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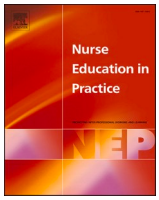

Generative AI in healthcare education: How AI literacy gaps could compromise learning and patient safety

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ABSTRACT

Aim: To examine the challenges and opportunities presented by generative artificial intelligence in healthcare education and explore how it can be used ethically to enhance rather than compromise future healthcare workforce competence.
Background: Generative artificial intelligence is fundamentally changing healthcare education, yet many universities and healthcare educators have failed to keep pace with its rapid development.
Design: A discussion paper.
Methods: Discussion and analysis of the challenges and opportunities presented by students' increasing use of generative artificial intelligence in healthcare education, with particular focus on assessment approaches, critical thinking development and artificial intelligence literacy.
Results: Students' widespread use of generative artificial intelligence threatens assessment integrity and may inhibit critical thinking, problem-solving skills and knowledge acquisition. Without adequate artificial intelligence literacy there is a risk of eroding future healthcare workforce competence and compromising patient safety and professional integrity.
Conclusion: While generative artificial intelligence presents significant challenges to healthcare education, it offers great promise if used carefully with awareness of its limitations. The development of artificial intelligence literacy is crucial for maintaining professional standards and ensuring patient safety and mitigating its potentially negative impact on the formation of critical thinking skills.

1. Introduction

Artificial intelligence (AI) could–and likely will–become a catalyst for transforming the future of healthcare education (Labrague et al., 2025). Its responsible adoption and integration are crucial for safeguarding the public, upholding trust in the nursing, midwifery and allied health professions and ensuring that graduates meet all the necessary clinical, ethical and professional standards. Regulators and the public expect thorough oversight of the risks posed by AI for healthcare education so that healthcare students remain competent and safe to practice (Thornton et al., 2024).

Generative artificial intelligence (GenAI), such as ChatGPT or Google Gemini, is a type of AI capable of generating human-like content, including text and images (Feuerriegel et al., 2024). GenAI models are trained on massive amounts of primarily human-generated data, enabling them to identify statistical patterns and generate responses based on human-entered text prompts. Increasingly, these responses are becoming indistinguishable from responses a skilled human might produce. GenAI has many valuable features in the academic context. For example, it can help plan written assignments, provide a detailed outline and essay structure and assess the strengths and weaknesses of arguments (Michel-Villarreal et al., 2023; Semrl et al., 2023; Bedington et al.,

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2024). However, it is also capable of producing work comparable to that produced by many students for assessment and indications are that many students are using it for these purposes (Nam, 2023; Turnitin, 2024). The release of ChatGPT to the public in November 2022 exposed how unprepared many universities and healthcare educators were for AI's impact on education. Students were quick to start using the technology to help plan and write assignments; healthcare educators were largely unaware of its capabilities and implications for their assessments; and very few universities had policies or guidelines that proactively addressed AI use. The evidence suggests that many universities and educators are still unprepared to handle the rise of GenAI use and its impact on assessments (Palmer, 2024; Freeman, 2024; Wang et al., 2024). This is concerning for nursing, midwifery and allied health education because a significant proportion of their education takes place in the university context.

Here, we discuss three important concerns regarding healthcare students' use of GenAI that have received either limited or no attention to date. First, it risks introducing problems around how to fairly assign credit–and potentially blame–for the work that a student might have produced with GenAI. Second, as GenAI becomes increasingly sophisticated, it is likely that its use will compromise several assessment methods commonly used in healthcare education. Third, there is the possibility that, without the necessary AI literacy skills, the use of GenAI could have a negative impact on critical thinking skill development, resulting in diminished critical thinking skills that are necessary for safe and effective care. Here, we explore these issues and offer recommendations to help mitigate their potential negative impact. Following a prior collaboration that identified these three concerns regarding GenAI's credit-blame asymmetry, a subsequent review of nursing and broader healthcare education literature revealed no existing discussion of these issues. Our aim here is to advance the ongoing conversation about the risks of overdependence on GenAI, particularly its potential to undermine students' critical thinking and independent problem-solving abilities, in the context of healthcare education (Abdulai and Hung, 2023; Tam et al., 2023; Ramírez-Baraldes et al., 2025). The potential for the erosion of essential critical thinking and problem-solving skills for healthcare students–due to GenAI dependence–requires ongoing discussion and should not be ignored.

