BMC Medical Education

RESEARCH

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Understanding the gap: a balanced multi-perspective approach to defining essential digital health competencies for medical graduates

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Abstract

Background Rapid technological advancements have left medical graduates potentially underprepared for the digital healthcare environment. Despite the importance of digital health education, consensus on essential primary medical degree content is lacking. Focusing on core competence domains can address critical skills while minimising additions to an already demanding curriculum. This study identifies the minimum essential digital health competency domains from the perspectives of learners, teachers, and content experts aiming to provide a framework for integrating digital health education into medical curricula.

Methods We conducted focus groups with students ($n=17$), and semi-structured interviews with medical educators ($n=12$) and digital sector experts ($n=11$) using video conferencing. Participants were recruited using purposive sampling. The data were analysed using framework analysis and inductive thematic analysis to identify common themes.

Results Four core themes and eleven sub-themes were identified and aggregated into four essential competency domains: "Understand the Local Digital Health Ecosystem and Landscape", "Safe, Secure and Ethical Information Literacy and Management", "Proficiency in Digital Health Tools and Associated Technologies" and "Scholarly Research and Evidence-based Practice". Medical educator and digital sector expert participants provided the greatest source of data for curriculum content consideration. Students demonstrated varying levels of aptitude, confidence, and interest in technology.

Conclusion Our balanced engagement with learners, educators, and digital health experts enabled the identification of a context-relevant framework for the minimum essential digital health competence domains for graduating medical students. The identification of focused, clinically relevant core competencies makes them amenable to integration into an existing curriculum tailored to local contexts. This approach addresses limitations of restricted curricular space and accommodates varying student interests, confidence and aptitude in technology. The delivery

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approach should consider a student-centred adaptive modality that takes advantage of advances in artificial intelligence (AI) as an effective pedagogical tool.

Keywords Medical education, Medical curriculum, Healthcare technology, Digital health, Ehealth

Background

The increasing adoption of healthcare technology, accelerated by the rise of telemedicine [1] and advancements in artificial intelligence (AI) [2, 3]. presents significant benefits and risks for patient care. The benefits include enhanced patient engagement, improved communication, and greater efficiency in diagnosis and treatment. Conversely, the risks involve heightened security concerns, ethical breaches and the exacerbation of disparities among underserved populations. Medical educators worldwide recognise the importance of technological advancements and advocate for curricula to be updated to equip future doctors with the essential competencies to navigate the digital landscape effectively and safely [4, 5]. However, incorporating extensive digital health content into an already crowded medical curriculum creates a significant challenge [6, 7]. Therefore, prioritising the integration of the minimum core essential digital health competencies that provide medical students with sufficient knowledge and skills to use digital health technology confidently and effectively without overcrowding the curriculum is highly desirable.

Many medical educators may assume that undergraduates, as digital natives [8], already possess inherent technology skills sufficient for safe, evidence-based patient care [9]. Despite some digital natives' self-assurance and confidence in their preparedness for digital healthcare environments [10], this assumption is not consistently supported by the literature [11–13]. Skills in consumer-level technology do not consistently translate to the profession-specific digital skills required for the clinical workplace [14–16]. Furthermore, medical students need to become more than just consumers of digital technology; they need to learn how to use digital tools for diagnosis and treatment solutions in a clinical practice environment [17]. Basic consumer technology skills also overlook the critical attitudinal components of digital health competence, such as digital professionalism, reputation, and responsibility [18]. Formal learning opportunities that address these needs are often sparse in medical education [19, 20]. This leaves many new doctors and medical students feeling underprepared for their roles in a digital healthcare environment [21–23].

A considerable number of digital native students are adept at using technology for social communication and, with sufficient training, are well-positioned to apply these skills to patient care [14]. However, they also need essential scaffolding to learn how to effectively leverage the vast and evolving array of information resources in healthcare [24]. While digital health capability frameworks are available, the literature presents a fragmented understanding of the optimal digital health competencies for health professionals [25]. To address this educational gap for medical students without overloading the curriculum, educators should carefully evaluate and select the most critical content, tailored to the local context, and determine effective delivery methods for integration. A comprehensive set of core competencies would include technical proficiency, data literacy and crucially, the ability to navigate the increasingly complex ethical landscape of digital technologies in healthcare.

For curriculum development, it is essential to consider the needs and expectations of key stakeholders within the local context, such as academics, educators, student communities, and vocational professionals [26]. Additionally, to ensure relevance and optimise resource use, the digital health curriculum should align with the nation's digital healthcare maturity and trajectory [27].

This multi-perspective study aims to identify, through consultation with learners, educators, and digital health experts, the minimum content and strategies necessary to achieve the required digital health competencies within the medical degree program at the University of Otago (UoO) in Aotearoa, New Zealand (NZ). We report our findings on the minimum essential competency domains sufficient to equip medical students with the skills needed to navigate the digital landscape effectively and safely upon graduation, while illustrating an effective approach to a context-specific, contemporary digital health curriculum.

Methods

Study setting

The UoO MB ChB degree (MB ChB) is a six-year primary medical program with an annual intake of about 300 students. The first three years largely focus on medical sciences, with predominantly classroom-based clinical skills, ethics, and professionalism learning, and the latter three are primarily clinical placements supported by structured teaching and directed self-learning. In the final year, students are fully embedded within clinical teams as trainee interns (TIs). Upon graduation, all graduates are employed in NZ and require two more years of supervised practice before achieving general medical registration.

