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Opinion

Towards a New Paradigm for Digital Health Training and Education in Australia: Exploring the Implication of the Fifth Industrial Revolution

Toh Yen Pang [1,*], Tsz-Kwan Lee [2] and Manzur Murshed [2]

[1] School of Engineering, STEM College, RMIT University, Melbourne, VIC 3000, Australia
[2] School of Information Technology, Faculty of Science Engineering & Built Environment, Deakin University, Waurn Ponds, Geelong, VIC 3216, Australia; glory.lee@deakin.edu.au (T.-K.L.); m.murshed@deakin.edu.au (M.M.)
* Correspondence: tohyen.pang@rmit.edu.au

Featured Application: This paper presents a new, fifth industrial revolution (Industry 5.0)-inspired paradigm for educating and training Australian healthcare professionals and students in the field of digital health. By leveraging Industry 5.0-enabling technologies, such as artificial intelligence, machine learning, blockchain, big data analytics, etc., we can cultivate students to be job-ready for the future of work by providing them with hands-on experience in advanced healthcare technologies. Ultimately, this new training and education paradigm in digital health can help bridge the gap between training and the world of work and prepare students to deliver a more efficient, effective, and sustainable healthcare system.

Abstract: Digital transformation, characterised by advanced digitalisation, blockchain, the Internet of Things, artificial intelligence, machine learning technologies, and robotics, has played a key role in revolutionising various industries, especially the healthcare sector. The adoption of and transition (from traditional) to new technology will bring challenges, opportunities, and disruptions to existing healthcare systems. According to the European Union, we must pursue both digital and green transitions to achieve sustainable, human-centric, and resilient industries to achieve a world of prosperity for all. The study aims to present a novel approach to education and training in the digital health field that is inspired by the fifth industrial revolution paradigm. The paper highlights the role of training and education interventions that are required to support digital health in the future so that students can develop the capacity to recognise and exploit the potential of new technologies. This article will briefly discuss the challenges and opportunities related to healthcare systems in the era of digital transformation and beyond. Then, we look at the enabling technologies from an Industry 5.0 perspective that supports digital health. Finally, we present a new teaching and learning paradigm and strategies that embed Industry 5.0 technologies in academic curricula so that students can develop their capacities to embrace a digital future and minimise the disruption that will inevitably accompany it. By incorporating Industry 5.0 principles into digital health education, we believe students can gain a deeper understanding of the industry and develop skills that will enable them to deliver a more efficient, effective, and sustainable healthcare system.

Keywords: digital health; Industry 5.0; training and education paradigm; digital transformation; Internet of Things; artificial intelligence; machine learning; smart healthcare

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1. Introduction

In recent years, the healthcare industry has experienced a revolution driven by advancements in technologies and applications, such as wearable devices, mobile health apps, telehealth and telemedicine, mobile health, electronic health, and health information technology. The use of such technologies and applications in healthcare systems is referred to as digital health, and this has transformed the way healthcare is delivered [1]. For example, digital health has enabled remote healthcare delivery through telemedicine, which became increasingly popular during the COVID-19 pandemic. Telemedicine allows patients to connect with their healthcare providers via video links and have remote consultations, which can save time, reduce costs, and improve accessibility, particularly for patients in remote areas [2]. Digital health also aims at a more patient-centric approach that empowers patients to take control of their health. For example, with the use of wearable devices and mobile health applications, patients can track their physical activity, diet, sleep patterns, and other activities. This can help patients make more informed decisions about their health and well-being and take an active role in preventing and managing chronic diseases. Such data can also be shared and used by healthcare professionals to identify any potential health issues and to provide personalised health recommendations [3].

The fifth industrial revolution (hereafter referred to as Industry 5.0) represents the latest iteration of industrial automation and refers to the integration of advanced technologies, such as the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) [4,5], to optimise the production process. Industry 5.0 also seeks to create a more human-centric approach to industry by emphasizing the importance of collaboration between humans and machines [6]. According to the European Union, Industry 5.0 provides a vision of industry that aims beyond efficiency and productivity as goals and reinforces the role and contribution of industry to society [5,7]. In the context of digital health, Industry 5.0 can be applied to improve patient care and treatment through the use of connected medical devices and telemedicine that, for example, allow for the remote monitoring and diagnosis of patients. Additionally, Industry 5.0 technologies can be used to improve the efficiency and effectiveness of healthcare systems by automating administrative tasks and enabling real-time data analysis to inform decision-making. Such technologies can also be used to optimise the supply chain of pharmaceutical and medical products. Smart factories can improve the efficiency of production, reduce waste, and improve the traceability and transparency of the supply chain, which can help to ensure patient safety. In summary, Industry 5.0 and digital health share a common goal of using advanced technologies to improve the efficiency and effectiveness of healthcare delivery while also ensuring patient safety and better outcomes. Nevertheless, a better understanding of such advanced technology and its limitations is an essential aspect of successful digital health applications [3].

Rapidly changing technology means that we need to prepare future healthcare professionals to embrace the continuous shifting of skills and leverage human/technology co-operation to solve future problems [8]. It is essential that healthcare professionals have the knowledge and skills to apply and manage advanced technologies and data analytics effectively in order to provide personalised digital healthcare solutions [9]. As a result, the education and training paradigms for professionals in healthcare must adapt to keep pace with this transformation. Most higher education institutions are sufficiently forward-thinking to play a central role in developing curricula that help their students to acquire the skills and knowledge related to new digital technologies. However, according to Ong et al. [10], the current unmet needs may also necessitate the training of a new breed of digital healthcare workers who have the skills and competencies to guide digital healthcare policies, understand and develop software, manage computer bugs and viruses, and safely conduct large-scale clinical trials using digital healthcare technology [10].

This paper, therefore, aims to provide insight into how Industry 5.0 intersects with learning and teaching in a digital health context and outline what educational models need to be addressed concerning future healthcare workforce preparedness. First, digital health and related factors, such as barriers and solutions in relation to security, safety, system resilience, and risks, will be discussed in Section 2. Industry 5.0 concepts and their enabling technologies and connection to healthcare education are presented in Section 3. Then, Section 4 focuses on a new teaching and learning paradigm for digital health, drawing from Industry 5.0 concepts and its enabling technologies, and suggests directions for future research. Finally, Section 5 provides a summary of the prospects, issues, and challenges of Industry 5.0 and digital health and provides the main conclusions.

2. Digital Health: Barrier and Solutions

Digital health is an emerging area in healthcare that involves the use of technologies for health and care promotion and aims to deliver better health outcomes, improved quality of life for patients, increased levels of satisfaction regarding the healthcare being received, and reduced healthcare costs [11,12]. Digital health may include (1) electronic health, such as independent and web-based software, (2) smartphone apps, such as mobile health/mHealth and text messaging applications, (3) health information technology, (4) telehealth/telemedicine, (5) electronic medical records, and (6) the use of developed computational science in big data, genomics, and artificial intelligence. Healthcare professionals not only have to keep pace with these technologies but also learn how to integrate the technologies into their daily work. Hence, the adoption of digital health is not without its challenges and barriers. The different benefits of, and barriers and solutions to, the implementation of digital health will be discussed here.

2.1. Security and Privacy

Security must be considered when a person is using digital technology so that they perceive the tool as safe and secure and know it will protect their personal information [13]. Ensuring the privacy and security of patient data is essential to the successful implementation of these new technologies in healthcare. Therefore, it is necessary for healthcare providers to develop proper staff training and implement secure infrastructure to use these technologies effectively [14]. This can be achieved by using secure, encrypted systems and regular data audits that identify and address potential breaches.

2.2. Traceability and Safety

The use of electronic medical records enables the digitization of patient information for easier access and sharing between healthcare providers. Such sharing can improve the continuity of care, reduce medical errors, and improve the efficiency of healthcare systems [15]. However, there are also challenges, such as inter-operability and data security.

2.3. Standardisation and Interoperability

There is currently a lack of standardization in the development and implantation of common technical specifications, data formats, and data exchange protocols that enable digital health data to be exchanged and integrated within different systems and platforms [14]. As health data can be obtained from multiple sources (e.g., sensors, devices, apps, tools, etc.), the challenges concerning the inter-operability of the digital health ecosystem can make it difficult for users to share data and collaborate effectively and, more importantly, without compromising patient safety and their data privacy.