2. Credit for success

When considering how much credit a student deserves for a given piece of work, their use or otherwise of assistive technology is relevant. When GenAI is used to assist or co-produce an output, it becomes unclear how credit should be fairly allocated (Porsdam Mann et al., 2023; Earp et al., 2024a). The traditional outcome-based approach—like an essay—is used to assess and award students' learning: i.e. their understanding, critical thinking, reasoning, research skills, application of knowledge, creativity and the overall quality of their work (Bryan and Clegg, 2006). It seems prima facie unfair that a student who submitted work using GenAI, which might have required minimal cognitive effort, research skills, or critical thinking, could receive comparable or better grades than someone who exerted much greater cognitive effort and invested significantly more time to research and learn without using GenAI. And yet, GenAI makes this scenario increasingly likely.

Generative AI takes on important, specific forms in the context of nursing, midwifery and allied health education and research. The traditional outcome-based approach is primarily suited to assessing the quality and understanding demonstrated from outputs, with less emphasis on the process that resulted in the output. Typically, an output would be assessed by agreed marking criteria with the assumption that it represents students' learning and that they produced the content submitted. If GenAI has generated a significant proportion of the content, it may no longer accurately represent a student's learning. As there is no reliable way of detecting AI content, it is difficult for educators to allocate credit fairly (Pudasaini et al., 2024; Giray, 2024). All of this means that the use of generative AI may weaken the correlation between the quality of an output and the quality of the student's reasoning and research that prepared it: outputs will track inputs less directly (Porsdam Mann et al., 2023). For healthcare students, this means that traditional assessments will become less reliable trackers of underlying skill and thus may be less able to catch deficiencies in skill and knowledge that could have real-world consequences on patient outcomes. This suggests that for outcome-based assessments, the use of GenAI should increase the bar for deserving credit, whether its use is encouraged by educators or not. In other words, it should be harder to earn credit for producing an outcome, such as an essay, that usually would require a certain level of research skills, critical thinking, application of knowledge and creativity on the part of the student to produce, if, in fact it was produced with a lesser level of student input. Therefore, to preserve the integrity of some assessments, the process of awarding credit would benefit from shifting toward process-based assessments focused on judgment, evaluation and curation skills. A process-based assessment would be designed to separate the learning process from the assessed output (Sallai et al., 2024). This allows students to demonstrate the requisite skills, knowledge and understanding by documenting the process involved with developing the final output, rather than the output alone. While these kinds of assessments do *not* necessarily need to involve AI use, they can more easily incorporate AI into them, making it clearer to allocate credit (Quality Assurance Agency for Higher Education, 2023). In healthcare education specifically, this might mean focusing some assessments on how students evaluate and adapt AI-generated ideas, their ability to identify potential risks or oversights in AI-suggested interventions and their capability to curate and modify AI-generated content for specific patient contexts. This kind of approach is especially important because, despite rapid advances in this area, GenAI continues to lack perfect accuracy and is still prone to making factual mistakes (Jaźwińska and Chandrasekar, 2025). The alternative is that educators will be using assessments that fail to meaningfully assess their students' knowledge and learning and that also ultimately lack sufficient integrity. A failure to make this shift could risk deskilling the future healthcare workforce and potentially compromising patient safety.