Study design and population sample

To identify relevant digital health competencies for medical students, we used a qualitative interpretivist and inductive research design [28]. The objective was to determine the most effective digital health content and educational interventions to equip medical students with the necessary competencies for contemporary and future medical practice within NZ. The study gathered insights from medical students, medical educators, and digital health subject matter experts within UoO and NZ to understand their expectations and recommendations regarding digital health content. The design and reporting of this study were guided by the consolidated criteria for reporting qualitative research (COREQ) framework [29] (Supplementary file S1).

Participant recruitment

The medical students were recruited through medical student-managed social media channels. To be eligible, participants were currently enrolled in any year of the MB ChB degree at the UoO or recently graduated. Students were offered a supermarket voucher of modest value after participation. The medical educators and digital sector experts were recruited by email. The potential participants were identified by research team members who work in medical education at UoO (RG and TW) or with networks in the New Zealand Digital Health sector (RG). The interview population was purposively recruited to ensure sufficient representation and expertise. All potential participants were directed to a project website for information, sign-up, and to complete an electronic consent form.

Data collection

Data collection took place between March and September 2023 using Zoom videoconferencing software for focus groups and individual interviews. Both formats used a semi-structured interview guide to facilitate discussions. Student data were collected from four focus groups ($n = 3$–6 per group, 60 min) and 23 interviews (30–45 min) with medical educators ($n = 12$) and digital sector experts ($n = 11$). The data collection style was exploratory, with prompts to encourage brainstorming and discussion on content and resources considered essential for facilitating the learning of necessary digital health competencies for medical students. The focus groups and interviews generated 16 h and 49 min of video-recorded data (student focus groups: 3 h, 55 min; medical educators: 6 h, 58 min; digital sector experts: 5 h, 56 min). Video files and audio recordings were transcribed before applying framework analysis and inductive thematic analysis to identify common themes. Anonymity of interview participants was adopted through the allocation of alphanumeric characters: 'DSEn' (Digital Sector Expert), 'En' (medial educator), Sn (medical student).

Data analysis

The interview data were read several times and coded within NVivo by the first author (BS). A descriptive data-driven thematic analysis with an inductive focus was chosen as our analytical approach [30]. At this point, we aimed to interpret semantic themes from the stakeholders that were close to surface-level meanings rather than delving into deeper thematic development that encourages greater researcher subjectivity [31]. Framework Analysis, which resides within the broader category of thematic analysis (TA) as a 'medium-Q' approach [32], was therefore used. This provided a comparative approach to thematic analysis, offering a systematic and structured method while preserving qualitative depth [33]. The process involved five stages: familiarisation, identifying a framework, indexing (coding), charting, mapping and interpretation. This flexibility was well-suited for the systematic handling of a large volume of opinion-based descriptive data while ensuring rigour [34, 35].

Author positionality and reflexivity

The first author, BS, is a senior and experienced information technology professional. All other authors are faculty at UoO. RG and TW are senior academics, medical educators and practicing physicians. RM is a healthcare professional and senior lecturer with extensive experience in realist research methods, and TG is an education adviser with a strong interest in technology and staff development. The study forms part of a larger multiphase project grounded in realist research. Data collection and analysis of this phase were approached without preconceived conclusion to provide fresh insights. While this phase included interpretivism, its primary objective was identifying surface-level themes to inform subsequent phases. It was noted that faculty involvement could have potentially influenced student opinions due to power dynamics. To mitigate this, faculty had limited direct involvement in participant interviews and BS was seen as neutral 'outsider'. RM participated in some initial student focus group interviews but does not teach the participants. All participants were assured of data anonymisation. Reflexivity was primarily achieved through individual reflections and regular collaborative team meetings over several months, with varying participation from the authors.

Results

Forty participants contributed data to the study, comprising 17 medical students, 12 medical educators and 11 digital sector experts. Most of the medical educator

Table 1 Study participant demographic characteristics

Participants	Role	Female *n* = 23 (57.5%)	Male *n* = 17 (42.5%)	Total (*N* = 40)
Digital Sector Experts	Clinical Informatics	6	3	9
(DSE1-11)	Senior Academic	1		1
	General Practitioner (GP)		1	1
				11 (27.5%)
Medical Educators	General Practitioner (GP)	1		1
(E1-12)	Academic / Medical Practitioner	2	7	9
	Academic / e-Learning		1	1
	Health Science		1	1
				12 (30%)
Medical Students	4th Year (ALM 4)	1	1	2
(S1-17; FG1-4)	5th Year (ALM 5)	9	2	11
	6th Year (ALM 6)	3	1	4
				17 (42.5%)

participants were both experienced educators and medical practitioners. Similarly, most digital sector expert participants were experienced medical practitioners involved with the practical application of clinical informatics (Table 1). Data analysis identified eleven sub-themes that were refined and grouped into four superordinate themes: "Understand the Local Digital Health Ecosystem and Landscape", "Safe, Secure and Ethical Information Literacy and Management", "Proficiency in Digital Health Tools and Associated Technologies", and "Scholarly Research and Evidence-based Practice". Each of the four themes has been summarised into an overarching digital health competence domain (Table 2). These four domains are interrelated and partially overlap in scope. Before expanding on each domain, we introduce an overarching contextual observation uncovered during the interviews. The following sections present results from the four core competence domains, with illustrative quotes.