2.4. Resilience and Sustainability

The resilience and sustainability of digital health solutions are critical factors in their success. Resilience means that the digital health system and technologies are designed and built to withstand and recover from cyber-attacks, database hacking, and the theft of big data. Moreover, sustainability is essential to address the development and implementation of digital health solutions that are financially viable, scalable, and effective and allows for a broad range of user adoption in the longer term [14,16].

2.5. Regulatory Policy and Framework

The key regulatory bodies that oversee the digital health sector include the Food and Drug Administration (FDA) in the United States [17], the European Medicines Agency (EMA) in Europe [18], the Medicines & Healthcare Products Regulatory Agency in the United Kingdom [10], and the Therapeutic Goods Administration (TGA) in Australia [19].

Their key mission is to promote and protect public health. Clear and logical regulatory guidelines on the requirements, process, development, deployment, and approval of digital health technologies will be essential and pose significant challenges to inventors and companies operating in the field. The challenges relate to testing, manufacturing, hardware, and software updates [17,20]. Currently, there is a regulatory gap and little-to-no binding regulation to evaluate the quality, safety, and efficacy of digital health technologies and products [10,21].

While the FDA, EMA, and TGA regulatory bodies oversee the safety, efficacy, and quality of medical products, including pharmaceuticals and medical devices, the health technology assessment (HTA) is a multidisciplinary process that systematically evaluates the evaluation of the medical, social, economic, and ethical issues related to the use of new health technologies [22,23]. Given the relatively recent emergence of digital health technologies and solutions, as well as their application in education, there is a lack of international consensus on HTA in these contexts [24,25]. As suggested by [26], very few of the applications of electronic or mobile health data have addressed technology, safety, ethical, and legal issues. As such, by working together and leveraging those guidelines, we could help facilitate the responsible and effective integration of new technologies into healthcare.

2.6. Equity

Digital health equity refers to the ability of individuals, regardless of their socio-economic status, race, ethnicity, or other demographic characteristics, to access and benefit from digital health technologies and services [27]. Therefore, a better understanding of health equity by all stakeholders would help support the design, development, and deployment of digital health tools that actively work to reduce health disparities and promote health equity for socially disadvantaged patient populations [28]. Richardson et al. [27] presented a framework for digital health equity at different determinant levels, e.g., individual, interpersonal, community, and societal. The authors envisaged that the framework could help digital health innovators from various sectors (e.g., industry, health systems operations, and academia) develop and scale their products and services to achieve health equity for all.

A recent study by Kaihlanen et al. [29] suggested some major problems in accessing digital health services. These are related to individuals' access to digital resources, insufficient digital skills or language skills, and a lack of support and training to access and use digital services. Therefore, governments, industries, and universities can play a key role in educating and training individuals to have a greater understanding and knowledge of using digital health technologies effectively.

2.7. Education, Training and Awareness

As the use of digital health tools continues to grow, it is essential to ensure that healthcare professionals, patients, and the general public are adequately educated, trained, and aware of the potential benefits and risks of using these technologies. Proper training and education for healthcare providers are essential to ensure they are equipped with the knowledge and skills not only on how to use new technologies but also in understanding how to interpret and integrate data into clinical decision-making. Similarly, patients need to be educated about digital health and ensure that they are trained and capable of using digital health systems properly and can use these tools for their benefit and to mitigate any negative effects. To date, three systematic reviews have critically evaluated 91 studies, each adhering to stringent eligibility criteria, to explore the impact of digital technologies on healthcare professionals' education [30–32]. The preliminary findings across several of these studies suggest improvements in outcomes attributable to the use of digital technologies. However, all three reviews concur that further research is required to substantiate these initial observations and confirm a significant effect conclusively. This highlights the necessity for direction and clarity in health education, especially considering the potential impact of technologies arising from Industry 5.0. In order to achieve this, it is essential to facilitate the integration of Industry 5.0 advancements into the sphere of digital health.

3. An Outlook on the Integration of Industry 5.0 and Digital Health

Digital health is closely related to Industry 5.0 as it relies on the integration of advanced technologies, such as IoT, AI, and ML, to improve healthcare delivery and outcomes. The integration of Industry 5.0 concepts and digital health can have a profound impact on the healthcare industry. By combining the power of human skills with technology, it is possible to create more personalised and effective healthcare solutions that can be tailored to the individual needs of each patient. The concepts of Industry 5.0 and its enabling technologies that support digital health are illustrated in Figure 1 [14,33–35].

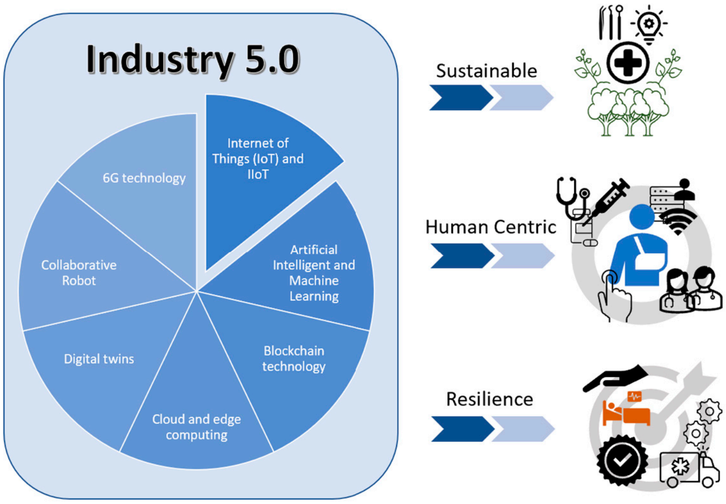


Figure 1. Fifth Industrial revolution concepts and technologies to support digital health.

3.1. Enabling Technologies

The ongoing coronavirus pandemic has catalysed the use of digital technologies all over the world. It has accelerated the process of digital transformation from the fourth industrial revolution (4IR) towards Industry 5.0 within different areas of society [36]. The 4IR is driven by technological advances of cyber-physical systems, which focus on integrating the enabling technologies (Table 1) within our daily lives and workplaces [37]. In contrast, the emerging Industry 5.0 seeks to utilise such enabling technologies to prioritise collaboration between humans and machines while maintaining sustainable development and practices [33,38]. State-of-the-art Industry 5.0 technologies, as illustrated in Figure 1, play a critical role in the digital transformation of the healthcare industry. Such transformation is being driven by various technologies, including digital twins, IoT, AI, ML, blockchain technology, and cloud computing. These technologies have produced a digital metamorphosis of the healthcare system [39], with an emphasis on human-centric design, which focuses on the needs and preferences of patients, healthcare professionals, and other stakeholders. By harnessing digital twins, IoT, AI, and ML, healthcare systems can improve their sustainability, human-centricity, and resilience. Table 1 provides a more detailed description of Industry 5.0-enabling technologies that facilitate digital health and clinical applications. These issues are being actively discussed within major healthcare professional sectors (see references in Table 1).

Table 1. Summary of innovative synergy: Industrial technology revolutionizes clinical applications.

