioritised framework

The following LOs have been organised according to the researchers' interpretation into three tiers: Core Literacy, Advanced/Enhanced Practice and Specialist/Leadership Roles reflecting the varying levels of technical depth and professional responsibility required across the radiography workforce as shown in Table 2. This is a conceptual organisation of the research findings and thus, requires further empirical validation in future studies, which is currently underway.

Core Literacy encompasses foundational KSCs that are universally applicable to all radiographers at the EQF 6 level, with a focus on clinical safety, ethical use and digital literacy. This ensures that practitioners can act and intervene appropriately to ensure safe use of AI tools.

Table 2
Prioritised framework.

Priority	Target level	Key subthemes	Example LOs
Core literacy	Undergraduate EQF 6 Clinical Personnel	1. Foundational Concepts and principles of AI 2. Knowledge of clinical applications and changing practice 3. Responsible clinical use and practice 4. Ethical and professional use of AI	1. Define basic AI terminology (e.g., deep learning, algorithms). 2. Identify AI's role in image acquisition and triage. 3. Recognise AI confabulations or errors to ensure patient safety. 4. Apply ethical principles to patient data privacy and informed consent.
Enhanced/Advanced practice	Postgraduate EQF7/8 AI implementation	1. Compliance, QA and governance 2. Evaluation of AI 3. Critical appraisal and evaluation 4. Research Engagement and evidence-based AI practice 5. Digital and informatics skills for AI integration 6. Learning and adaptive practice 7. Implementation	1. Design and execute quality assurance (QA) protocols for AI tools. 2. Critically appraise clinical validity and limitations of AI research. 3. Lead interdisciplinary teams in the selection and integration of AI software.
Specialist/Leadership	High level EQF 7/8 AI development	1. Coding and systems 2. AI development and coding 3. Collaboration and interdisciplinary Engagement	1. Apply programming languages (e.g., Python) to process medical datasets. 2. Contribute to the design, training, or fine-tuning of AI models. 3. Troubleshoot technical infrastructure and systems architecture for AI.

Advanced/Enhanced Practice transitions towards the governance and evaluation of AI tools. These LOs are more appropriate to senior roles involving critical appraisal of AI research and the management of quality assurance protocols.

Specialist/Leadership Roles addresses the most technical and complex outcomes identified in the literature, such as model development and programming. While prominent in the data, the researchers believe these are more essential of those working or leading in AI implementation, development or research, rather than entry-level practitioners.

The key subthemes are taken directly from the coding process, while the example LOs are summarisations of the sub-subthemes and items that emerged from the coding.

While Table 2 summarises the prioritised framework, a granular and more itemised list of all LOs and their original codes, including specific technical requirements, is provided in Supplementary Tables 1–3 for detailed curriculum mapping.

Recommendations for practice and future research

This study highlights a knowledge gap regarding which learning outcomes are priorities for inclusion in undergraduate programs and which should be left to postgraduate programs. While this study provides a theoretical grouping of priorities based on current literature, it is acknowledged that these classifications require **empirical validation**. A follow-up study is currently underway to determine which LOs are priorities at different educational levels and for various radiography roles.

Future work must empirically test and refine the proposed AI LOs in real-world educational and clinical settings. Pilot studies across undergraduate, postgraduate, and CPD programmes are necessary to determine the feasibility and impact of integrating these LOs for various target roles. Further research is vital to develop context-specific guidance that accounts for the variation in radiography roles and modalities, clearly defining which LOs are indicated for each.

Successful implementation and adaptation require essential collaboration among professional bodies, educational institutions, healthcare providers, practitioners, policy makers, and industry stakeholders. As the field evolves, a continuous review of AI-related LOs must be performed to ensure radiographer education remains responsive to emerging technologies and changing policy, infrastructure, and regulatory contexts.

Limitations

The limited available literature constrained this review, with only eight peer-reviewed studies meeting the inclusion criteria, many of which presented conceptual rather than empirically validated frameworks. While grey literature enhanced coverage of current professional discourse, the research team acknowledges that these sources are not peer-reviewed as journal articles are.

The organisation of the LOs identified in the literature outlined in Table 2 - Prioritised Framework reflects the researchers' interpretation and may contain personal biases. Therefore, it is essential that these priorities and education levels are validated through future research, which is currently in progress.

The search was restricted to English-language publications from December 2019 to March 2025, potentially omitting relevant studies outside this scope. In addition, reliance on document analysis means the identified KSCs reflect reported LOs rather than directly observed educational practices or learner outcomes. Although steps were taken to minimise bias, including double coding, some subjectivity in interpretation by the principal researcher is an acknowledged limitation of qualitative research.[13]

Conclusion

This study provides the first thematic analysis of published and grey literature, specifically mapping KSCs and educational principles for AI education in radiography. While previous integration studies exist, none offered a structured list of LOs organised according to the EQF[12] framework.

Educational approaches varied widely in scope and depth, and although the importance of AI-KSCs is recognised, practical guidance for large-scale implementation or role-specific tailoring remains limited. The findings emphasise the need for differentiated role-specific educational frameworks. Attempting to integrate all identified AI-KSCs into a single curriculum would be impractical and pedagogically unsound. Instead, a staged and context-sensitive approach supports progressive curriculum integration, CPD, and the development of AI-enhanced career pathways. Despite the breadth of available sources, the limited empirical evidence highlights the need for further research to determine priority learning outcomes and to test their implementation in real-world academic and clinical settings.

Ethics approval and consent to participate

Ethical approval was not sought for the present study because **the study was a thematic document review from published and grey literature only.**

Availability of data

Data required for this study is available from MEDLINE, ScienceDirect, the British Medical Journal (BMJ), and Web of Science using the query: ("AI" OR "Artificial Intelligence") AND ("Radiographer" OR "Radiation Therapist" OR "Nuclear Medicine Technologist") AND ("Knowledge" OR "skills" OR "competencies" OR "training" OR "education").

Author contributions

DM: Conceptualisation, Methodology, Formal Analysis, Investigation, Resources, Data Curation, Visualisation, Writing – Original Draft. **JGC:** Methodology, Writing - Review & Editing, Supervision. **MM:** Methodology, Writing - Review & Editing, Supervision. **SM:** Investigation. **JLP:** Investigation. **JA**: Investigation. **CM:** Writing - Review & Editing.

Generative AI use

During the preparation of this work the author used Gemini 3.5 to increase readability, brainstorming, assistance with structure and organisation and language refinement for pre-draft material.

After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication and hereby declares that all the work is the author's own and no AI-generated text was presented as the author's work.

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Conflict of interest statement

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2026.103546.

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