Student heterogeneity

There was notable heterogeneity in the self-perceived digital proficiency among the medical student participants. The student focus groups provided varying perspectives, demonstrating mixed confidence, interest, and perceived readiness for the digital healthcare environment. Some self-assured digital native students expressed little interest in digital health, questioning the primary benefits of such content and how it would enhance their medical education.

> *The people who are writing those parts of the curriculum, not to generalise, but a lot of them maybe feel like that is a really difficult area. And maybe those are the technology things that they're struggling with. But they're not necessarily the technology things that we're struggling with. And so, it's kind of like you're writing a curriculum for yourself, not for us. (ALM5, S3, FG1)*
>
> *I think if someone put teaching into our curriculum. It was like, you have a digital health session. I would probably roll my eyes and rather not go. (ALM5, S1, FG1)*
>
> *I think part of that is, I feel like medical students might not be the target audience. You know that sort of digital… having grown up with that sort of stuff, the basic issues we're running into, probably isn't how do I? You know, work this thing? It's more like I don't have access, so I can't do things like. (ALM5 S2, FG1)*

Table 2 Competence domain descriptions

Theme	Sub-Themes	Description
1. Understand the Local Digital Health Ecosystem and Landscape	a). Benefits and Opportunities b). Risks and Limitations c). The Digital Health Ecosystem	Knows about digital health terminology and the local digital health ecosystem. Recognises the benefits, opportunities, limitations, and risks of current and future digital health technologies at both patient and community levels.
2. Safe, Secure and Ethical Information Literacy and Management	a). Health Information Literacy b). Privacy, Confidentiality, Safety and Security c). Ethics, Governance, Legalities, Provenance and Sovereignty	Knows about clinical workflows and associated data collection along with its management, storage, and transmission. Knows how to use patient health data and understands the importance of its quality, origin, sovereignty, ethics, policies, and legalities for secure confidential healthcare.
3. Proficiency in Digital Health Tools and Associated Technologies	a). Digital Technology Proficiency b). Digital Health Proficiency c). Digital Professionalism	Proficient in the use of digital technology and digital health tools for informed decision-making and accurate, safe, secure, and ethical patient care. Ensure professional and confidential electronic communication with stakeholders and uphold digital professionalism in all online activities.
4. Scholarly Research and Evidence-based Practice	a). Critical Appraisal Skills b). Research Proficiency	Demonstrates critical evidence-based research and reflective appraisal skills to evaluate the quality of health information sources as well as digital health interventions. Applies scholarly rigour to insights and analysis to produce evaluative reports through academic writing.

A digital sector expert held the perception that emerging medical professionals, being digital natives, possess both inherent technological aptitude and natural confidence in their digital capabilities.

> *You see the new graduates, you know, the young doctors, associates, registrars coming through to the practice very quick to pick up the IT stuff very quick to adopt, very comfortable with doing that, whereas it can be much harder to get the more established colleagues to adapt those new things. (DSE3)*

However, not all the medical students shared the same high level of self-assurance in their perceived technology competence. Many student participants with lower confidence in their abilities showed greater interest in the subject and expressed a need for formal digital health education.

> *I think it's probably super important going forward that there is more training because, at the moment, going into clinical years, I do feel a little bit out of depth (ALM4, S11, FG3).*

Several interview participants recognised the disparity in confidence and capability with technology, expressing disappointment in some students' proficiency with basic technology skills.

> *I think we sometimes overestimate how capable they really are with digital things. (E11)*
> *Even touch typing, I mean, I am still stunned that people come out of university and cannot touch type. (DSE7)*

Domain 1: understand the local digital health ecosystem and landscape

The first identified competence domain centres on the need for students to understand the local digital health ecosystem and the landscape. Data from student focus groups revealed that many students did not fully appreciate the broad scope of the local digital health ecosystem and wanted to learn more about it.

> *A general lecture would be a good start, really, because when you talk about digital health. I really do have to sit down and think on what that includes. So, I think that's already an indication of how lacking of knowledge you have in this area. (ALM5, S6, FG2)*

Despite some recognition of its interconnectedness, many students perceived digital health primarily through specific applications, such as telemedicine for remote patient care. However, they appreciated the relevance of digital health for their future, especially when they had experienced its use first-hand.

> *As soon as we got into the hospital, you kind of see the relevance of it, and I felt a lot more interested in wanting to learn how it'll work and how to use it to my advantage. (ALM5, S5, FG2)*

Digital sector experts reasoned that when students more fully comprehend the local digital health landscape and their role within it, they are better equipped to identify and assess the strengths, weaknesses, opportunities, and threats of both current and emerging digital health interventions. They noted that a holistic understanding enables students to critically evaluate digital health solutions and their implications for effective healthcare delivery within the local context.

> *Understanding what comes in and where it comes from, what's done with that information, you know, and all the things to consider when you're doing it. That would certainly be a place to start for me. (DSE08)*
> *Even just an overview of how it's used in clinical practice and the different issues facing it, you know, facing clinicians when they're trying to, you know, trying to get through their day. (DSE11)*

Domain 2: safe, secure and ethical information literacy and management

This domain builds on the foundational macro-level knowledge of the previous domain. While it overlaps with acquiring a high-level understanding of the local clinical workflows, it is more concerned about the workflow content and data management. It underscores the importance of safe, secure, and ethical patient data management. Several digital sector experts and medical educator participants emphasised the need for students to understand patient data collection, storage, transmission and how it is used within the digital health ecosystem. They highlighted critical curriculum competencies to promote safe, secure, and ethical information literacy and data management.