Enabling Technology in Industrial Revolution	Clinical Applications	References
Internet of Things (IoT) and Industrial Internet of Things (IIoT)	- real-time data acquisition and analysis from wearable devices in healthcare delivery	[40]
	- seamless connectivity between physical devices and objects equipped with sensors and software	[41–43]
	- promptly collect and respond to vital and physical activities	[44]
Cloud and Edge Computing	- enables healthcare professionals to remotely access and analyse patient data from mobile devices	[45]
	- enhances the accessibility, quality, and efficacy of information delivery by minimising the latency of data flow	[46]
Blockchain Technology for Healthcare	- data encrypted and distributed through a decentralised network to improve security	[47,48]
	- Examples are Medicalchain, Hashed Health, Guardtime, and IBM	[49]
	- implementation of robust security protocols, such as encryption and access control, to prevent data breaches and cyber-attacks	[50]
Artificial Intelligent (AI) and Machine Learning (ML)	- AI-powered chatbots respond to questions on health, provide diagnoses and treatment advice	[51]
	- [concern:] ethical concerns about ownership, access right, privacy, and security of the use of patient data in AI algorithms	[48,52]

Table 1. *Cont.*

Enabling Technology in Industrial Revolution	Clinical Applications	References
Big Data and Analytics	- enhance the accuracy and reliability of predictions and enable healthcare organisations to make better-informed decisions	[53]
	- address concerns on the quality of the data used to train these algorithms and can improve the transparency and accountability of the algorithms	[54]
Digital Twins and Real-Time Data	- envision personalised healthcare to incorporate human-centric attributes	[55]
	- support the collection of real-time data from a variety of sources, such as wearable devices and electronic health records, which can be used to create and update the digital twin instantaneously	[56–58]
	- simulate the progression of a disease and test different treatment options to improve disease diagnosis and treatment	[59]
	- develop a deeper understanding of complex healthcare systems and improve the quality of care provided to patients	[60]
	- optimise the supply chain of pharmaceutical and medical products and affect the efficiency of production	[61]
Collaborative Robots (Cobots) and Automation	- beneficial in delivering different daily services efficiently, such as sterilisation, cleaning, and logistics, in the healthcare domain	[62]
	- analyse large amounts of patient data, identify patterns, and make predictions about patient health	[63,64]
	- [concern:] safety of patients and professionals must be prioritised by adhering to strict regulations and guidelines during cobot design and implementation	[65]

Table 1. *Cont.*

Enabling Technology in Industrial Revolution	Clinical Applications	References
6G Technology	- support telemedicine and remote healthcare delivery, enabling real-time communication and improved data transfer	[66,67]
	- improve the accessibility and quality of care with the integrated use of wearable healthcare devices, particularly in remote or underserved areas	[68]
	- [concern:] 6G technology advances; new regulations and guidelines governing its use in healthcare will need to emerge	[69]
Nanotechnology	- develop new diagnostic and therapeutic tools	[70]
	- molecular imaging using nanoparticles in computed tomography (CT) imaging, magnetic resonance imaging (MRI), positron emission tomography (PET), and nanorobots and nanosensors	[71]
	- nanomedicine is one of the emerging issues in biomedical engineering and pharmacy	[72,73]

Figure 2 further visually illustrates the relationship between, and dynamics within, the technological transformations of each industrial revolution epoch from the first, denoted as 1IR, to the latest (5IR) (now underway) [33] and their impact on healthcare education and training. It serves as a roadmap, highlighting each epoch's technological advancements and the evolving knowledge and skills, abilities, and changes in healthcare education and training for each [74]. Recognising these shifts provides a deeper understanding of the crucial role of embracing and aligning healthcare education with industrial revolutions to equip professionals with the necessary competencies to thrive in the future healthcare environment.

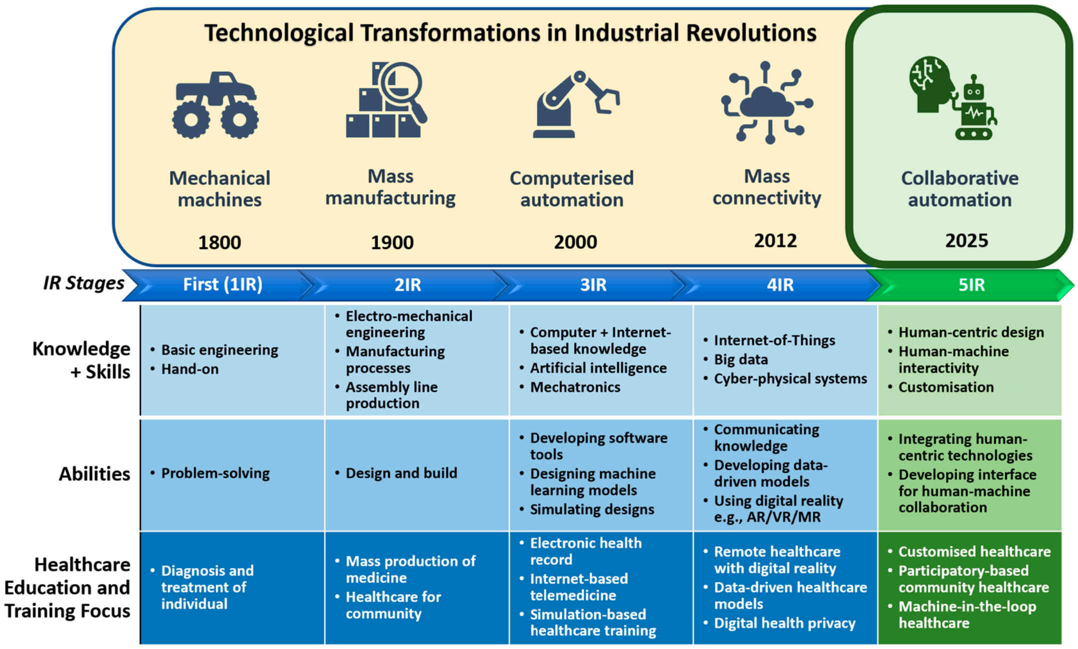


Figure 2. Charting the path: mapping the links between industrial revolution (IR) and healthcare education for the future.

Digital health and education, underpinned by relevant enabling technologies (Table 1), presents a transformative opportunity for healthcare disciplines, such as nursing, medicine, and pharmacy. When effectively integrated, these advancements can enhance patient care, streamline healthcare management, and revolutionise health systems worldwide. These technologies have varied levels of adoption and integration into digital health education and practice in countries such as the United States, United Kingdom, Canada, Australia, and New Zealand [30–32]. It is generally true that healthcare professionals can exchange and work between the United States, Canada, Australia, the United Kingdom, and some European countries, which are subjected to certain conditions and requirements to address health workforce mobility and shortages [75,76]. Moving forward, we need a more standardised and global approach to digital health and education in order to improve overall professional skills and patient outcomes as well as tackle global shortages of healthcare professional workforce [32,77].

3.2. Prospects, Issues, and Challenges for the Healthcare Workforce

The working environment in digital health is constantly evolving, and new technologies are being developed at a rapid pace. Therefore, a new training paradigm is required for the workforce to work well with those technologies. As educators, we need to consider how to prepare the workforce of the future. However, educators are constantly faced with many possibilities and complex decisions as they design learning and teaching content, assessment tasks, and instructions focused on the knowledge and skills learners need to be successful in this fast-changing world. In order to stay ahead in this complex environment, it is necessary to understand how the future of work will evolve in the years ahead with the advancement of Industry 5.0 technologies [8,78,79].

The idea of the future of work comprises three elements: the *workplace*, the actual *work* carried out, and the *workforce* (Figure 3) [79,80]. *Workplace* refers to where and when work is carried out. *Work* presupposes that it is inevitable that future employees will be collaborating with analytic software, chatbots, and robotics to get carry out work efficiently and innovatively. This magnifies the need for targeted interventions funded by national governments and other stakeholders to bridge the skills gaps precipitated by advanced technological change. *Workforce* focuses on the people who do the work. New Industry 5.0 technologies are increasingly replacing manually repetitive labour tasks. Employers must prepare their workforce for moving into, within, or out of an organization due to the changing skill requirements caused by advances in technology.