3. Who is accountable?

GenAI is susceptible to mistakes, misinformation, factual error and bias, which highlights the importance of AI literacy as well as the challenges involved in assigning responsibility for these issues. This is especially apparent when determining who is accountable for them. Possible candidates for accountability include: the creators of the GenAI, as it is the introduction of their products which raises these issues in the first place; students who use GenAI, at least where this use involves uncritically or insufficiently evaluating content produced by it; and regulatory bodies like the Nursing and Midwifery Council (NMC) and the Health and Care Professions Council (HCPC). While the HCPC do provide some AI guidance for education providers, including the need to maintain academic integrity and support educators and students to become 'AI literate', the NMC has not currently published any explicit AI guidance. However, the NMC have stated that their modernised Code—due to come into effect in 2027—will incorporate clear standards regarding AI. Lastly, institutions and educators may be accountable for not providing sufficient guidance and AI literacy training; however, this is complicated by the fact that many educators lack the necessary AI literacy and must be given the time and resources to equip themselves and their students. It is worth noting that the European Union (2024) AI Act (European Union, 2024) obligates both providers of AI systems and those who deploy them in their organisations to ensure users have sufficient levels of AI literacy. Two well-documented concerns must be considered when considering accountability for a GenAI content: bias and 'hallucinations'. Bias describes the inclination or tendency to lack impartiality when considering a particular issue or question for which impartiality is required. Such biases may relate, for instance, to sex,

ethnicity, culture, or political and ideological commitments (Currie et al., 2024; De Nadai, 2024). AI 'hallucinations' refer to the generation by a model of false or misleading content; for example, describing credible sounding but non-existent studies or events as fact (Farquhar et al., 2024). In some contexts, the potential for hallucinations is a key, positive feature of AI—that which enables it to recombine information in ways that would be considered creative had they been carried out by humans (Jiang et al., 2024). However, in areas of healthcare and research that rely crucially on existing evidence, such as prescription and dosing regimens, hallucinations are nearly always concerning.

The reasons for AI bias are multifactorial—being trained on biased data due to a lack of diversity and representativeness, as well as missing or incomplete data (Gichoya et al., 2023). In healthcare settings, biased content accepted uncritically risks reinforcing existing biases or developing new ones, which could have a negative impact on clinical decision-making and patient care. For this reason, scepticism remains about how GenAI can be adopted into healthcare when an AI hallucination could pose a risk to patient safety (Shen et al., 2023). Some AI experts have posited that it may not be possible to ever eliminate AI hallucinations (Xu et al., 2024).

We suggest that integral to addressing accountability concerns for educators and healthcare students lies in the development of comprehensive AI literacy and clear accountability frameworks at the university level. This will help to ensure that, whether or not GenAI is incorporated into teaching or assessment, students will be better equipped with the necessary literacy skills to use it effectively and ethically. Healthcare students should be held accountable for failing to critically assess any information they used from GenAI; depending on the severity, this could include failing an assessment, receiving a reduced mark and being reported for academic misconduct. Furthermore, healthcare educators have a responsibility to effectively inform students about the strengths and limitations of GenAI. This means shifting assessment focus toward evaluating students' abilities to detect, evaluate and mitigate AI-generated errors and biases. Assessment tasks should emphasise judgment skills; having students critique AI-generated clinical recommendations, identify potential biases in AI-generated care plans and demonstrate their ability to verify and validate AI-generated content against reliable clinical or peer-reviewed sources.

