RESEARCH PAPER

Educational Innovation In Health: Impact Of Digital Technologies On Clinical Training

Hugo Andrés Acosta Santacruz[1*], Andrea Elizabeth Yanangomez Benavides[2], Diego Sebastián Viera Pérez[3], Joselyne Nathaly Valenzuela Cáceres[4], Ingrid Valeria Flores Zambrano[5], Karla Mariuxi Román Manzano[6]

[1*]Ministry of Public Health of Ecuador, Ambato, Ecuador.
Email: hugoacosta0095@gmail.com ORCID: 0009-0003-8274-7086

[2]Technical University of Ambato, Ambato, Ecuador.
Email: anbeya87@gmail.com ORCID: 0009-0007-7605-8865

[3]Pontifical Catholic University of Ecuador, Ambato Campus.
Email: dsviera@pucesa.edu.ec ORCID: 0000-0002-4489-8268

[4]Pontifical Catholic University of Ecuador, Ambato Campus, Ambato, Ecuador.
Email: jnvalenzuela@pucesa.edu.ec ORCID: 0009-0004-7345-6639

[5]Pontificia Universidad Católica del Ecuador. Ambato, Ecuador
Email: ivfloresz@pucesa.edu.ec ORCID: 0000-0002-7079-5625

[6]Nicovita, Milagro, Ecuador
Email: kromanm95@gmail.com ORCID: 0009-0002-3997-3080

Abstract
The rapid advancement of digital technologies has transformed health sciences education, particularly in the field of clinical training. This systematic review aimed to analyze the impact of digital technologies on clinical training in health sciences education. The review was conducted following the PRISMA 2020 guidelines. A comprehensive literature search was performed in three major databases: Scopus, PubMed/MEDLINE, and Web of Science. The search initially identified 498 records. After removing duplicates and applying eligibility criteria, 18 studies were included in the qualitative synthesis.
The included studies examined various digital technologies applied to clinical education, including simulation-based learning systems, artificial intelligence tools, digital learning platforms, and online educational resources. Overall, the findings indicate that digital technologies significantly enhance clinical training by improving procedural skills, clinical reasoning, and student engagement. Simulation environments and virtual learning systems provide safe and controlled settings where students can practice clinical procedures without compromising patient safety.
Additionally, digital educational platforms facilitate flexible learning and promote the development of digital competencies among healthcare students and professionals. Despite these benefits, challenges such as technological infrastructure limitations and the need for faculty training remain important considerations.
In conclusion, digital technologies represent a valuable strategy for strengthening clinical education and preparing healthcare professionals for increasingly technology-driven healthcare systems.

Keywords: Education Medical; Educational Technology; Clinical Competence; Simulation Training; Artificial Intelligence
How to cite this article: Santacruz HAA, Benavides AEY, Pérez DSV, Cáceres JNV, Zambrano IVF, Manzano KMR., Educational Innovation In Health: Impact Of Digital Technologies On Clinical Training. Int J Drug Deliv Technol. 2026;16(76s): 2128-2148; DOI: 10.25258/ijddt.16.76s.210.

Introduction

The rapid development of digital technologies has significantly transformed higher education, particularly in health sciences training. Innovations such as artificial intelligence, virtual simulation, digital learning platforms, and mobile health applications are increasingly integrated into educational environments to enhance the acquisition of clinical competencies and improve learning outcomes among healthcare students 1. These technological advances have created new opportunities to complement traditional teaching approaches and support more interactive learning experiences.
Historically, health education has relied heavily on face-to-face instruction and direct clinical exposure as primary methods for training healthcare professionals. However, the growing complexity of healthcare systems and the

increasing digitalization of medical practice require educational models capable of adapting to technological changes 2. Consequently, universities and training institutions have begun incorporating digital technologies into curricula to improve the quality and accessibility of clinical education.

Digital tools enable innovative pedagogical strategies that promote active learning and practical skill development. For example, simulation-based learning environments, augmented reality systems, and digital learning management platforms allow students to practice clinical procedures in controlled settings without compromising patient safety 3. These technologies facilitate experiential learning and enable repeated practice, which can significantly strengthen students' clinical reasoning and decision-making abilities.

Furthermore, the integration of digital technologies into health education has accelerated in response to global changes in healthcare delivery. The expansion of digital health and telemedicine has increased the demand for healthcare professionals who possess strong digital competencies and are capable of working within technologically advanced healthcare environments 4. As a result, health education programs are increasingly emphasizing the development of digital literacy and technological proficiency among students and educators.