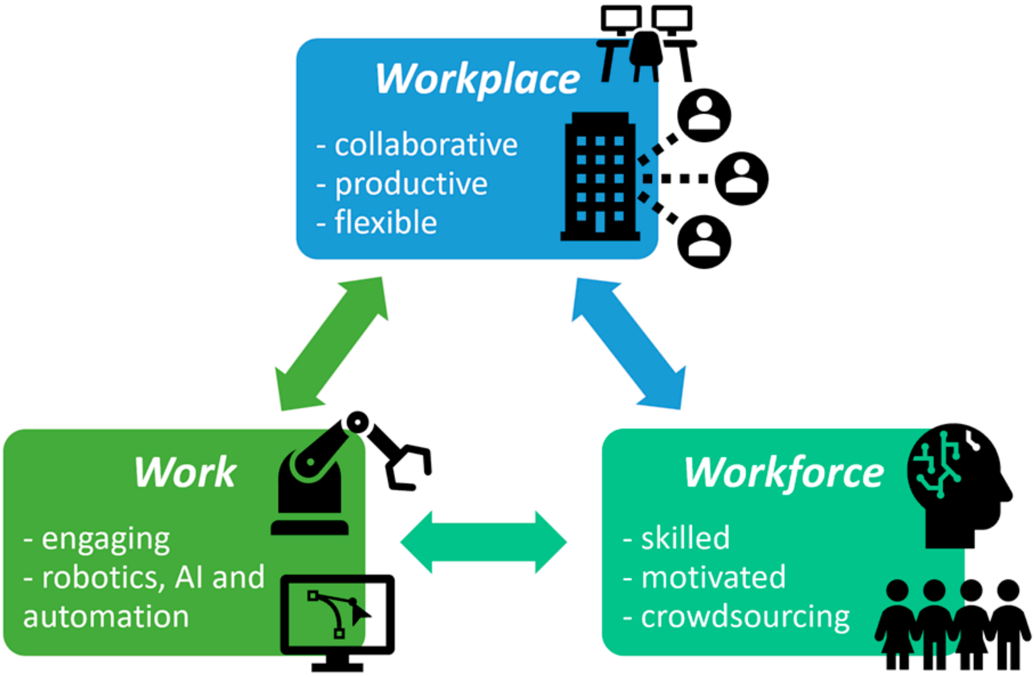


Figure 3. The future of work from the perspective of Industry 5.0.

Although big data usage and analytics, AI, and ML will become fundamental skills in the future, it is less clear how these should be integrated into existing education curricula to ensure that the relevance of graduates' skills focuses on human-centric technology and personalized and sustainable healthcare. It has been argued that traditional education and training methods may be unable to keep up with the rapid changes and advancements and may fail to prepare students for the future digital health workforce. The European Commission notes [5,7] that the future of work is shifting to Industry 5.0, where its core elements are focused on human-centricity, sustainability, and resilience. It is becoming urgent for all levels of government, economy, and society to support education and skills training to enable workers to adapt to a shifting job market and the nature of healthcare work [5,7]. Australia provides a useful example of these dilemmas.

3.3. Australian Educational Context in Digital Health

The Australian higher education system has a long history of quality assurance and accreditation. As such, all the degrees meet the rigorous Australia Qualifications Framework [81], meaning that graduates are well-prepared for the workforce. In order to address the need for digital health, many universities in Australia have started offering various digital health-related degrees. In this context, we assessed and compared Australian universities that offer digital health degrees in terms of pedagogy and technological competencies (software, hardware, resources, infrastructure, etc.), assessments, and industry collaborations to provide insight into the strengths and weaknesses of the degrees in preparing students for Industry 5.0 in the field of digital health (Table 2).

Table 2. Australian Universities: analysis of graduate certificates in digital health in terms of pedagogy, technology, assessment, and industry collaboration.

University/Title of Certificate	Pedagogical Interaction	Technological Competences	Assessments	Industry Partners or Work Integrated Learning
Australian College of Nursing/Graduate Certificate in Digital Health [1]	Online	Machine Learning	Research-led teaching; Evidence-based	No
Australian Catholic University/Graduate Certificate in Digital Health [2]	Online, webinars, discussion forums	Not clear	Group work, essay; reflective journals;	No
Curtin University/Graduate Certificate in Big Data and Digital Health [3]	On campus; Online;	Machine learning for data analytics	Research Projects; Reflective journals;	No
Flinders University/Graduate Certificate in Digital Health Management [4]	On campus; Online	Virtual hospitals; intelligence, the Internet of Things (IoT), digital safety, and cybersecurity in the health- and age-care sectors	Not Clear	Recognised by the Australasian Institute of Digital Health and the Australasian College of Health Service Management for continuing professional development (CPD) points eligibility
Griffith University/Graduate Certificate in Digital Health [5]	On campus; Online;	Teaching focus: technologies associated with health information; data and information acquisition, structure, use and value; the ability to utilise digital health research, as well as project management skills, to support managing resources and delivering initiatives in health information applications	Reflective journals;	Accredited by the Australasian College of Health Service Management (ACHSM).
La Trobe University/Graduate Certificate in Digital Health [6]	On campus; Online; Role plays; Discussions;	Not clear; as general as the interface of healthcare and digital technologies	Presentation; Reports;	No
Queensland University of Technology/Graduate Certificate in Digital Health Leadership and Management [7]	On campus; Online	Not clear	Not clear	No
RMIT University/Graduate Certificate in Digital Health [8]	Online learning; structured hand-on activities;	AT and IoT, electronic health records (EHR)	Case study; reports; vodcast; presentation; project portfolio	Digital Health CRC, Telstra Health, AWS

Table 2. *Cont.*

University/Title of Certificate	Pedagogical Interaction	Technological Competences	Assessments	Industry Partners or Work Integrated Learning
The University of Sydney/Graduate Certificate in Digital Health and Data Science [9]	On campus	Different eHealth tools	Case study	No
The University of Queensland/Graduate Certificate in Clinical Informatics and Digital Health [10]	Online	Application/contextualisation; interac-tion/collaboration; reflection/evaluation [information from Discover UQ's Graduate Certificate in Clinical Informatics and Digital Health—Faculty of Medicine—University of Queensland]	Not Clear	Eligible memberships of the Australian Institute of Digital Health support progression to a clinical fellowship with the Australian Institute of Digital Health (AIDH)
University of Melbourne/Graduate Certificate in Health Informatics and Digital Health [11]	Online, face-to-face, workshops, seminar of group interaction	health informatics tools;	Assignments; individual and team reports; quizzes; presentations.	No
University of Tasmania/Graduate Certificate in Digital Health [12]	Online	Electronic health records (EHR)	Presentation; Essay; Report	No

[1] Graduate Certificate in Digital Health—Australian College of Nursing (acn.edu.au), [2] Graduate Certificate in Digital Health—Australian Catholic University (online.acu.edu.au), [3] Graduate Certificate in Big Data and Digital Health—Curtin University (curtin.edu.au), [4] Graduate Certificate in Digital Health Management—Flinders University (flinders.edu.au), [5] Graduate Certificate in Digital Health—Griffith University (griffith.edu.au), [6] Graduate Certificate in Digital Health—La Trobe University (latrobe.edu.au), [7] Graduate Certificate in Digital Health Leadership and Management—Queensland University of Technology (qut.edu.au), [8] Graduate Certificate in Digital Health—RMIT University (rmit.edu.au), [9] Graduate Certificate in Digital Health and Data Science—The University of Sydney (sydney.edu.au), [10] Graduate Certificate in Clinical Informatics and Digital Health—The University of Queensland (uq.edu.au), [11] Graduate Certificate in Health Informatics and Digital Health—University of Melbourne (unimelb.edu.au), [12] Graduate Certificate in Digital Health—University of Tasmania (utas.edu.au).

As noted in Tables 2 and 3, most digital health degrees are offered at the graduate certificate level in the Australian context. They are designed to cater to the needs of professionals who are already working in healthcare and want to upskill or reskill in the digital health field. Graduate certificates seem to offer a shorter and more flexible pathway for professionals to acquire the knowledge and skills necessary to advance their careers without committing to a full-time postgraduate degree. Appendix A provides detailed information about the entry requirements for each graduate certificate, as well as the courses or topics covered and the learning outcomes that students can expect to achieve upon the completion of the degrees. According to the analysis in Table 3, most degrees lack industry partnerships that can provide students with real-world exposure so that they can apply their knowledge in practice and gain experience.

Table 3. Postgraduate, Master's, and Bachelor's degrees in digital health.