4. Implications for critical thinking

One of the most important sets of implications of GenAI use concerns its potentially negative impact on critical thinking skill development and this has been raised as one of the primary concerns across healthcare education (Abdulai and Hung, 2023; Gosak et al., 2024; Ramírez-Baraldes et al., 2025; Kwan et al., 2025). This is because critical thinking is associated with higher-quality care and patient safety (Fesler-Birch, 2005; Dewi et al., 2021; Zhang et al., 2025). Healthcare students are expected to develop and hone a range of crucial critical thinking skills—such as distinguishing between facts and opinions, critically appraising information, identifying and solving problems and making clinical judgments—whilst using these skills in often stressful settings (Papathanasiou et al., 2014; Christianson, 2020). Consequently, any technologies that risk diminishing their development should be taken seriously. Suppose a healthcare student develops an overreliance on GenAI for their learning. In that case, the work that they receive credit for may not accurately reflect their understanding, with potentially serious real-world implications. If the resulting nurse, midwife, or allied health professional is less likely to possess the necessary critical thinking skills, they may be more likely to misinterpret or misunderstand patient information. This could lead them to be more likely to fail to anticipate or recognise changes in their patient (Berkow et al., 2011; Lynn, 2019). In a systematic review, Zhai et al. (2024) found that when students become overly dependent on GenAI, the result can be decreased creativity and diminished critical and analytical thinking abilities. The ethical use of GenAI requires specific capabilities—the ability to critically evaluate outputs, verify factual claims, detect potential biases or hallucinations and appropriately curate and integrate AI-generated content (Porsdam Mann et al., 2024). However, without the necessary AI literacy skills, we are concerned that students will use GenAI merely to generate assignments without meaningful engagement. For instance, some students might be tempted to directly copy AI-generated essays or uncritically accept AI-produced analyses. In so doing, they not only bypass the learning process but also fail to develop the very capabilities required for ethical AI use in their future careers. As the use of GenAI becomes normalised, there is a risk that it will develop into a type of overreliance, where students uncritically accept AI-generated claims and overestimate the degree of trust its claims warrant (Rahman and Watanobe, 2023; Zhai et al., 2024). The risk is that students failing to exercise and develop essential cognitive processes and skills; there is emerging evidence to support these concerns (Al-Zahrani, 2024; Summers et al., 2024). Furthermore, there is evidence from other domains showing that the use of GenAI can diminish critical thinking and independent problem-solving skills over time (Lee et al., 2025). We suggest that the solution, or part of the solution, involves fundamentally reconceptualising how we teach and assess critical thinking in healthcare education, focusing on judgment, evaluation and curation skills (see Table 1). While there may be ways educators themselves can integrate GenAI to mitigate these risks, these concerns should be at the forefront of decisions about its adoption in healthcare education. This is particularly crucial because AI systems, while powerful, cannot make value judgments or treatment decisions themselves—they can only provide facts about medicine or raise relevant values for consideration (cf. Earp et al., 2024b). Human healthcare professionals must remain the agents who make medical decisions with AI assistance, requiring robust critical thinking skills to evaluate AI-provided information. The cardinal values of contemporary biomedical ethics—respect for autonomy, beneficence, non-maleficence and justice—will remain central to healthcare practice, requiring professionals who can thoughtfully apply these principles when using AI tools. Assessment approaches should emphasise these higher-order thinking skills by requiring students to demonstrate their ability to evaluate, curate and adapt AI-generated content for specific clinical contexts. This type of use develops precisely the types of skills healthcare students will need to use these technologies responsibly in their professional practice. However, caution remains warranted. Different ways of incorporating GenAI into teaching and assessment by educators and different methods of use by students will each have different associated costs and benefits that must be carefully weighed and compared. For example, in some cases, students have used GenAI to help them successfully engage in problem-solving activities, only to perform worse than those who never had access to it when it is taken away (Bastani et al., 2024). Consequently, we should view any studies reporting short-term critical thinking benefits from GenAI use with scepticism if they lack long-term follow-up on student performance when they do not have AI access or in real-world clinical settings. Moreover, this also highlights the importance of ensuring that students develop AI literacy to help mitigate the potential negative impact on critical thinking from any cognitive offloading (Gerlich, 2025).

5. Discussion

The integration of GenAI into healthcare education represents both an opportunity and a challenge, each of which requires careful consideration of how we prepare future healthcare professionals. Our analysis suggests that the traditional approaches to healthcare education and assessment must evolve to address these new challenges while preserving the essential skills that underpin safe and effective healthcare practice. While there is debate about how best to define AI literacy, we propose that healthcare students—by the end of their education—should be able to use a range of GenAI technologies, understand their strengths and limitations, relevant ethical and regulatory compliance issues (e.g. relating to patients and data), develop prompt engineering

Table 1
Opportunities, challenges and mitigation strategies for using GenAI in teaching and assessment.