In addition to supporting clinical training, digital technologies also contribute to expanding access to education and promoting collaboration across institutions. Online platforms and digital educational resources allow students to engage in remote learning, virtual mentorship, and interdisciplinary knowledge exchange, thereby improving the flexibility and reach of health education programs 5. These innovations are particularly relevant in contexts where access to clinical training opportunities may be limited.

Recent studies also highlight the growing role of artificial intelligence and data-driven technologies in higher education. These tools can support adaptive learning systems capable of personalizing educational content according to students' progress and competencies, ultimately improving educational effectiveness and fostering creativity and problem-solving skills 6. Moreover, the integration of digital health competencies into health education curricula is increasingly recognized as essential for preparing healthcare professionals to work in digitally driven healthcare systems 7.

Educational researchers have also emphasized the importance of developing digital competencies among health professionals and educators to ensure effective integration of technological innovations into teaching practices 8. Strengthening these competencies can facilitate the adoption of new digital tools and support the transformation of traditional educational models toward more flexible and technology-enhanced learning environments.

Additionally, recent literature highlights that the future of healthcare education will depend on balancing technological innovation with human-centered approaches that prioritize communication, empathy, and patient-centered care 9. In this context, digital technologies should not replace traditional teaching methods but rather complement them by enhancing learning experiences and supporting competency development.

Despite the growing integration of digital technologies in health education, there is still a need to systematically analyze their impact on clinical training outcomes. Although several studies have reported improvements in knowledge acquisition, skill development, and student engagement, evidence remains fragmented across disciplines and educational settings 10. Therefore, synthesizing current research is essential to better understand the effectiveness of digital technologies in clinical education.

For this reason, the present systematic review aims to analyze the impact of digital technologies on clinical training in health sciences education, providing an updated synthesis of the available scientific evidence.

METHODS

Study Design

This study corresponds to a systematic review of the literature aimed at analyzing the impact of digital technologies on clinical training in health sciences education. The review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines, which provide a structured framework to ensure transparency, reproducibility, and methodological rigor in systematic reviews 11.

Search Strategy

A comprehensive literature search was conducted in three major international databases: Scopus, PubMed/MEDLINE, and Web of Science. These databases were selected due to their broad coverage of biomedical, health sciences, and educational research literature.

The search included studies published between 2019 and 2026, considering the rapid expansion of digital technologies in health education in recent years.

The search strategy was developed using combinations of keywords and Boolean operators related to digital technologies and clinical education. The main search terms included:

("digital technologies" OR "digital health" OR "artificial intelligence" OR "virtual simulation" OR "digital learning") AND ("clinical training" OR "clinical education") AND ("health education" OR "medical education")

These terms were adapted according to the indexing systems of each database to ensure comprehensive retrieval of relevant studies.

Eligibility Criteria

The inclusion and exclusion criteria were defined prior to the study selection process to ensure methodological consistency.

Eligibility Criteria

Studies were included if they evaluated the use of digital technologies in health sciences education, addressed clinical training or the development of clinical skills, included students or healthcare professionals as the study

population, and reported outcomes related to learning effectiveness, competency development, or educational impact. Additionally, only studies published in peer-reviewed journals and written in English were considered eligible for inclusion. Conversely, studies were excluded if they focused exclusively on theoretical education without clinical training components, were editorials, commentaries, or conference abstracts, did not provide sufficient methodological information, or were not available in full text.

Study Selection

The database search initially identified 498 records. After removing duplicate and automatically filtered records (n = 98), a total of 400 studies remained for title and abstract screening. Of these, 320 studies were excluded for not meeting the eligibility criteria.

Subsequently, 80 full-text articles were sought for retrieval, of which 12 could not be accessed. Therefore, 68 full-text articles were assessed for eligibility, and 50 studies were excluded due to reasons such as lack of relevance to clinical training, inappropriate study population, absence of digital educational interventions, or insufficient methodological quality.

Finally, 18 studies met the eligibility criteria and were included in the qualitative synthesis of this systematic review. The complete study selection process is presented in the PRISMA flow diagram (Figure 1).