> *We need safe, competent practitioners, and at the top of my list is actually privacy and security, which I think just a basic understanding of the importance of protecting health information. (DSE2)*
> *In terms of the ethics of it, it's a matter of being aware of what the unintended consequences of making some digital move. (E6)*

Some participants recognised the need for students to gain a thorough understanding of local regulations, policies, and data governance principles, particularly in relation to the local cultural context. They emphasised the importance of special considerations for Indigenous and diverse populations concerning the use and management of patient data with digital technologies. For instance, a digital sector expert highlighted the necessity for students to understand data sovereignty and the complexities of data sharing between organisations.

> *What are the issues about sharing data between organisations? What is Māori data sovereignty? You know what is taonga? [data or information that is considered precious and significant to the Māori people] You know all these different things that affects the New Zealand digital health ecosystem. (DSE11)*

Domain 3: proficiency in digital health tools and associated technologies

The third competence domain involves developing hands-on skills and building confidence in using digital technology and digital health tools. Participants agreed that by the time students graduate, they need to be proficient in effectively using the technology they are most likely to encounter in the local clinical environment. This proficiency is essential for making informed clinical decisions that ensure safe, secure, and ethical patient care. As one digital sector expert commented:

> *Students 'should understand what tools are available, how do you use them effectively? And yeah, and they need to have quite a good understanding of how those tools work in order to use them properly (DSE7).*

This proficiency extends beyond the clinical environment to encompass using technology effectively for confidential and secure electronic communication for all digital activities, ensuring that demonstrable digital professionalism is maintained in all online interactions with patients and colleagues. As another digital sector expert pointed out:

> *A lot of what we do is non-clinical type work. How do you do that? How do you set yourself up on a VPN to work remotely from home? So, if people aren't expecting that, it can come as a bit of a shock to the system… there's a lot of non-clinical facing administrative type work that still needs to be done efficiently using good tools. (DSE1)*

This sentiment was succinctly summarised by a digital sector expert who suggested that by the time medical students graduate, they should confidently be able to answer the following questions: "How do I use organisation tools? How do I communicate? (DSE2).

The primary concern among some of the less confident student focus group participants was learning to use specific applications necessary for their roles. Some also disagreed with the assumption that, as digital natives, they require little to no training, recognising a need for adequate training.

> *I think just mostly some more like formal teaching on how to use like different apps and stuff, rather than just like assuming that students or others will know how to use them and kind of leaving it up to them. Because not all the time, not everyone does. (ALM5, S13, FG3)*

However, a medical educator noted that the extensive variety of site-specific applications make in-depth exploration of applications impractical in an academic setting:

> *We don't teach, really, how to use the system because, as we said, it's different. It's a bit like operating systems for our hardware or software. It's a different system at every hospital. (E3)*

Participants suggested that focusing on the fundamental principles and the broader, holistic perspective of digital health is a more effective use of medical school resources for developing digital health competence, rather than delving into the specifics of individual applications. A medical educator added that clinicians and professional staff within the workplace are better equipped to train students in the necessary system commands and demonstrate the use of specific applications within the clinical context:

> *I think things like training them on how to use a particular electronic health record system probably should be done by the hospital that they're going to work in. (E2)*

Several interview participants reiterated that training in consultation skills is an integral component of achieving proficiency with digital health tools. This is exemplified by demonstrable behaviour in digital professionalism, as future doctors must also consider patients' technology capabilities. A General Practitioner (GP) who is also a digital sector expert illustrated this by highlighting the triadic relationship between the doctor, patient, and computer when developing a shared management plan: *'How you maintain the consultation while using these*

tools without the tools taking over the consultation, I think that's kind of a really important' (DSE3).

Building on the theme of digital professionalism, medical educator participants also emphasised the importance of incorporating the responsible use of social media into digital health proficiency education:

> *Social media and using social media and as a doctor. So helping students work through the, the tensions between sharing everything and maintaining their professional identity and behaving professionally, given social media. I mean, I would take that as being also an important part of being a digitally competent doctor. (E9)*

Most participants recognised digital professionalism as a crucial facet of technological proficiency, particularly in emerging areas like artificial intelligence (AI). They acknowledged that sufficient understanding and proficiency in using AI, alongside maintaining professional conduct, is essential for preparing students to meet the challenges of the modern digital healthcare environment. Some students noted the potential benefits and limitations of generative AI in this context, with one student commenting:

> *I feel like teaching on it would be quite valuable, because I know, like, even though it is this really cool piece of technology. I know there are like downfalls like when you're like asking it clinical type questions.... how to work around those kinds of like pitfalls and the technology to get like the best outcome from it. (ALM5, S7, FG4).*

A senior medical educator fully endorsed the use of generative AI as a pedagogy tool, noting that:

> *Students should use it and learn how to use it. It's the same as they need to learn how to use a calculator or software package.... So I think we should embrace this. I think we should teach on it. (E3)*

Domain 4: scholarly research and Evidence-based practice

The final domain, building on the others, focusses on enabling students to apply evidence-based research and critical appraisal skills into digital health settings. This integration enables students to effectively evaluate the opportunities and risks associated with digital health tools. Participants noted that, akin to the skills required for practicing evidence-based medicine, students must develop and apply reflection, critical thinking, and scholarly rigour. These skills are essential for competently assessing the efficacy, effectiveness, suitability, and risks of digital health interventions and include:

> *How do I access and trust information that I'm resourcing digitally? So, how do I pick through what's accurate and what's not? And what do I use to help make those decisions? (DSE2)*
> *How to find information resources, how to translate those information resources, and to inform your practice. (DSE11)*
> *The ability to look up evidence-based information using online techniques. I don't mean Dr. Google. (E7)*

Educators also suggested that, along with technology proficiency, digital professionalism, and ethical responsibility, students also need to exhibit the foresight to anticipate future trends, challenges, and opportunities in the field of digital health and develop the scholarly skills to communicate complex ideas clearly and concisely in writing, for example:

> *The ability to use an array of programs to run to assist the skills in terms of research in terms of writing reports in terms of analysis and the ability to look up guideline-based techniques for prescribing and so on. (E7)*
> *Synthesising information and then presenting it in an electronic format with appropriate referencing. I think that's a useful skill because that incorporates both the critical appraisal component and also being able to work with different formats. (E9)*

Discussion

Through interviews with learners, educators, and digital health experts, this multi-perspective study has identified the essential core competency domains necessary for foundational digital health education for medical students. The four essential domains encompass the knowledge, skills and attitudes required to prepare medical graduates for effective and safe navigation of the digital healthcare environment. The identification of focused, clinically relevant core competencies makes them amenable to integration into an existing curriculum tailored to local contexts. Our approach maintains this focus on local adaptation while ensuring alignment with the proposed digital health curriculum [36].

Consistent with the literature, our interview data indicates that future doctors need more than consumer-level technology and social media skills to navigate the complexities of the emerging digital healthcare environment. Developing an effective digital health curriculum necessitates balanced input from multiple perspectives. Student perspectives are crucial for designing engaging learning experiences, while insights from educators and local digital sector experts ensure that the curriculum is both

contextually relevant and appropriately adapted to local needs.

Data from the student focus groups revealed a diverse population with varying levels of digital capability, confidence, and interest, suggesting that a "one size fits all" approach to digital health education is unlikely to be effective. While some students lacked confidence in their digital skills yet were enthusiastic about digital health training, others were more confident in their preparedness for the digital healthcare environment and less enthusiastic about the training's necessity. Comments from one student suggested that they perceived their digital literacy to be more advanced than that of their medical educators, creating a paradox since teachers are expected to have greater expertise. Supporting this view, a digital sector expert noted that today's digital natives often have technological aptitude exceeding that of more established colleagues. Although genuine differences in student digital proficiency exist, some of this variation may be attributable to the Dunning-Kruger effect [37], whereby individuals, including medical trainees [38], tend to overestimate or underestimate their own skills. Therefore, it is important to avoid assumptions about students' digital literacy based solely on their 'digital native' status. A successful curriculum must adapt to this real or perceived diversity, ensuring all students achieve foundational digital health competencies while offering advanced learning opportunities for those with higher confidence and skills.

Our research findings align with other studies with similar objectives and challenges [39, 40]. However, these studies typically develop frameworks with a large number of digital health competence domains aimed at a broad range of healthcare professionals. Additionally, some studies incorporate input from broader stakeholder groups with fewer student contributions [41], or focus exclusively on the perspectives of medical students [10, 19, 22, 26] or physicians [42]. In contrast, our study is distinguished by its balanced insights from learners, educators, and digital health experts. It identifies the minimum essential digital health competencies necessary for medical graduates within the local healthcare setting. This approach provides a nuanced and comprehensive framework for curriculum design, ensuring that it is manageable for students while optimising resource use.

Insights from digital sector expert interview participants underscored the crucial importance of understanding the local digital health landscape, noting that students often overlook the broader digital health ecosystem and their role within it, focusing on learning how to operate individual applications. This limitation may result from a lack of understanding of digital health terms and concepts [26], making technological jargon challenging to grasp and negatively affecting learning outcomes [43]. This knowledge gap jeopardises the opportunity to enhance patient care outcomes. Previous research indicates that offering a whole-system perspective and demonstrating the purposeful use of technology can improve student comprehension [44].

To address these challenges, educators from our interviews suggested that the medical school programme should focus on teaching the fundamentals, including the "big picture" to provide students with a comprehensive understanding of their future environment and role. They also recommended that detailed instruction on specific applications be entrusted to practice settings, where their relevance can be demonstrated. This may help mitigate challenges associated with curricular overload. Additionally, the medical programme is well-suited to provide guided instruction for students to develop digital professionalism [18]. This includes maintaining ethical and professional behavior that extends beyond patient care to ensure safe, secure, and confidential communication across all digital platforms and activities. A thorough understanding of relevant local regulations and data governance is also essential to address the cultural sensitivities of Indigenous and diverse populations.