Domain	Opportunities	Challenges	Mitigation strategies
Credit and assessment integrity	Enables process-based, transparent documentation of student–AI interaction (e.g. prompt logs, revision history) to award credit more fairly. Can use AI as an explicit 'co-author' that students then critique, shifting focus from the final output to more evaluative skills.	Outcome-only grading breaks down when GenAI inflates grades with minimal student effort. No reliable GenAI-detection tools weaken the correlation between output quality and genuine student learning.	Adopt process-based assessments that require students to submit annotated prompt logs, drafts and reflections. Set performance standards that exceed current GenAI capabilities, ensuring student insight surpasses what GenAI alone can generate. Incorporate structured oral assessments to evaluate students' knowledge, reasoning and critical thinking skills, thus limiting the potential impact of GenAI use.
Accountability and ethics	Drives clear GenAI-use policies and accountability frameworks, delineating student and educator responsibilities. GenAI can provide a consistent second opinion that can flag information or details that an individual could have missed or forgotten. Clear policies and explicit accountability frameworks promote transparency, reinforcing professional standards and public trust in healthcare education.	Ambiguity over who is liable when GenAI hallucinations or biases produce harmful recommendations: model creators, institutions, educators, or students? Hallucinations remain inherent to GenAI, potentially risking patient safety if unchecked.	Policy co-creation that involves faculty, students and relevant stakeholders drafting GenAI-use guidance. Integrate case-based discussions on GenAI bias and hallucinations into the curriculum. Require students to sign declarations of critical evaluation when using GenAI tools, with clear sanctions for uncritical reliance.
Critical thinking development	As an interactive tutor, GenAI can model expert reasoning, scaffold problem-solving and explain complex concepts. Embedding GenAI-critique tasks (e.g. spotting flaws in AI-generated care plans) strengthens analytical skills.	Overreliance can lead to cognitive offloading: students bypass deep engagement, yielding poorer long-term critical thinking and creativity declines. Short-term performance gains potentially vanish without GenAI access, undermining real-world transfer.	Structured critique assignments that require students to annotate AI outputs, identify errors and suggest revisions. Reflective journals that require regular written reflections on how GenAI influenced their reasoning. Delay the early introduction of Gen AI in teaching to ensure initial critical thinking skill development and discourage dependence.
AI literacy	Formal GenAI literacy curriculum can equip students to understand model limitations, biases and prompt engineering; these will be key for safe clinical practice. Cross-disciplinary training helps ensure all students, regardless of technical background, can engage responsibly.	Many educators lack GenAI literacy themselves, creating a downstream training bottleneck. Without standardised guidelines, GenAI literacy uptake is uneven, risking patchy student preparedness.	Develop faculty and mandate AI-tool workshops and certification for educators. Standardised modules partnered with national bodies (e.g. QAA) to deliver a core GenAI literacy syllabus Peer mentoring and the establishment of student 'AI ambassadors' to support students.
Assessment and resource needs	Process-based and oral exams benchmarked against GenAI capabilities offer richer insight into reasoning while still leveraging GenAI. Automated formative quizzes and GenAI-powered feedback free up educator time.	Resource-intensive approaches (oral/practical exams) strain budgets and staffing, especially in current financial climates. Digital-divide issues mean unequal access to high-quality GenAI tools may exacerbate inequities.	Blended assessments that combine low-stakes automated quizzes with high-stakes oral components (e.g. vivas). Gaining institutional licences so all students have equitable access to high-quality GenAI tools.

skills (i.e. the process of creating text-based instructions for a GenAI to produce a particular output) and be able to critically reflect on their use and applications (Long et al., 2021; Laupichler et al., 2022; Pupic et al., 2023; O'Connor et al., 2024). This literacy must go beyond technical proficiency to encompass the ability to critically evaluate AI outputs, understand AI's limitations and biases and make informed judgments about when and how to use AI tools in clinical practice. Importantly, the content of any AI literacy education must not be limited to those with a technical background but should be accessible to students from diverse backgrounds (Walter, 2024). Many healthcare educators do not necessarily possess these AI literacy skills themselves (Lérias et al., 2024), suggesting that higher education institutions should prioritise developing the resources and training needed to ensure they do (Sallai et al., 2024).