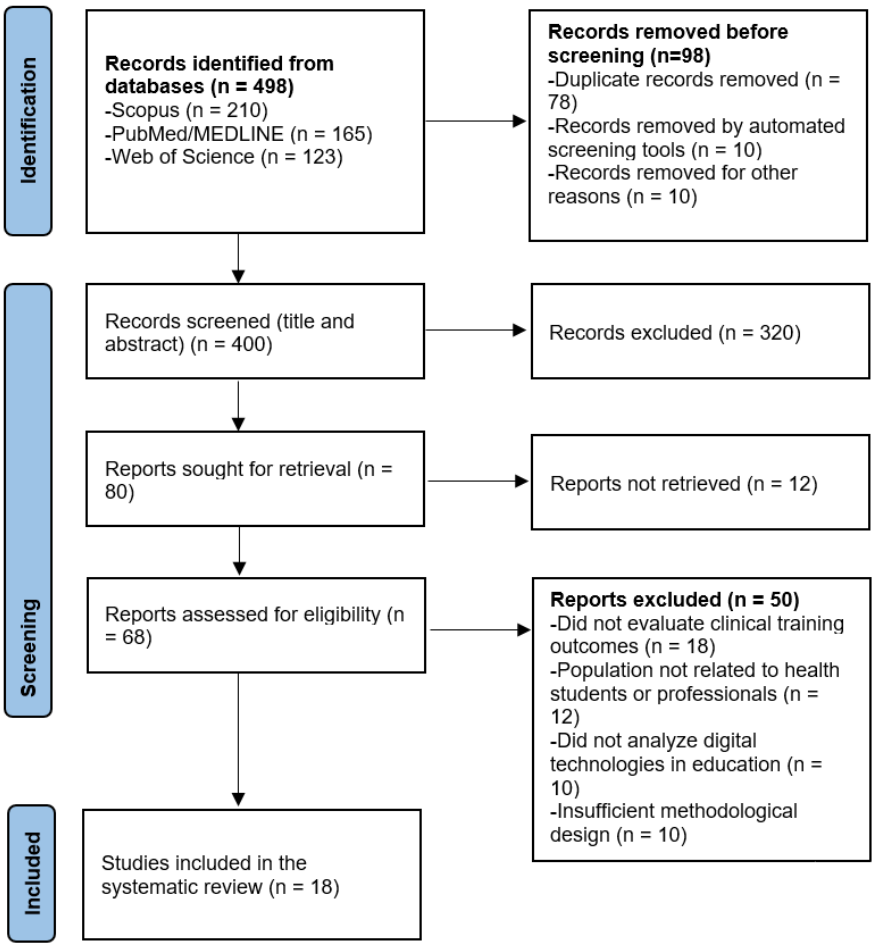

Figure 1. PRISMA 2020 Flow Diagram of the Study Selection Process for the Systematic Review

Data Extraction

Relevant information from the included studies was systematically extracted using a structured data extraction form. The variables collected included the author and year of publication, study design, type of digital technology used, target population (students or healthcare professionals), educational setting, and the main outcomes related to clinical training. The extracted information was subsequently organized into a data extraction matrix (Table 1), which facilitated the comparison of study characteristics and supported the synthesis of findings across the included studies.

Data Synthesis

Due to the heterogeneity of study designs, educational interventions, and outcome measures among the included studies, a narrative synthesis approach was adopted. This method allowed the identification of major thematic areas related to digital technologies in clinical education, including simulation-based learning, artificial intelligence-assisted education, virtual learning environments, and digital educational platforms.

RESULTS

A total of 18 studies met the eligibility criteria and were included in the qualitative synthesis of this systematic review. The characteristics of the included studies are summarized in Table 1. Overall, the selected studies explored the implementation of various digital technologies in health sciences education, particularly focusing on their role in enhancing clinical training, competency development, and digital literacy among healthcare students and professionals.