Research suggests that in countries at an early stage of national digital health transformation, student education should focus more on fundamental digital health competencies rather than advanced emerging technologies [27]. Our data supports this perspective, prioritising the teaching of digital health fundamentals with a comprehensive overview that aligns with regional requirements. This approach ensures that medical students can effectively and safely apply their skills within the local clinical environment. However, interview participants recognised the significance of the rapid advancement of AI, underscoring the need for its inclusion in the digital health curriculum to adequately prepare medical students for emerging digital health environments and meet patient expectations. AI education can be aligned with local contextual requirements, ensuring that students, at a minimum, become familiar with AI terminology, appropriate use cases, and relevant ethical, privacy, and data governance regulations [5]. This will enable students to appreciate both the opportunities and risks of using AI, as well as to interpret and critically reflect on AI-generated outcomes [45]. Learning outcomes could also be developed to include the effective use of generative AI language models, and the development of prompt engineering skills [46, 47].

It is important to note that this study has identified competency domains rather than specific learning outcomes, and deliberate strategies will be needed to incorporate digital health teaching into the medical curricula. This will need thoughtful modification of the existing curriculum. Established frameworks, such as Miller's

Pyramid [48], which aligns with competency-based medical education, can assist curriculum planners in developing progressive learning outcomes for such integration. Given the potential diversity among students and the possibility that some faculty members may have limited digital health experience, tailored approaches will need to be developed. This may include faculty development programs, interdisciplinary collaboration, and leveraging external expertise for curriculum co-design [40, 49]. As several medical educators noted, faculty may particularly lack specific knowledge of the different electronic health record systems and the various other local specialist applications used in the clinical environment.

Consideration should be given to an adaptive curriculum style for digital health topics to tailor learning experiences [50] and provide rapid and effective feedback [51]. This approach ensures that all students achieve minimum foundational digital health competencies, while adjusting to each student's pace and current understanding. Some of these curriculum adaptations could be achieved by taking advantage of AI's dual role as both a subject of study and an effective pedagogical tool [52, 53], particularly in tutoring virtual patient scenarios and clinical decision-making. Moreover, when AI competencies are effectively developed, medical students report an improved learning experience [54]. The use of AI in teaching medical students has been shown to increase motivation and reduce anxiety, thereby enhancing the overall learning environment [55]. Our interview data from student and educator participants indicated that students have been motivated and enthusiastic to learn about AI's potential benefits and risks from the outset. This speciality has been captured within the third digital competence domain as part of digital professionalism and proficiency with health tools, which highlights the need to develop confidence and proficiency in providing informed, safe, secure, and ethical patient care.

The study has limitations. While the stakeholder sample offers a balanced representation, it is relatively small and focused on a single medical school within a local and national context. Although the diversity in responses suggests a broad range of opinions, applicability may depend on local context.

Future/Next steps

To mitigate some of the challenges of a crowded curriculum, our study data suggest that focusing on the minimum essential digital health competencies necessary for clinical practice will likely be more effective than teaching numerous technical skills on applications that are likely to change over time [36]. Hence, the identified competence domains are not intended as a comprehensive syllabus, but rather as a starting point and model for others for tailoring a curriculum to local needs. The next steps for this multi-phase study include refining the four identified competency domains into a framework for actionable learning outcomes that can be integrated into an existing medical curriculum. The new learning outcomes will then be mapped against the existing learning outcomes within the current curriculum with a view to gradually transition from the more traditional practices where appropriate to those more suitable for the emerging local digital healthcare environment. This should enable students to acquire the necessary digital professionalism competencies identified by digital sector experts and medical educator participants as described in the four competence domains (Table 2), allowing them to become what one medical educator describes as: "digitally competent doctors" (E9). To achieve this, we will adopt realist research methods to synthesise literature with stakeholder recommendations, ensuring that the digital health competencies are contextually sound and effectively tailored for students. The final framework will be further refined with key stakeholders. This meticulous approach aims to increase the likelihood of successful integration into the existing medical curriculum and enhance its local applicability.

Conclusions

The lack of consensus in the literature on digital health content, skills and pedagogies for medical curricula may lead to overloaded frameworks with excessive content, hindering implementation. This study uniquely engaged learners, educators, and digital health experts to identify the minimum essential core competency domains for a digital health curriculum within the local healthcare context and could be an approach used in other contexts. Our findings suggest that to equip future doctors with the essential competencies to effectively and safely navigate the digital healthcare landscape, they must, at a minimum, possess competencies in four domains. These competence domains include a comprehensive understanding of the local digital health ecosystem, skills in data management, knowledge of local regulations, cultural safety, and ethical principles. Additionally, they include proficiency with relevant digital tools and critical evidence-based research abilities - all of which need to be integrated within traditional medical subjects while preserving the integrity of the existing curriculum.

Abbreviations

ALM	Advanced Learning in Medicine
AI	Artificial Intelligence
COVID-19	coronavirus disease of 2019
En	Medical Educator
DSEn	Digital Sector Expert
FG	Focus Group
Sn	Medical Student
UoO	University of Otago
NZ	Aotearoa New Zealand

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-025-07194-8.

Supplementary Material 1

Acknowledgements
The authors thank the participants in the study for their time and expertise.

Author contributions
BS, designed the study framework, conducted the data collection and analysis, and drafted the initial manuscript. All authors contributed to developing the interview questions. RM facilitated the initial student focus group interview, after which BS conducted the subsequent student focus group sessions and all other interviews. All authors engaged in the iterative review and revision of the manuscript and approved the final version for submission. All authors agree to be accountable for the work.

Funding
No funding to declare.

Data availability
The datasets generated and analysed for the present study are not publicly available to protect the confidentiality and anonymity of participants. However, some data can be made available from the corresponding author (BS) upon receipt of a reasonable request.