University/Title of Degrees	Outcomes	Pedagogical Interaction	Technological Competences	Assessments	Industry Partners or Work Integrated Learning
La Trobe University/Master of Digital Health #	Three major outcomes: 1. Demonstrate proficient knowledge about core health; 2. Use of information and technology in healthcare; 3. Understand public health policy and planning	Online, face-to-face, workshops, seminars of group interaction	health informatics tools;	Assignments, individual and team reports, quizzes, and presentations.	Not clear
The University of Sydney/Master of Digital Health and Data Science §	Two major outcomes: 1. Gain advanced skills to develop, implement, evaluate, and manage data-driven technologies; 2. Ultimately stand out in a global healthcare sector on the cusp of a major transformation through big data, machine learning, and computation.	Face-to-face	Not clear	Not clear	No
Flinders University/Bachelor of Health Science (Digital Health) ‡	Nine major outcomes, including the aims to develop skills in identifying and utilizing big data sets ethically, applying knowledge of big data, visualisation, governance, and machine learning to effectively communicate health data, while maintaining cultural awareness and using in-demand technologies.	Online; face-to-face	Not clear	Essays and presentations,	Not clear
Western Sydney University/Master of Health Science (Digital Health) *	Three major outcomes: 1. Study contemporary issues associated with information management in healthcare organisations with the integration of a sound understanding of the impact of digital health; 2. Develop innovation and entrepreneurship and research and development in the digital health space	On campus; Online	Not clear		Work-integrated learning. A Master's in Health Science (Health Service Management) has professional accreditation with the Australasian College of Health Service Management (ACHSM).

Master of Digital Health—La Trobe University (latrobe.edu.au), § Master of Digital Health and Data Science—The University of Sydney (sydney.edu.au), ‡ Bachelor of Health Science (Digital Health)—Flinders University (flinders.edu.au), * Master of Health Science (Digital Health)—Western Sydney University (westernsydney.edu.au).

Australian universities have their own core curriculum and vary in terms of how they address key issues related to digital health, such as security, privacy, standardisation, and interoperability, as well as regulatory policy. Table 4 presents a thorough review of how each university addresses the key issues related to digital health and Industry 5.0 in order to equip their graduates with the skills and knowledge essential to success in the ever-evolving and complex world of digital health.

Table 4. Informed perspectives on addressing contemporary issues in course design focus and their relevance to Industry 5.0 among university certificates.

University/Title of Certificate	Courses Co-Delivered by School/Discipline Area	Approach to Addressing Issues in Sections 2.1–2.6	Industry 5.0 Integration Status
Australian College of Nursing/Graduate Certificate in Digital Health [1]	Nursing	- analyse the current trends and contemporary practices in healthcare data management - determine privacy, ethical and legal implications of collecting healthcare data	*Sustainable*: Not clear *Human Centric*: Discuss the principles of user-centric design *Resilience*: Not clear
Australian Catholic University/Graduate Certificate in Digital Health [2]	Health Sciences, Information Technology, Law	- address data integrity throughout the data supply chain - address equity perspective of healthcare - understand the benefits and risks of digital health developments	*Sustainable*: address equity perspective of healthcare *Human Centric*: Not clear *Resilience*: explore risks and benefits of digital health developments
Curtin University/ Graduate Certificate in Big Data and Digital Health [3]	Health Sciences, Population Health, Computing and Mathematical Sciences	- develop students' skills and knowledge related to the philosophy and practice of qualitative research in public health - understand biostatistics, big data, and analytics	*Sustainable*: explore ways in which big data analytics can be used to reduce waste and inefficiency in healthcare systems *Human Centric*: Covers the importance of putting patients at the centre of digital health initiatives *Resilience*: Not clear
Flinders University/ Graduate Certificate in Digital Health Management [4]	Computer Science, Medicine	- interdisciplinary approach to digital health management, with a focus on both the technical and managerial aspects of digital health initiatives	*Sustainable*: Not clear *Human Centric*: strong emphasis on patient engagement and ethical considerations in the use of digital health technologies. *Resilience*: explores ways in which digital health technologies bring disaster response, telemedicine, and remote patient monitoring

Table 4. *Cont.*

University/Title of Certificate	Courses Co-Delivered by School/Discipline Area	Approach to Addressing Issues in Sections 2.1–2.6	Industry 5.0 Integration Status
Griffith University/ Graduate Certificate in Digital Health [5]	Medicine, Nursing and Midwifery, Information and Communication Technology	- equip healthcare professionals with the skills and knowledge necessary to effectively implement digital health technologies, including digital health governance and regulation and health informatics	*Sustainable*: explores development and implementation of projects and programs relating to this critical area in both organisations and professional practice *Human Centric*: Not Clear *Resilience*: Not Clear
La Trobe University/ Graduate Certificate in Digital Health [6]	Nursing and Midwifery, Psychology and Public Health, Computer Science and Information Technology	- develop students' skills in digital health fundamentals, health data analytics, and leadership - build students' knowledge of health data management fundamentals, data quality, privacy, and security, as well as analytical techniques for extracting insights from health data.	*Sustainable*: strong emphasis on reducing waste and inefficiency in healthcare systems by implementing automation *Human Centric*: Not Clear *Resilience*: enhancing the capacity of healthcare systems to respond to crises and emergencies
Queensland University of Technology/Graduate Certificate in Digital Health Leadership and Management [7]	Computer Science, Management	- study of factors that influence the full and effective use of evidence and can accelerate the systematic uptake and integration of evidence-based interventions into routine practice and public health - healthcare professionals to appreciate contemporary technological trends and research evidence, especially those relating to the transition from paper-based to electronic medical records (EMRs)	*Sustainable*: consider the environmental and resource implications of digital health technologies and develop solutions that efficiently utilise resources while minimising waste and energy consumption *Human Centric*: prioritise a patient-centred approach *Resilience*: Not Clear
RMIT University/ Graduate Certificate in Digital Health [8]	Health and Biomedical Sciences, Engineering	- provides healthcare professionals with the skills and knowledge necessary to lead digital health initiatives in their organisations - education approach combines technical and clinical perspectives.	*Sustainable*: exploring automating processes and reducing the use of paper-based systems in digital health solutions *Human Centric*: Strong emphasis on patients centric in digital health systems design, services, and ubiquity of technologies, applied telehealth and virtual care *Resilience*: Not Clear

Table 4. *Cont.*

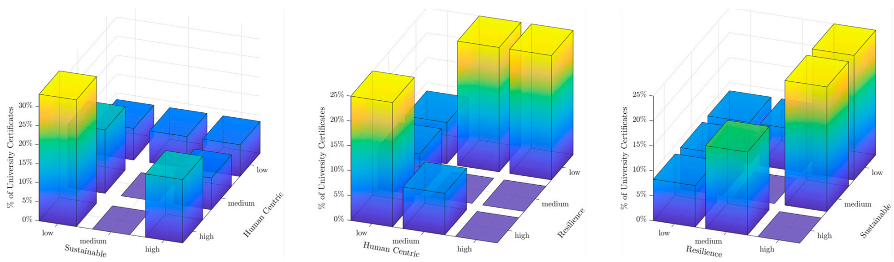
University/Title of Certificate	Courses Co-Delivered by School/Discipline Area	Approach to Addressing Issues in Sections 2.1–2.6	Industry 5.0 Integration Status
The University of Sydney/Graduate Certificate in Digital Health and Data Science [9]	Public Health, Computer Science	- gain the skills to develop, implement, evaluate, and manage data-driven technologies to effectively use data science in the context of digital health	*Sustainable*: By analysing large amounts of data, healthcare professionals can identify areas where resources are being underutilised and implement strategies to reduce waste and improve efficiency *Human Centric*: Not Clear *Resilience*: importance of using the data to its stakeholders (patients, clinicians, society etc.) by taking into account of the ethics, privacy, security and measurable benefits
The University of Queensland/ Graduate Certificate in Clinical Informatics and Digital Health [10]	Health and Rehabilitation Sciences, Information Technology, Electrical Engineering	- provides healthcare professionals with the skills and knowledge necessary to effectively use digital health solutions in clinical settings - brings a unique technical perspective to the program and provides students with opportunities to learn about cutting-edge technologies and their applications in healthcare.	*Sustainable*: Focus on entrepreneurship to drive innovation and entrepreneurship in digital health *Human Centric*: No Clear *Resilience*: specifically on the use of data analytics
University of Melbourne/Graduate Certificate in Health Informatics and Digital Health [11]	Engineering, Health Sciences	- demonstrate an understanding of how digital data, information, and knowledge are generated and managed for clinical care, biomedical research, public health, and health policy and planning - communicate knowledgeably about the uses of core health and biomedical informatics concepts, tools, and methods	*Sustainable*: Focus on usage of information and communication technologies in healthcare, including the rise of Digital Health, eHealth, Mobile Health and Telehealth *Human Centric*: Not Clear *Resilience*: Critically evaluate approaches to information systems and information technology in contemporary healthcare

Table 4. *Cont.*

University/Title of Certificate	Courses Co-Delivered by School/Discipline Area	Approach to Addressing Issues in Sections 2.1–2.6	Industry 5.0 Integration Status
University of Tasmania/ Graduate Certificate in Digital Health [12]	Medicine, Health Sciences	- gain experience and knowledge on the key concepts of health informatics, security, and data, while also considering the ethical, social, and economic considerations.	*Sustainable*: Not Clear *Human Centric*: Not Clear *Resilience*: Focus on security and data while also considering ethical, social and economic considerations.