The challenge of evolving assessment practices requires specific,

practical approaches that actively develop students' abilities to use AI responsibly and ethically. Critical evaluation exercises could present students with deliberately flawed AI-generated content, assessing their ability to detect errors, biases and limitations in healthcare contexts. Structured oral examinations could evaluate students' deeper understanding and clinical reasoning while naturally limiting direct GenAI use—these could include case presentations, ethical discussions and a defence of clinical decisions. For written assignments, standards could be explicitly benchmarked against GenAI capabilities, requiring students to demonstrate analysis and insight beyond what current AI systems can produce independently.

The benefit of these more process-based approaches is that they are more likely to maintain assessment integrity while developing crucial skills for future practice. While some of these approaches can still be partially bypassed by GenAI use, they create a framework where successful bypassing would require developing exactly the kind of critical engagement we should aim to foster (Farrokhnia et al., 2024; Xu et al., 2024). Oral examinations and benchmarked written assignments offer complementary benefits, directly evaluating students' clinical reasoning, ethical judgment and ability to defend decisions. While potentially resource-intensive, they provide unique opportunities to assess the depth of understanding that safe AI use requires. A more regressive solution would be to revert to invigilated closed-book or oral exams, which, while maintaining assessment integrity, would come at the expense of being resource-intensive, reducing accessibility and, in the current financial climate, is likely to be unsustainable in the long term (Quality Assurance Agency for Higher Education, 2023).

The World Health Organization (2024) has highlighted the significant role that AI is likely to play in the future of healthcare education and practice and recognises that students must develop AI literacy and understand how to use it responsibly and ethically. Just as science education is mandatory because it equips students to understand and make informed decisions in society, AI literacy is becoming equally fundamental for future healthcare professionals and indeed students in virtually every discipline (Dabbagh et al., 2024). Given the current knowledge gap and burden on healthcare educators, there may be value in national health organisations developing mandatory AI training that all healthcare students must complete during their education to ensure an equitable distribution of knowledge.

To address these challenges effectively, healthcare education institutions must develop evidence-based AI policies that clearly outline acceptable uses of GenAI and provide unambiguous guidance on integration into teaching and assessment. These policies should emphasise the development of judgment skills, requiring students to demonstrate analysis and insight beyond what current AI systems can produce independently. The goal should be to develop healthcare professionals who can work effectively and ethically with AI tools, maintaining their critical thinking capabilities while enhancing their practice through responsible AI use.

Success in addressing these challenges depends crucially on maintaining focus on developing students' judgment and evaluation skills while leveraging AI's benefits. This requires investing in educator training, establishing regular review processes to evaluate and update AI education approaches and creating clear institutional frameworks that promote responsible AI use while maintaining educational integrity. The ultimate aim must be to ensure that the integration of AI into healthcare education enhances rather than compromises the development of essential clinical skills and judgment needed for safe and effective patient care.

6. Conclusion

Integrating GenAI into healthcare education will offer significant potential as well as complex challenges that must not be ignored. While GenAI can enhance the learning experience of students, the temptation to misuse it risks fostering overdependence and eroding critical thinking and other cognitive skills that are necessary to provide effective care and patient safety. Success in addressing these concerns depends crucially on AI literacy. As we have argued, this should go beyond technical proficiency to encompass the ability to critically evaluate AI outputs, understand AI's limitations and biases and make informed judgments about when and how to use AI tools in clinical practice. Healthcare educators must embrace innovative, process-based and judgement-focused assessments that prioritise fairness, accountability and active engagement that ensure the integrity of the assessment in an era of easily accessible AI. Together, they can help prepare the future healthcare workforce to use AI effectively and ethically.

CRediT authorship contribution statement

Sebastian Porsdam Mann: Writing – review & editing. **Daniel Rodger:** Writing – review & editing, Writing – original draft, Conceptualization. **Christopher Bobier:** Writing – review & editing. **Bruce P. Blackshaw:** Writing – review & editing. **Brian Earp:** Writing – review & editing. **Julian Savulescu:** Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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During the preparation of this work, the author(s) used Claude 3.5 Sonnet to improve and edit the author(s)'s own written text. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication. The use of generative AI in this manuscript thus adheres to guidelines for the use of generative AI in academic writing (Porsdam Mann et al., 2024)

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