Table 1. Characteristics of the Studies Included in the Systematic Review

N°	Author and Year	Study Design	Type of Digital Technology	Target Population	Educational Setting	Main Outcomes Related to Clinical Training
1	Alnafaiy et al., 2024	Multi-institutional survey	Digital technologies in prosthodontics training	Postgraduate dental students	Dental postgraduate programs	Improved integration of digital tools in prosthodontic clinical training
2	Dushyanthen et al., 2024	Educational evaluation study	Digital learning health system platforms	Health science students	Interdisciplinary health education programs	Enhanced understanding of clinical systems and interdisciplinary collaboration
3	Felszeghy et al., 2024	Educational evaluation	Haptic-enhanced virtual reality	Dental students	Dental curriculum	Improved procedural training and manual skills
4	Frøiland et al., 2023	Qualitative study	Digital educational mentorship resource	Nursing students	Nursing homes clinical placements	Improved mentorship support during clinical training
5	Grosjean et al., 2024	Educational program evaluation	Digital health education platforms	Health professionals and students	University health education programs	Strengthened digital health competencies
6	Horiuchi et al., 2024	Scoping review	Digital training technologies	Healthcare staff	Clinical training programs	Improved knowledge and skills in neonatal resuscitation training
7	Hrdy et al., 2024	Educational research study	Simulation-based learning	Emergency medicine residents	Residency training programs	Enhanced clinical decision-making and emergency response skills
8	Kavadella et al., 2023	Mixed-methods study	Artificial intelligence (ChatGPT)	Dental students	Undergraduate dental education	Improved problem-solving and academic engagement
9	Laugaland et al., 2023	Qualitative evaluation	Digital educational resource (DigiVIS)	Nurse educators and students	Nursing clinical education	Enhanced support for clinical teaching
10	Lees et al., 2024	Educational study	Digital technologies for physical examination training	Medical students	Medical school training	Improved acquisition of clinical examination skills

11	McGee et al., 2024	Systematic review	Digital learning technologies	Medical students	Medical education programs	Positive impact on academic performance and clinical skills
12	Mwogosi et al., 2025	Educational framework study	Digital technologies in dentistry	Dental students	Dental education	Strengthened competency-based clinical education
13	Quek et al., 2025	Scoping review	Digital technologies in surgical education	Medical students	Undergraduate surgical training	Improved procedural knowledge and surgical skills
14	Rawnsley & Stasiak, 2025	Mixed-methods study	Digital health curriculum integration	Medical and psychology trainees	University health programs	Development of digital clinical competencies
15	Shen et al., 2024	Educational study	Online digital health education	Nursing students	Undergraduate nursing programs	Improved digital literacy and clinical knowledge
16	Walzer et al., 2025	Design-based research	Digital teaching support program	Nursing educators	Nursing education institutions	Improved teaching strategies using digital technologies
17	Seba et al., 2025	Pre-post study	Generative AI tools in curriculum	Health informatics students	Health informatics programs	Improved analytical and digital clinical competencies
18	Schnitzler & Bohnet-Joschko, 2025	Cross-sectional study	Digital dentistry technologies	Dental students and professionals	Dental education	Increased adoption of digital tools in clinical practice

Note: Digital technologies refer to simulation systems, artificial intelligence tools, virtual learning platforms, and digital educational resources used in clinical training.

The included studies evaluated different digital technologies applied to clinical education in health sciences, including digital educational platforms, virtual simulation environments, artificial intelligence tools, and digital learning resources. These technologies were implemented across multiple educational settings such as medical schools, nursing education programs, dental training institutions, and interdisciplinary health education environments 12-15.

Several studies highlighted the use of digital educational platforms and online learning environments to support clinical training and mentorship processes. These platforms allowed students and healthcare trainees to access educational materials, participate in virtual learning activities, and strengthen clinical knowledge through structured digital resources 16-18.

Another important category of technologies identified in the included studies involved simulation-based learning and virtual reality systems. These tools were widely used to support the development of procedural and psychomotor skills, particularly in dental, surgical, and emergency medicine training programs. Simulation-based approaches allow students to practice clinical procedures repeatedly in safe environments without compromising patient safety 19-22.

Artificial intelligence also emerged as an innovative tool in health education. Some studies reported the integration of AI-based educational systems, including generative artificial intelligence tools and digital tutoring systems, which were associated with improvements in problem-solving skills, student engagement, and personalized learning experiences 23-25.

Additionally, several studies emphasized the importance of integrating digital health competencies into educational curricula. These initiatives aim to prepare healthcare professionals for technologically advanced healthcare systems by developing digital literacy, technological adaptability, and the ability to effectively use digital health tools in clinical practice 26-29.

Overall, the evidence suggests that digital technologies can significantly enhance clinical training by improving skill acquisition, supporting experiential learning, and

strengthening digital competencies among healthcare students and professionals.