[1] Graduate Certificate in Digital Health—Australian College of Nursing (acn.edu.au), [2] Graduate Certificate in Digital Health—Australian Catholic University (online.acu.edu.au), [3] Graduate Certificate in Big Data and Digital Health—Curtin University (curtin.edu.au), [4] Graduate Certificate in Digital Health Management—Flinders University (flinders.edu.au), [5] Graduate Certificate in Digital Health—Griffith University (griffith.edu.au), [6] Graduate Certificate in Digital Health—La Trobe University (latrobe.edu.au), [7] Graduate Certificate in Digital Health Leadership and Management—Queensland University of Technology (qut.edu.au), [8] Graduate Certificate in Digital Health—RMIT University (rmit.edu.au), [9] Graduate Certificate in Digital Health and Data Science—The University of Sydney (sydney.edu.au), [10] Graduate Certificate in Clinical Informatics and Digital Health—The University of Queensland (uq.edu.au), [11] Graduate Certificate in Health Informatics and Digital Health—University of Melbourne (unimelb.edu.au), [12] Graduate Certificate in Digital Health—University of Tasmania (utas.edu.au).

It is important to note that the comparison in Tables 2–4 might not be simple, as diverse degrees may have distinct objectives, intended audiences, and pre-requisites. Furthermore, it is important to consider the context in which these degrees are being designed and offered, such as accessible resources and local industry needs. Therefore, a visual representation through histograms capturing the prevailing trends in the adoption of the three key principles: sustainability, human centricity, and resilience in digital health curriculum design is presented in Figure 4. The distribution of the data in Table 4 has been mapped to the histograms, indicating the extent to which the programs emphasise these key principles. By segmenting the results into high, median, and low categories, we can effectively identify trends, gaps and potential areas for improvement in the educational offerings within this field. As shown in Figure 4a, merely about 10% of the programs strongly incorporate the two key digital health principles of sustainability and human centricity. Similarly, as illustrated in Figure 4b, the emphasis on both human centricity and resilience is given low priority in the majority of the programs. Figure 4c reveals that most programs exhibit a high-to-medium focus on the resilience principle, combined with a medium-to-low emphasis on the sustainability principle in their digital health curriculum. The purpose of the comparison is not to provide an exhaustive list but rather to offer insights for students, educators, policymakers, and universities to better understand the delivery of digital health and improve the quality of learning and teaching.



(a) (b) (c)

Figure 4. The distribution of the degree programs regarding their adaptation of the three key sustainable, human-centric, and resilience principles in digital health curriculum design, illustrating an incorporated emphasis on (**a**): sustainability and human centricity, (**b**): human centricity and resilience, and (**c**): resilience and sustainability.

We also noticed that the information about the infrastructure, resources, and technologies used in these programs is often not well documented. Such information is essential to help students make informed decisions about their education and career paths, help educators design and deliver effective courses, help policymakers shape policies to support digital health initiatives and help universities enhance their degrees and partnerships with industry to meet the needs of the rapidly evolving digital health landscape.

It is clear that the fifth industrial revolution requires us to change our education and training for healthcare professionals, and our findings to date indicate that much needs to be carried out to develop a new paradigm for digital health education.

4. The Fifth Industrial Revolution and a New Teaching Paradigm for Digital Health

Students need to be able to work effectively alongside machines and technology while also being able to communicate and collaborate with their colleagues. As new technologies emerge, students need to learn and upskill continuously throughout their careers. We propose a new learning and teaching framework that integrates pedagogical methods, technologies, and assessment strategies to deliver a skilled workforce in the future (Figure 5).

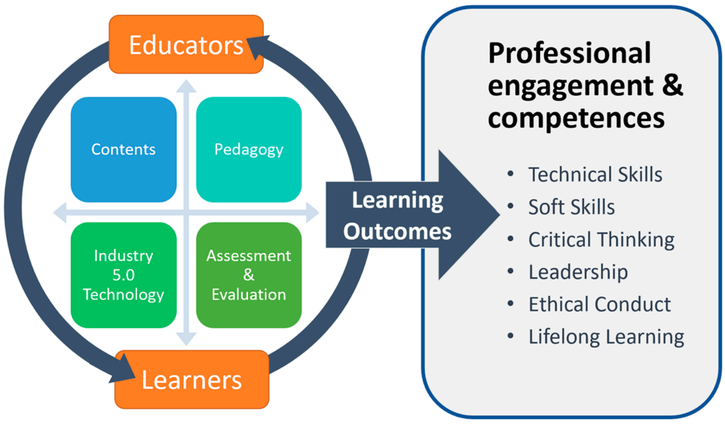


Figure 5. The proposed learning and teaching framework, pedagogical methods, integration of technologies, and assessment strategies to deliver the skilled workforce of the future.

4.1. Learning Content and Source

Industry 5.0 will present significant challenges and demands to contemporary learning and the education approaches that help learners to leverage human/technology co-operation to solve future problems [34,82]. It is incumbent upon educational institutions that they provide students with exposure to emerging technologies and educational situations in which students interact with technology and learn to apply it. In order to stay relevant and build a competitive advantage for graduates and universities, higher education should consider how Industry 5.0 and digital health can interact with the learning and teaching context, at the same time answering the overarching questions about what kind of learning models, content, program planning, digital credentials, and good practice are needed to improve and reshape educational approaches [83].

4.2. Infrastructure, Resources and Technologies

Despite growth in the use of Industry 5.0 technologies that support the entire teaching and learning process [38], most educational institutions still focus on ensuring students develop familiarity with the tools used within simulated work scenarios [84] rather than incorporate authentic, real-world problems that involve multiple stakeholders, including patients, clinicians, industry partners, etc. Additionally, the barriers to, and enablers of, the successful adoption and implementation of Industry 5.0 technologies to support learning and teaching activities have so far been ignored or not well documented.

The information and communications technology (ICT) infrastructure refers to the essential hardware, software, networks, and other technologies that facilitate communication and data management. ICT infrastructure is important for network connectivity and computing devices and provides collaboration and organisational platforms to integrate processes and people [85]. It is also crucial for the development and implementation of Industry 5.0. However, ICT infrastructure often presents a challenge in low-income or resource-poor countries [14,86].

Hashim et al. [87] emphasised that, in addition to budgetary allotments, universities need to formulate agile, realistic, and scalable digital transformation strategies for the adoption of new technologies. Universities can leverage open-source software and technologies, which will radically reduce the fixed costs of investing in digital technologies for supporting educational practice [87–89]. Although it can be used free of charge, open-source software presents challenges related to security, support, compatibility, and governance, which need to be carefully considered [11].

4.3. Strategies to Reinvent Education Pedagogy

Recent studies [8,90] have reported on the third wave of automation and have predicted that by 2030, approximately 90% of jobs may be replaced by autonomous robots. As a result, there will be increased demand for knowledge-based (cognitive) occupations, driven by a continuing shift from routine manual skills to non-routine, metacognition-based skills, such as problem-solving, collaboration, and leadership. However, education researchers have noted that the current research on preparing students for the future of work is still in its infancy [84,91,92]. Despite many of the digital technologies already existing in the higher education system [84,91,92], these are becoming less relevant in addressing the complex future labour market in the context of Industry 5.0. Hence, educational institutions require a comprehensive overhaul of their existing curricula and learning and teaching strategies to help students in becoming lifelong learners who know how to identify and define the right problems for complex systems that need solving and working collaboratively to achieve the desired outcomes. Some examples of how Industry 5.0 technologies can be applied to learning and teaching pedagogy may include the following.