Declarations

Ethics approval and consent to participate
Ethical approval was obtained from the University of Otago Human Research Ethics Committee (Reference: D23/042). All aspects of the study adhered to the Declaration of Helsinki. Participation was voluntary, and informed consent was obtained from all participants.

Consent for publication
Not applicable.

Competing interests
Tim Wilkinson is a Senior Editorial Board member of BMC Medical Education. Tehmina Gladman is an Editorial Board member of BMC Medical Education.

Clinical trial number
Not applicable.

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Received: 3 March 2025 / Accepted: 18 April 2025
Published online: 09 May 2025

References

1. Wosik J, Fudim M, Cameron B, Gellad ZF, Cho A, Phinney D, et al. Telehealth transformation: COVID-19 and the rise of virtual care. J Am Med Inf Assoc. 2020;27(6):957–62.
2. Weidener L, Fischer M. Teaching AI ethics in medical education: A scoping review of current literature and practices. Perspect Med Educ. 2023;12(1):399–410.
3. Masters K. Artificial intelligence in medical education. Med Teach. 2019;41(9):976–80.
4. Zainal H, Xin X, Thumboo J, Fong KY. Medical school curriculum in the digital age: perspectives of clinical educators and teachers. BMC Med Educ. 2022;22(1):428.
5. Weidener L, Fischer M. Artificial intelligence teaching as part of medical education: qualitative analysis of expert interviews. JMIR Med Educ. 2023;9:e46428.
6. Edirippulige S, Brooks P, Carati C, Wade VA, Smith AC, Wickramasinghe S, et al. It's important, but not important enough: eHealth as a curriculum priority in medical education in Australia. J Telemed Telecare. 2018;24(10):697–702.
7. Slavin S, D'Eon MF. Overcrowded curriculum is an impediment to change (Part A). Can Med Educ J. 2021;12(4):1–6.
8. Prensky M. Digital natives, digital immigrants. On the horizon. Volume 9. MCB University; 2001. pp. 1–6. 5.
9. Reid L, Button D, Brommeyer M. Challenging the myth of the digital Native: A narrative review. Nurs Rep. 2023;13(2):573–600.
10. Townsley H, Sumner B, O'Neill A, Kenwright D, Wilkinson T, Grainger R. Student perspectives on health informatics in a medical curriculum: A case study. Focus Health Prof Education: Multi-Professional J. 2024;25(1).
11. Cummings E, Whetton S, Mather C. Integrating health informatics into Australian higher education health profession curricula. Elsevier Inc.; 2017. pp. 323–43.
12. Smith EE, Kahlke R, Judd T. Not just digital Natives: integrating technologies in professional education contexts. Australasian J Educational Technol. 2020;36(3):1–14.
13. Kirschner PA, De Bruyckere P. The Myths of the digital native and the multitasker. Teach Teacher Educ. 2017;67:135–42.
14. Pathipati AS, Azad TD, Jethwani K. Telemedical education: training digital natives in telemedicine. J Med Internet Res. 2016;18(7):e193.
15. Kuhn S, Müller N, Kirchgässner E, Ulzheimer L, Deutsch KL. Digital skills for medical students - qualitative evaluation of the curriculum 4.0 medicine in the digital age. GMS J Med Educ. 2020;37(6):Doc60.
16. Lam M, Hines M, Lowe R, Nagarajan S, Keep M, Penman M, et al. Preparedness for eHealth: health sciences students' knowledge, skills, and confidence. J Inform Technol Education: Res. 2016;15:305–34.
17. McGregor D, Keep M, Brunner M, Janssen A, Quinn D, Avery J, et al. Preparing E-Health ready graduates: A qualitative focus group study. Stud Health Technol Inf. 2017;239:91–6.
18. Ellaway RH, Coral J, Topps D, Topps M. Exploring digital professionalism. Med Teach. 2015;37(9):844–9.
19. Machleid F, Kaczmarczyk R, Johann D, Balčiūnas J, Atienza-Carbonell B, von Maltzahn F, et al. Perceptions of digital health education among European medical students: mixed methods survey. J Med Internet Res. 2020;22(8):e19827.
20. Utukuri M, D'Souza F, Deighton A, Le EP, Osei-Boadu B, Gadi N, et al. Digital health: a neglected part of health curricula? Future Healthc J. 2022;9(1):18–20.
21. Nazeer MNM, Baig H, Subeh A, Khan QI, Majeed SA, Ashraf MA. Multicentric analysis of the perceptions and knowledge of digital health amongst undergraduate medical students. Scott Med J. 2022;67(2):56–63.
22. Vossen K, Rethans JJ, van Kuijk SMJ, van der Vleuten CP, Kubben PL. Understanding medical students' attitudes toward learning eHealth: questionnaire study. JMIR Med Educ. 2020;6(2):e17030.
23. Zainal H, Xiaohui X, Thumboo J, Yong FK. Exploring the views of Singapore junior Doctors on medical curricula for the digital age: A case study. PLoS ONE. 2023;18(3):e0281108.
24. Cutrer WB, Spickard WA 3rd, Triola MM, Allen BL, Spell N 3rd, Herrine SK, et al. Exploiting the power of information in medical education. Med Teach. 2021;43(sup2):S17–24.
25. Mainz A, Nitsche J, Weirauch V, Meister S. Measuring the digital competence of health professionals: scoping review. JMIR Med Educ. 2024;10:e55737.
26. Edirippulige S, Gong S, Hathurusinghe M, Jhetam S, Kirk J, Lao H, et al. Medical students' perceptions and expectations regarding digital health education and training: A qualitative study. J Telemed Telecare. 2022;28(4):258–65.
27. Zainal H, Tan JK, Xiaohui X, Thumboo J, Yong FK. Clinical informatics training in medical school education curricula: a scoping review. J Am Med Inf Assoc. 2023;30(3):604–16.
28. Thomas DR. A general inductive approach for analyzing qualitative evaluation data. Am J Evaluation. 2006;27(2):237–46.
29. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. Int J Qual Health Care. 2007;19(6):349–57.
30. Ritchie J, Spencer L. Qualitative data analysis for applied policy research. In: Bryman A, Burgess RG, editors. Analysing qualitative data. London: London: Taylor & Francis.; 1994. pp. 173–94.
31. Braun V, Clarke V, Hayfield N, Terry G. Thematic Analysis. Handbook of Research Methods in Health Social Sciences. 2019;843–60.