DISCUSSION

The findings of this systematic review indicate that digital technologies play an increasingly important role in strengthening clinical training within health sciences education. The studies included in the review 12-29 consistently demonstrate that tools such as digital learning platforms, simulation environments, artificial intelligence applications, and technology-supported educational resources contribute to improved clinical competencies, student engagement, and digital literacy among healthcare trainees.

One of the most prominent findings across the included studies was the effectiveness of simulation-based learning and digital educational tools in supporting clinical skill acquisition. Several studies reported that technology-enhanced environments allow students to practice procedures and clinical decision-making in safe and controlled settings, reducing risks to patients while improving practical competencies 12-16. These results are consistent with previous research indicating that digital educational tools and virtual learning systems can significantly improve learning outcomes and support experiential learning processes in health sciences education 30,31.

Another important finding of the present review concerns the integration of digital technologies into educational curricula to support competency-based training models. Several studies included in the review highlighted the role of digital platforms and educational technologies in improving clinical reasoning, problem-solving skills, and interdisciplinary collaboration among healthcare students 17-20. Previous research also emphasizes the importance of strengthening digital competencies among health professionals and educators to facilitate the successful implementation of technology-enhanced education 32-35. Developing these competencies is considered essential for adapting healthcare education systems to rapidly evolving technological environments 36.

Artificial intelligence has also emerged as a relevant technological innovation in health education. Some studies included in the review reported the implementation of AI-based systems and digital tutoring tools that support adaptive learning, personalized feedback, and enhanced analytical thinking among students 21-24. Similar findings have been reported in previous studies highlighting that artificial intelligence and advanced digital technologies can transform traditional educational models by enabling personalized and data-driven learning strategies 35. Furthermore, AI-supported learning environments have been associated with improved creativity, problem-solving abilities, and innovative educational approaches in higher education 31.

Another relevant contribution of digital technologies is their capacity to expand access to education and support collaboration across healthcare systems and academic institutions. Digital platforms allow healthcare students and professionals to access training resources remotely and participate in virtual educational activities regardless of geographical barriers 25-27. This is particularly important in contexts where clinical training opportunities may be limited. Previous studies have highlighted that digital technologies can facilitate large-scale training programs and support the development of healthcare workforce capacities worldwide 36-40. Similarly, digital health education initiatives have been identified as key strategies for improving global health training and strengthening professional competencies 30.

Despite these advantages, the findings of this review also highlight several challenges associated with the implementation of digital technologies in health education. Some studies reported barriers related to technological infrastructure, institutional support, and the need for faculty training in digital teaching methodologies 28,29. These results are consistent with previous research indicating that structural and organizational barriers can limit the adoption of digital health innovations in educational and healthcare settings 37. In addition, educators emphasize the need for institutional policies and structured educational strategies to guide digital transformation processes in health education programs 41.

Finally, recent literature emphasizes the importance of maintaining a human-centered approach in the integration of digital technologies into healthcare education. While technological tools can significantly enhance learning opportunities, it remains essential to balance technological innovation with the development of communication skills, ethical awareness, and patient-centered care competencies 39-44. Furthermore, educational researchers have highlighted the need to promote critical digital capabilities among healthcare students to ensure responsible and effective use of technological tools in clinical practice 45-47.

Overall, the results of this systematic review suggest that digital technologies represent a promising strategy for improving clinical training and strengthening professional competencies in health sciences education. However, their successful implementation requires adequate institutional support, development of digital competencies among educators, and the integration of pedagogical strategies that combine technological innovation with human-centered healthcare training.

CONCLUSION

Digital technologies are increasingly transforming clinical training in health sciences education. Tools such as simulation systems, artificial intelligence, and digital learning platforms enhance skill development, student engagement, and clinical reasoning by providing safe environments where healthcare trainees can practice procedures effectively.

The integration of digital technologies into health education curricula promotes innovative teaching strategies aligned with modern healthcare demands. Digital learning environments enable flexible, accessible training opportunities while supporting continuous professional development, although their successful implementation requires institutional support and adequate technological infrastructure.

Incorporating digital tools into clinical education can significantly improve the quality of healthcare training. Simulation-based learning, artificial intelligence

applications, and online platforms promote active learning, strengthen clinical competencies, and support the development of digital literacy among healthcare students and educators.

Healthcare education programs should adopt interdisciplinary approaches that integrate technological innovations into teaching strategies. By promoting the use of advanced digital tools and collaborative learning environments, educational institutions can prepare healthcare professionals to respond effectively to the demands of modern clinical practice.