4.3.1. Experiential Learning in Project-Based Learning

An experiential learning approach means students are given a set of problems, and while trying to solve them, they not only need to search for information but also implement the theoretical concepts that they have learned [93]. One popular experiential learning approach is project-based learning (PBL) [88]. PBL involves students working on real-world projects that allow them to apply their knowledge and skills in a practical and meaningful way. In the context of digital health and Industry 5.0, PBL could involve working on projects, such as developing a health application, designing an AI-powered medical diagnosis tool, or creating a virtual reality training program for industrial workers.

4.3.2. Collaborative Learning

Some studies [16,94] have suggested that to implement digital solutions and competencies successfully to solve real-world clinical and public health problems, there must be multidisciplinary collaboration between medical science and science and technology disciplines. However, collaboration can be challenging, as it involves two or more people interacting with each other [95]. We believe that the available tools and resources, together with a systematic approach to teamwork and communication skills, can play a relevant role in preparing the next generation of workers for the challenges of the future [96].

4.3.3. Transdisciplinary Learning

Digital health is a multidisciplinary field that includes health sciences, engineering, computer science, and information technology. Embracing transdisciplinary processes in research and education [97] and sharing knowledge has become an important aspect of new teaching paradigms and was reported as helpful [94] in equipping students with a thorough education that covers all aspects of digital health. A recent study by Broo and colleagues [97,98] highlighted the importance of transdisciplinary working environments for a sustainable future. The authors suggested the complex problems of the fifth industrial revolution (i.e., Industry 5.0) cannot be adequately tackled by an individual from a single discipline but require the consideration of individuals and experts from different disciplines or areas to work together to address complex, real-world problems. Therefore, the authors urged higher education institutions to introduce transdisciplinary environments combined with new frameworks, such as blending systems and design thinking, in the teaching and learning programs.

4.3.4. Lifelong Learning

Lifelong learning, which is defined as an ongoing, voluntary, and self-motivated pursuit of knowledge [97], has been increasingly promoted in recent decades. It involves a shift away from traditional lecture-based instruction towards a more hands-on and student-centred approach to teaching and learning. With such an approach, students take responsibility for their education by participating in real-world case studies, interactive activities, and group projects and discussions. This student-centred approach focuses on cultivating critical thinking and collaboration, and through hands-on laboratories, students gain practical experience in the application of advanced technologies. Furthermore, this approach can be customised to adapt to the needs of students by incorporating real-world scenarios, simulated patient cases, and personalised instruction.

By using a lifelong learning approach, educators can better prepare healthcare students for success in their future careers by developing critical thinking skills, teamwork abilities, and a deeper understanding of applied skills. These skills are particularly important in the context of Industry 5.0, where professionals must be able to think creatively and work effectively with others and understand patient information flows in these technologies. However, it is still unknown how well the higher education system's education and training approaches help students develop agility in response to fast-changing technologies and also maintain motivation and capacity for learning in the longer term.

4.3.5. Assessment Model

In order to transform a healthcare professional from an aspiring learner to an expert who masters independent thinking, efficient problem-solving, and has the capacity to adapt their abilities to previously unencountered problems and tasks [15,99–101], the following assessment methods have been proposed:

- Standardised assessments, such as hands-on laboratory work and structured clinical assessments;
- Reflective learning, involving self-analysing of a person's own experiences and learning from past behaviours in order to maintain up-to-date knowledge and skills;
- Capstone projects;
- Electronic examination that contains different written examination formats, including short-answer, multiple-choice questions as an option.

4.3.6. Guided by Ethics

Longo et al. [102] emphasised that ethics is expected to fuel a symbiotic relationship between humans and the cyber-physical world in Industry 5.0. Ethics principles can be related to (i) the design and development of digital technologies, (ii) the technologies themselves, and (iii) the use of digital technologies. However, there is currently still a lack of a robust framework that teaches ethical conduct and professional accountability for learners to engage with and deepen their understanding of the ethical issues related to digital health.

5. Conclusions

Industry 5.0 emphasises the importance of human-centric design and aims to create a more equitable and sustainable future by balancing the benefits of technology with the needs of people. Industry 5.0 can help address equity issues in health, for example, by ensuring that digital health solutions are accessible, affordable, and culturally sensitive. This can be achieved by involving diverse stakeholders, including patients, caregivers, healthcare providers, and community organisations in the design, development, and implementation of digital health solutions. Hence, this project aimed to identify how educators can move to integrate Industry 5.0 technologies into pedagogical interventions that support students in developing sophisticated and transferable skills in the new worlds of work they will be entering. In order to help educators better understand the potential of these technologies for improving students' learning outcomes, the proposed learning and teaching framework highlights the importance of pedagogical methods, technologies, and assessment strategies that support a skilled workforce of the future. Life-long learning, with its focus on hands-on experience, critical thinking, and collaboration, is an effective approach for equipping healthcare students with the skills and knowledge necessary for success in this rapidly evolving industry. However, there is a need for a comprehensive overhaul of existing academic curricula and learning and teaching strategies to ensure that students are prepared for the complex challenges of Industry 5.0.

Further research is needed to explore strategies for embedding Industry 5.0 technologies into academic curricula and for developing a robust framework for teaching ethical conduct and professional accountability in the context of digital health. The ultimate goal is to create healthcare solutions that are both sustainable and resilient and prioritise the needs of patients and the larger community. This could include research on the use of virtual and augmented reality in education, the development of personalised learning experiences, and the impact of Industry 5.0 technologies on student outcomes. Additionally, further research could explore the ethical implications of using these technologies in education and the role of educators in preparing students for the ethical challenges posed by Industry 5.0.

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Appendix A

Appendix A provides a comprehensive overview of the graduate certifications related to digital health offered by Australian universities. Table A1 provides detailed information on the entry requirements for each degree, the subjects and topics that will be covered, and the learning outcomes. This comprehensive overview will help potential students determine which program is the best fit for their career goals.

Table A1. Summary of graduate certifications in digital health offered by Australian Universities: entry requirements, courses, and learning outcomes.

University/Title of Certificate	Entry Requirements	Subjects/Topics Covered	Outcomes
Australian College of Nursing/ Graduate Certificate in Digital Health [1]	Bachelor's of Nursing or registered nurse equivalent qualification Or be currently employed in the clinical area of specialisation	Complete all of the following: - Leadership and Professional Practice - Understanding Data in Health Care - Principles of Healthcare Digitalisation - Digital Healthcare Governance	Five major outcomes: - Apply the knowledge, skills, and attitudes of the nurse working in the digitalised health environment to practice - analysing complex clinical data integrity problems using critical thinking and multiple modes of inquiry - Critically analyse current literature regarding data use and nursing practice in digitalised health environments - model the skills and abilities that provide a foundation for future leadership roles in digitalised healthcare environments - Critically reflect on personal values and ethics as central to the development of culturally safe practice in digitalised health environments
Australian Catholic University/ Graduate Certificate in Digital Health [2]	Bachelor's degree in health Bachelor's degree in information technology	Complete any five subjects from below: - Health Data Fundamentals - Strategic Management in Digital Health Service Delivery - Ethical Practice in Digital Health - Introduction to Data Science with Python - Machine Learning with Scikit-Learn - Information Technology Essentials	Three major outcomes: - Develop foundation of digital health - Understand concept and technologies for digital health - Understand ethical decisions about digital health technologies
Curtin University/Graduate Certificate in Big Data and Digital Health [3]	Bachelor's degree or equivalent	Complete all of the following: - Quantitative Methods - Introduction to Big Data for Health - Machine Learning Applications in Health and complete any one of the following options: - Health System Planning - Health Economics - Qualitative Research in Public Health - Health Policy and Decision Making - Epidemiology and Evidence	Six major outcomes: - Identify existing big data sets with a potential to provide strategic insights into a health issue - Apply knowledge in key areas of big data, visualisation, governance, and machine learning to ensure robust information for strategic decision making in health - Communicate health data effectively, including visualisations to audiences from the lay public to technical professionals - Ensure ethical utilisation of data from public and private populations - Demonstrate cultural awareness and sensitivity in local and international contexts; recognise the importance of communicating in a culturally respectful way - Use technologies that are in high demand in industry
Flinders University/Graduate Certificate in Digital Health Management [4]	healthcare or related undergraduate degree or equivalent qualification	Complete all the below: - Digital Health - Virtual Health, Innovation and Co-Design - Health Informatics - Strategic Management	Three major outcomes: - Build key digital health management skills for future health workplaces - Builds capabilities in analytical and problem-solving skills in digital health, development and management of digital health solutions, and strategic digital transformation - Gain exposure to digital transformation and the benefits of Big Data and the IoT landscape in health

