Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Radiography 29 (2023) 391–397

Contents lists available at ScienceDirect

Radiography

journal homepage: www.elsevier.com/locate/radi

Narrative Review

Radiography education in 2022 and beyond - Writing the history of the present: A narrative review

Y.X. Tay [a, *], J.P. McNulty [b]

[a] Radiography Department, Allied Health Division, Singapore General Hospital, Singapore
[b] Radiography and Diagnostic Imaging, School of Medicine, University College Dublin, Ireland

ARTICLE INFO

Article history:
Received 6 September 2022
Received in revised form
4 January 2023
Accepted 19 January 2023
Available online 10 February 2023

Keywords:
Radiography
Education
COVID-19
Training
Teaching and learning

ABSTRACT

Objectives: The COVID-19 pandemic had a major effect on teaching and learning. This study aimed to describe a range of teaching, learning, and assessment strategies related to radiography education which have become more common due to the pandemic through a narrative literature review.
Key findings: Educational change in radiography was accelerated by the disruption caused by the pandemic. Changes included the site and mode of teaching and conducting of assessment. While some of the digital transformation trends were introduced before the pandemic, others were further amplified during this period of time. Alternative solutions such as virtual reality technology, gamification, and technology-enhanced learning were especially salient and have the potential to mitigate challenges brought about by the pandemic. The use of technology in the clinical setting, in assessment, and to facilitate feedback, are important tools for improving learners' clinical skills performance. Collectively, these digital technologies can maximise learning and support mastery of knowledge, skills and attitudes.
Conclusion: The pandemic has cast a new light on existing methodologies and pedagogies in education. This review suggests that digital technology is shaping teaching and learning within radiography education and also that educators cannot ignore this digital shift. With the digital trajectory, it would be highly useful to transform approaches to education within radiography to support learning as radiography education moves towards the new normal era.
Implications for practice: Digital technology in education can help improve the learning experience for learners but educators need to be equipped with the technological skills and be adaptable to these changes. Continual sharing of experiences and knowledge among radiography educators is essential. Safety nets need to be in place to ensure digital inclusiveness and that no learner gets left behind due to the digital divide in education.

Introduction

In June 2020, Professor Klaus Schwab, Founder and Executive Chairman, World Economic Forum, stated *"The pandemic represents a rare but narrow window of opportunity to reflect, reimagine, and reset our world"*.[1] While the pandemic has disrupted our normal lives, time has shown that it also presented a golden opportunity for many to seize something positive from this unprecedented crisis.

Following the declaration of the COVID-19 outbreak as a pandemic, the disease reached almost every country in the world.[2] With the prospects of an endemic, many radiography educators, and students, continue to 'pick up the pieces' of this pandemic on radiography education.[3] The progression of COVID-19 over the past few years had a substantial impact on both the students and radiography educators, with profound impact at low resource/resource-constrained settings.[4–6]

The pandemic has intensified some of the existing education trends. Technology-enhanced learning and simulation were the epitome of education trends amplified by the crisis.[7] Indeed, recent international studies, both pre- and during the pandemic, have

Abbreviations: AR, Augmented Reality; GBL, Game-Based Learning; LMS, Learning Management System; MOOCs, Massive Online Open Courses; MOODLE, Modular Object-Oriented Dynamic Learning Environment; MR, Mixed Reality; OSCE, Objective Structured Clinical Examinations; TEL, Technology-Enhanced Learning; VAP, Voice Annotated Presentations; VOSCE, Virtual Objective Structured Clinical Examinations; VR, Virtual Reality.

* Corresponding author. Singapore General Hospital, Radiography Department, Outram Road, Singapore 169608.
E-mail address: tay.yi.xiang@sgh.com.sg (Y.X. Tay).

https://doi.org/10.1016/j.radi.2023.01.014
1078-8174/

highlighted the need for further exploration of the changing uses of simulation in radiography education.[8,9] In addition, '*timely change is needed to keep up with the times*'[10] which is always true of education.

A narrative review involves discussion of important topics from a theoretical point of view; taking a less formal approach than systematic reviews.[11] This narrative review will explore a range of teaching, learning, and assessment strategies which have become more common due to the pandemic and where the pedagogical value, when used appropriately, cannot now be ignored within radiography education.

Literature search

Literature searches were performed in February 2022 with PubMed and Google Scholar using specific keywords e.g. "Radiography", "Education", "COVID-19" and "Training". Additionally, key radiography related journals e.g. *Radiography, the Journal of Medical Imaging and Radiation Sciences*, and the *Journal of Medical Radiation Sciences* were searched to retrieve relevant information. Publications had to draw on radiography or radiology education and training. Original research articles, reviews, editorials, commentaries, perspectives and short communications were reviewed. The first and second authors reviewed the articles for inclusion.