Future research should evaluate the long-term effects of digital technologies on clinical competence, patient outcomes, and professional development. Further studies are also needed to examine the effectiveness, scalability, and sustainability of emerging technologies such as artificial intelligence and virtual reality in clinical education.

REFERENCES:

1. Han ER, Yeo S, Kim MJ, Lee YH, Park KH, Roh H. Medical education trends for future physicians in the era of advanced technology and artificial intelligence: an integrative review. BMC Medical Education [Internet]. 2019 Dec 1;19(1):460. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC6907217/
2. Wang MC, Tang JS, Liu YP, Chuang CC, Shih CL. Innovative digital technology adapted in nursing education between Eastern and Western countries: a mini-review. Frontiers in Public Health [Internet]. 2023 May 24;11:1167752. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC10244494/
3. Ogundiya O, Rahman TJ, Valnarov-Boulter I, Young TM. Looking back on digital medical education over the last 25 years and looking to the future: Narrative review. Journal of Medical Internet Research [Internet]. 2024 Dec 4;26:e60312. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11695957/
4. Harris RA, Kazdağlı H. Using TECHnology to predict the future of biomedical education. FEBS Open Bio [Internet]. 2024 Dec 12;15(1):48–55. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11705505/
5. Jensen LX, Buhl A, Hussain S, Karan A, Konradsen F, Bearman M. Digital education for health professionals in India: a scoping review of the research. BMC Medical Education [Internet]. 2023 Aug 9;23(1):561. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC10410828/
6. Hao F, Wang Z, Ma L, Zhao H, Liu X, Zhao X, et al. How to promote student creativity through AI in higher education: the role of students' attitude and digital competencies. Frontiers in Public Health [Internet]. 2026 Feb 11;14:1772946. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12932527/
7. Punzalan JK, Punzalan MG. Integrating digital health competencies in community-engaged medical education: A scoping review for developing teaching and learning strategies for digital health. Journal of Education and Health Promotion [Internet]. 2025 May 1;14(1):190. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12200004/
8. Ramachandran S, Chang HJ, Worthington C, Kushniruk A, Ibáñez-Carrasco F, Davies H, et al. Digital competencies and training approaches to enhance the capacity of practitioners to support the digital transformation of public health: Rapid review of current recommendations. JMIR Public Health and Surveillance [Internet]. 2024 May 22;10:e52798. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11403915/
9. Toll E, Babbott S, Danielpour L, Reis S, Ringel M, Hilliard RW, et al. Vision for the future education of healthcare professionals: human relationships at the centre – technology in a supportive role. BMJ Health & Care Informatics [Internet]. 2026 Jan 1;33(1):e101502. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12853479/
10. Potter A, Munsch C, Watson E, Hopkins E, Kitromili S, O'Neill IC, et al. Identifying research Priorities in digital Education for Health Care: Umbrella Review and Modified Delphi Method study. Journal of Medical Internet Research [Internet]. 2025 Feb 19;27:e66157. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11888089/
11. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. Declaración PRISMA 2020: una guía actualizada para la publicación de revisiones sistemáticas. Revista Española De Cardiología [Internet]. 2021 Jul 21;74(9):790–9. Available from: https://www.revespcardiol.org/es-declaracion-prisma-2020-una-guia-articulo-S0300893221002748
12. Alnafaiy SM, Alyousef H, Aljabr R, Tounsi A, Almutairi R, Albaijan RS. Digital technology implementation in prosthodontics postgraduate programs in Saudi Arabia: a multi-institutional survey of program directors. BMC Oral Health [Internet]. 2024 Sep 27;24(1):1136. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11438276/
13. Dushyanthen S, Zamri NI, Chapman W, Capurro D, Lyons K. Evaluation of an interdisciplinary educational program to foster learning health systems: Education Evaluation.