Table A1. *Cont.*

University/Title of Certificate	Entry Requirements	Subjects/Topics Covered	Outcomes
Griffith University/Graduate Certificate in Digital Health [5]	Bachelor's degree; or a health-related diploma PLUS two years relevant work experience in the health- or age-care sector; or a minimum of five years equivalent full-time work experience in administrative, management and leadership roles within healthcare organisations	Complete all of the following: - Digital Health - Health Services and Information Systems - Introduction to Digital Health Research and complete any one of the following options: - Financing Health and Social Care - Change Management in Dynamic Healthcare Systems - Translating Health Innovation into Practice - Quality and Risk Management in Healthcare	Two major outcomes: - Study contemporary issues associated with information management in healthcare organisations with the integration of a sound understanding of the impact of digital health research - Develop and implement projects and programs relating to this critical area in both organisations and professional practice
La Trobe University/Graduate Certificate in Digital Health [6]	Australian bachelor's degree (or equivalent)	Complete any four subjects from the following options: - Big Data and The Internet of Medical Things - Communicating Digital Health - Digital Health Design and Implementation - Epidemiology and Biostatistics - Strategic Digital Transformation of Health - Systems Thinking and Leadership - Trends in Digital Health - Virtual and Telehealth	Three major outcomes: - Demonstrate problem-solving skill in digital health, - Design, develop and implement digital solutions, - Analyse, interpret and present health related data
Queensland University of Technology/Graduate Certificate in Digital Health Leadership and Management [7]	Bachelor's degree (or higher qualification) in any discipline or diploma in any discipline followed by at least three (3) years professional experience, including at least one year in a supervisory or leadership role in any field	Complete all of the following: - Foundations of Digital Health - Implementation Science—Theory and Application in Health - Clinical Informatics for Intelligent Healthcare - Leadership in Digital Health Management	Five major outcomes: - Apply high-level leadership, formulate strategic vision to affect technological change, and leverage digital data - Gain future-focused skills, knowledge, and values that are immediately applicable and transferable across a variety of health service delivery contexts - Implement the professional knowledge, skills, and values to initiate, evaluate, communicate, and lead culturally safe use of digital health systems - Be enabled to lead and manage clinical informatics initiatives to inform improved decision making - Develop an appreciation of the complex, diverse, and challenging nature of digital health management - Build capacity and capability to respond to the changing needs of Australasian health systems and beyond, associated with complex information technology ecosystems

Table A1. *Cont.*

University/Title of Certificate	Entry Requirements	Subjects/Topics Covered	Outcomes
RMIT University/Graduate Certificate in Digital Health [8]	Bachelor's degree or equivalent, or higher-level qualification, in any discipline and at least 1 year's full-time experience in a health care or social setting Or At least five years full-time experience working in health or social care	Complete all of the following: - Digital Health Enablers and Technologies - Data and Electronic Health Records - Applied Telehealth and Virtual Care and complete any one from the following options: - Digital Health in Service Delivery - Strategy, Design and Change Management in Digital Health	Four major outcomes: - Critically analyse societal, cultural, economic and technological factors that enable or inhibit patient, consumer and citizen engagement in safe, effective and efficient digital health service delivery and business models - Evaluate the importance of data, information and knowledge management in digital health and the implications for effective governance in both health service delivery and citizens' rights - Analyse contextual considerations, including regulation, policies and standards, socio-economic, socio-technical and cultural sensitivities, funding, workforce and other capabilities, to the provision of digital health services - Design an effective strategy for implementing digital health initiatives in two core socio-technical domains—electronic health records and virtual care delivery—using reflective leadership
The University of Sydney/Graduate Certificate in Digital Health and Data Science [9]	An honours bachelor's degree or A bachelor's degree and a minimum of two years of relevant work experience	Complete all of the following: - Implementation Science in Digital Health - Foundations of Digital Health - Applied Healthcare Data Science - Foundations of Healthcare Data Science and - 1× data science-related elective subject - 1× digital health-related elective subject - 1× capstone project with industry to gain real-world experience sharing your data insights with hospitals, clinicians and primary health networks	Two major outcomes: - Gain the skills to develop, implement, evaluate, and manage data-driven technologies - Expand their digital science expertise to health data, or expand their skills in data science to specialise in digital health
The University of Queensland/ Graduate Certificate in Clinical Informatics and Digital Health [10]	An honours bachelor's degree or A bachelor's degree and two years of relevant work experience	Complete all of the following: - Digital Health Foundations - Digital Health in Action - Data and Analytics for Quality Improvement - Re-imagining Healthcare	Two major outcomes: - Develop and apply clinical informatics tools to improve healthcare outcomes, operations, and management practice - Learn to embrace change and become an innovative leader with the ability to identify, explain and use digital technologies in the health field
University of Melbourne/ Graduate Certificate in Health Informatics and Digital Health [11]	A health-related degree or equivalent; or an undergraduate degree in a cognate discipline or equivalent	Complete all of the following: - Biostatistics - Health Informatics Methods and complete two from the following options: - Digital Transformation of Health - 1× Elective	Three major outcomes: - Demonstrate proficient knowledge about core health - Use of information and technology in healthcare - Understand public health policy and planning

Table A1. *Cont.*

University/Title of Certificate	Entry Requirements	Subjects/Topics Covered	Outcomes
University of Tasmania/ Graduate Certificate in Digital Health [12]	Bachelor level (AQF7) or higher (or equivalent); in healthcare, or communications technology or Be working in a healthcare or IT setting	Complete all of the following: - Introduction to Health Informatics - Digital Health Privacy and Security Issues - Electronic Health Records - Health Data Management, Information Analysis and Improvement	Four major outcomes: - Consolidate and synthesise specialised health informatics disciplinary knowledge and apply that knowledge within their healthcare professional area of practice - Analyse complex healthcare problems and apply specialised technical skills to identify informatics-specific solutions - Initiate, plan, implement, and evaluate health informatics solutions, with independent judgement - Communicate health informatics theoretical concepts, knowledge, and ideas to a range of audiences

[1] Graduate Certificate in Digital Health—Australian College of Nursing (acn.edu.au), [2] Graduate Certificate in Digital Health—Australian Catholic University (online.acu.edu.au), [3] Graduate Certificate in Big Data and Digital Health—Curtin University (curtin.edu.au), [4] Graduate Certificate in Digital Health Management—Flinders University (flinders.edu.au), [5] Graduate Certificate in Digital Health—Griffith University (griffith.edu.au), [6] Graduate Certificate in Digital Health—La Trobe University (latrobe.edu.au), [7] Graduate Certificate in Digital Health Leadership and Management—Queensland University of Technology (qut.edu.au), [8] Graduate Certificate in Digital Health—RMIT University (rmit.edu.au), [9] Graduate Certificate in Digital Health and Data Science—The University of Sydney (sydney.edu.au), [10] Graduate Certificate in Clinical Informatics and Digital Health—The University of Queensland (uq.edu.au), [11] Graduate Certificate in Health Informatics and Digital Health—University of Melbourne (unimelb.edu.au), [12] Graduate Certificate in Digital Health—University of Tasmania (utas.edu.au).

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