32. Clarke V, Braun V. Using thematic analysis in counselling and psychotherapy research: A critical reflection. Counselling Psychother Res. 2018;18(2):107–10.
33. Goldsmith L. Using Framework Analysis in Applied Qualitative Research. The Qualitative Report. 2021.
34. Gale NK, Heath G, Cameron E, Rashid S, Redwood S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. BMC Med Res Methodol. 2013;13:117.
35. Ward DJ, Furber C, Tierney S, Swallow V. Using framework analysis in nursing research: a worked example. J Adv Nurs. 2013;69(11):2423–31.
36. Car J, Ong QC, Erlikh Fox T, Leightley D, Kemp SJ, Svab I, et al. The digital health competencies in medical education framework: an international consensus statement based on a Delphi study. JAMA Netw Open. 2025;8(1):e2453131.
37. Kruger J, Dunning D. Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. J Pers Soc Psychol. 1999;77(6):1121–34.
38. Rahmani M. Medical trainees and the Dunning-Kruger effect: when they don't know what they don't know. J Grad Med Educ. 2020;12(5):532–4.
39. Nazeha N, Pavagadhi D, Kyaw BM, Car J, Jimenez G, Tudor Car L. A digitally competent health workforce: scoping review of educational frameworks. J Med Internet Res. 2020;22(11):e22706.
40. Foadi N, Koop C, Mikuteit M, Paulmann V, Steffens S, Behrends M. Defining learning outcomes as a prerequisite of implementing a longitudinal and transdisciplinary curriculum with regard to digital competencies at Hannover medical school. J Med Educ Curric Dev. 2021;8:23821205211028347.
41. Brunner M, McGregor D, Keep M, Janssen A, Spallek H, Quinn D, et al. An eHealth capabilities framework for graduates and health professionals: Mixed-Methods study. J Med Internet Res. 2018;20(5):e10229.
42. Scott IA, Shaw T, Slade C, Wan TT, Coorey C, Johnson SLJ, et al. Digital health competencies for the next generation of physicians. Intern Med J. 2023;53(6):1042–9.
43. Fernando J, Lindley J. Lessons learned from piloting mHealth informatics practice curriculum into a medical elective. J Am Med Inf Assoc. 2018;25(4):380–4.
44. Klecun E, Lichtner V, Cornford T. e-Literacy in health care. Stud Health Technol Inf. 2014;205:843–7.
45. Charow R, Jeyakumar T, Younus S, Dolatabadi E, Salhia M, Al-Mouaswas D, et al. Artificial intelligence education programs for health care professionals: scoping review. JMIR Med Educ. 2021;7(4):e31043.
46. Meskó B. Prompt engineering as an important emerging skill for medical professionals: tutorial. J Med Internet Res. 2023;25:e50638.
47. Heston T, Khun C. Prompt engineering in medical education. Int Med Educ. 2023;2(3):198–205.
48. Miller GE. The assessment of clinical skills/competence/performance. Acad Med. 1990;65(9 Suppl):S63–7.
49. Krive J, Isola M, Chang L, Patel T, Anderson M, Sreedhar R. Grounded in reality: artificial intelligence in medical education. JAMIA Open. 2023;6(2):ooad037.
50. Quirk M, Chumley H. The adaptive medical curriculum: A model for continuous improvement. Med Teach. 2018;40(8):786–90.
51. Carney PA, Mejicano GC, Bumsted T, Quirk M. Assessing learning in the adaptive curriculum. Med Teach. 2018;40(8):813–9.
52. Boscardin CK, Gin B, Golde PB, Hauer KE. ChatGPT and generative artificial intelligence for medical education: potential impact and opportunity. Acad Med. 2024;99(1):22–7.
53. Prachnakorn N, Preecha K, Sri UTT, Jaroenyod T, Sawang K, Patwong N, et al. Incorporating artificial intelligence into a workshop on scientific and scholarly report writing for preclinical medical students. Med Teach. 2024;46(6):746–8.
54. Thomae AV, Witt CM, Barth J. Integration of ChatGPT into a course for medical students: explorative study on teaching scenarios, students' perception, and applications. JMIR Med Educ. 2024;10:e50545.
55. Beketov V, Lebedeva M, Taranova M. The use of artificial intelligence in teaching medical students to increase motivation and reduce anxiety during academic practice. Curr Psychol. 2024;43(16):14367–77.

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