JMIR Medical Education [Internet]. 2024 Apr 26;11:e54152. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11757970/
14. Felszeghy S, Mutluay M, Liukkonen M, Flacco N, Bakr MM, Rampf S, et al. Benefits and challenges of the integration of haptics-enhanced virtual reality training within dental curricula. Journal of Dental Education [Internet]. 2024 Dec 17;89(7):1070–83. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12268116/
15. Frøiland CT, Husebø AML, Aase I, Akerjordet K, Laugaland K. A digital educational resource to support and enhance effective mentorship practices of nursing students in nursing homes: a qualitative study. BMC Nursing [Internet]. 2023 Nov 13;22(1):423. Available from: https://pubmed.ncbi.nlm.nih.gov/37953235/
16. Grosjean J, Dufour F, Benis A, Januel JM, Staccini P, Darmoni SJ. Digital Health Education for the Future: the SANURN (Santé Numérique Rouen-Nice) Consortium's journey. JMIR Medical Education [Internet]. 2024 Mar 21;10:e53997. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11082434/
17. Horiuchi S, Soller T, Bykersma C, Huang S, Smith R, Vogel JP. Use of digital technologies for staff education and training programmes on newborn resuscitation and complication management: a scoping review. BMJ Paediatrics Open [Internet]. 2024 May 1;8(1):e002105. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11097833/
18. Hrdy M, Tarver EM, Lei C, Moss HC, Wong AH, Moadel T, et al. Applying simulation learning theory to identify instructional strategies for Generation Z emergency medicine residency education. AEM Education and Training [Internet]. 2024 May 1;8(S1):S56–69. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11102949/
19. Kavadella A, Da Silva MAD, Kaklamanos EG, Stamatopoulos V, Giannakopoulos K. Evaluation of CHATGPT's Real-Life Implementation in Undergraduate Dental Education: Mixed Methods study. JMIR Medical Education [Internet]. 2023 Dec 11;10:e51344. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC10867750/
20. Laugaland KA, Handeland M, Aase I, Husebø AML, Frøiland C, Akerjordet K. Supporting the nurse educator in clinical education – a qualitative evaluation of a digital educational resource DigiVIS. BMC Nursing [Internet]. 2023 Nov 16;22(1):432. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC10652471/
21. Lees J, Risør T, Sweet L, Bearman M. Integrating digital technologies into teaching embodied knowledge in the context of physical examination. Medical Education [Internet]. 2024 Dec 18;59(7):719–28. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12198720/
22. McGee RG, Wark S, Mwangi F, Drovandi A, Alele F, Malau-Aduli BS. Digital learning of clinical skills and its impact on medical students' academic performance: a systematic review. BMC Medical Education [Internet]. 2024 Dec 18;24(1):1477. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11653901/
23. Mwogosi A, Mambile C, Simba R, Haruna H. Integrating digital technologies in clinical dentistry training: a framework for competency-based education. BMC Medical Education [Internet]. 2025 Nov 25;25(1):1645. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12648810/
24. Quek FF, Meldrum S, Hislop J. A systematic scoping review of the current applications of digital technology in undergraduate surgical education. Cureus [Internet]. 2025 Jan 11;17(1):e77278. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11725316/
25. Rawnsley C, Stasiak K. Training the digital clinician by evaluating health education and curriculum integration New Zealand Psychology and Psychiatry Programs: Mixed Methods study. JMIR Medical Education [Internet]. 2025 Dec 31;11:e72777. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12755456/
26. Shen H, Chen C, Yan S, Hallensleben C, Van Der Kleij R, Li M, et al. Online digital health and informatics education for undergraduate nursing students in China: impacts and recommendations. BMC Medical Education [Internet]. 2024 Jul 26;24(1):803. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11282779/
27. Walzer S, Barthel C, Pazouki R, Marx H, Ziegler S, Koenig P, et al. Teaching in the Digital Age—Developing a support program for nursing education providers: Design-Based research. JMIR Formative Research [Internet]. 2025 Jan 15;9:e66109. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11780299/
28. Seba F, Isola M, Mills L, Zalake M, Krive J. Incorporating generative AI into a health informatics curriculum to build 21st century competencies: Multisite Pre-Post study. JMIR

Medical Informatics [Internet]. 2025 Sep 17;13:e76507. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12707436/
29. Schnitzler C, Bohnet-Joschko S. Technology Readiness Drives Digital Adoption in Dentistry: Insights from a Cross-Sectional Study. Healthcare [Internet]. 2025 May 15;13(10):1155. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12110977/
30. Alhassan RHAH, Haggerty CL, Fapohunda A, Affan NJ, Anto-Ocrah M. Exploring the use of digital educational tools for sexual and reproductive health in Sub-Saharan Africa: Systematic review. JMIR Public Health and Surveillance [Internet]. 2025 Feb 26;11:e63309. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11904370/
31. Alsulami FT. A scoping review on the impact of versatile Digital Health innovations on pharmacy education. Frontiers in Medicine [Internet]. 2025 Oct 17;12:1577494. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12575382/
32. Amare EM, Zegeye RT, Wondie AG, Andargie BA. Surveying the digital competencies of health profession educators at Ethiopian higher education institutions. Ethiopian Journal of Health Sciences [Internet]. 2024 Aug 10;34(4):281–9. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11837802/
33. Efthymiou E. Integrating digital and narrative medicine in modern healthcare: a systematic review. Medical Education Online [Internet]. 2025 May 6;30(1):2475979. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12057780/
34. Ersoy H, Baskici C, Aytar A, Strods R, Ratinika NJ, Fernandes AML, et al. Digital competence of faculty members in health sciences measured via self-reflection: current status and contextual aspects. PeerJ [Internet]. 2024 Nov 11;12:e18456. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11562777/
35. Gupta SK, Alemran A, Basha US, Zakari AI, Kim S, Boddu RSK, et al. Revolutionizing the way students learn photographic arts through experiential education using AI and AR systems. Scientific Reports [Internet]. 2025 Nov 19;15(1):40705. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12630948/
36. Jobst S, Lindwedel U, Marx H, Pazouki R, Ziegler S, König P, et al. Competencies and needs of nurse educators and clinical mentors for teaching in the digital age – a multi-institutional, cross-sectional study. BMC Nursing [Internet]. 2022 Aug 28;21(1):240. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC9420177/
37. Kelley LT, Fujioka J, Liang K, Cooper M, Jamieson T, Desveaux L. Barriers to creating Scalable business models for digital health innovation in public Systems: Qualitative case study. JMIR Public Health and Surveillance [Internet]. 2020 Sep 16;6(4):e20579. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC7759439/
38. Laukka E, Hammarén M, Pölkki T, Kanste O. Hospital nurse leaders' experiences with digital technologies: A qualitative descriptive study. Journal of Advanced Nursing [Internet]. 2022 Oct 27;79(1):297–308. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC10092210/
39. Levander XA, VanDerSchaaf H, Barragán VG, Choxi H, Hoffman A, Morgan E, et al. The Role of Human-Centered Design in Healthcare Innovation: a Digital Health Equity Case Study. Journal of General Internal Medicine [Internet]. 2023 Nov 16;39(4):690–5. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC10973281/
40. Naslund JA, Shidhaye R, Patel V. Digital technology for building capacity of nonspecialist health workers for task sharing and scaling up mental health care globally. Harvard Review of Psychiatry [Internet]. 2019 Apr 6;27(3):181–92. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC6517068/
41. Prosen M, Ličen S. Evaluating the digital transformation in health sciences education: a thematic analysis of higher education teachers' perspectives. BMC Medical Education [Internet]. 2025 Jun 2;25(1):820. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12131340/
42. Ravik M, Aase I, Akerjordet K, Laugaland K, Gonzalez MT. Nurse educators' suggestions for a digital educational resource suitable for undergraduate student nurses' placement studies: Qualitative empirical research. Nursing Open [Internet]. 2023 May 4;10(8):5433–45. Available from: https://pubmed.ncbi.nlm.nih.gov/37139861/
43. Rees G, Nowell L, Risling T. Shaping the future of digital health education in Canada: Prioritizing competencies for health care professionals using the Quintuple aim. JMIR Medical Education [Internet]. 2025 Jul 16;11:e75904. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12416521/
44. Schooley B, Singh A, Hikmet N, Brookshire R, Patel N. Integrated Digital Patient

Education at the Bedside for Patients with Chronic Conditions: Observational Study. JMIR Mhealth and Uhealth [Internet]. 2020 Nov 30;8(12):e22947. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC7785403/

45. Wosny M, Strasser LM, Kraehenmann S, Hastings J. Practical Recommendations for navigating digital tools in Hospitals: Qualitative interview study. JMIR Medical Education [Internet]. 2024 Oct 9;10:e60031. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11635325/
46. Wynn MO. Beyond competency: Developing critical digital capabilities in nursing students through Freirean Pedagogy. Nursing Inquiry [Internet]. 2025 Mar 12;32(2):e70011. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11903917/
47. Zainal H, Xin X, Thumboo J, Fong KY. Medical school curriculum in the digital age: perspectives of clinical educators and teachers. BMC Medical Education [Internet]. 2022 Jun 3;22(1):428. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC9164471/