The new normal: online teaching and learning during the pandemic

For many, the pandemic accelerated the adoption of digital technologies and internet access is now considered an essential service, the fourth utility after electricity, gas, and water.[12] This is indeed no surprise as global education transited towards a new normal of virtual teaching and learning.

According to the Organisation for Economic Cooperation and Development,[13] searches for terms such as *online learning, e-learning* and *Massive Online Open Courses (MOOCs)* increased up to fourfold between end-March and early April 2020. Education of allied health sciences undergraduates including radiographers,[14,15] moved virtually with much of the teaching that was originally planned for face-to-face being delivered online. This is mirrored in radiology education where in-person teaching also moved online, teaching conferences transitioned to a fully virtual platform and digital learning resources were used as alternatives to in-person teaching.[16]

However, not everyone can embrace online teaching and learning. Individuals who thrive on human interaction may find virtual classes a challenging environment.[17] Others who are accustomed to a planned fixed schedule may find themselves under pressure to keep up with the lessons following the transfer of "ownership" where asynchronous teaching is provided.[18] Some may even disengage from their learning and risk falling behind their peers. Indeed, a systematic review by Astirbadi and Lockwood[19] evaluating the impact of COVID-19 on diagnostic radiography students highlighted that the transition to online learning impacted the students significantly and posed challenges for them during the pandemic. In addition, the significant amount of screen time for online learning also resulted in screen fatigue for many.[20]

Similarly, faculty and educators are also "victims" of the transition to online teaching or "emergency remote teaching". The trajectory to virtual learning was remarkable but with the implementation under considerable time pressure, developing a well-structured, dedicated online teaching curriculum was a challenge.[21] Moreover, some may feel ill-equipped to facilitate online teaching due to a lack of awareness of innovative teaching methods and effective online teaching pedagogies.[22] Indeed, educators now also face the challenge of motivating learners with diverse abilities in a virtual setting.[20]

Fortunately, literature also suggests that the rapid move to online learning resulted in a good learner experience that is conducive to sustained growth. A study[23] involving 3286 medical students from 12 different countries demonstrated the positive attitude of learners towards online learning. The authors further concluded that the COVID-19 pandemic might be the long-awaited catalyst for a new "online era" in the education of healthcare professionals.

Although it is impossible to predict when we will be able to put COVID-19 behind us, there is no doubt that it has had a lasting impact on education systems globally with future expansion of online teaching and learning options.

The virtual reality landscape: bridging the theory-practice-gap

Considering the limitation of online learning in the acquisition of clinical skills for student radiographers, educators may still leverage learning innovation and digitisation to support radiography education. In fact, as early as August 2007, Emeritus Professor Audrey Paterson, then Director of Professional Policy at the Society of Radiographers (UK),[24] said: *"there is much discussion as to whether virtual training can replace clinical time. We don't know the answer to this question yet but what is clear from the evidence is that the time spent on clinical placement is very much enhanced by the confidence and skills built in the virtual environment."*

Fast-forward 15 years, some educators in this time of disruption are desperately sourcing for viable simulation-based solutions to support continual clinical education and assessment.[25] There were also others who were facing the challenge of transforming simulation-based activities into distance-learning.[26] With social distancing, curricula in medical schools were restructured under considerable time pressure to move towards online teaching.[27] This posed challenges to the conducting of practical courses or activities that require group interactions in nursing, medical and physiotherapy.[28,29] Likewise, clinical placements had to be delayed or cancelled, especially at the onset of the pandemic.[5,30,31] However, teaching must continue and alternatives to real-life simulation must be identified to support learning in the interim period.[32]

Besides coping with the loss of training opportunities for students, educators also had to ensure that learning was sufficient for the current workforce. Learning had to be delivered "just-in-time" to upskill current healthcare professionals while supporting those returning to practice through refresher courses - thus ensuring sufficient and well-equipped workforce during the pandemic.[33] The focus of educators now lies on innovating in a new environment with novel technologies and adapting to flexible learning plans and outcomes. With today's immersive technology, these simulations can now happen in various realities such as augmented reality (AR), virtual reality (VR) or mixed reality (MR) while providing *"omni-learning"* - the ability to learn anywhere, anytime, with anyone.[33,34] Though at the time of writing, there were no available AR-enabled simulation environments for training of radiographers, the prospects of AR simulation in healthcare education was positive.[35] Conversely, VR simulation for training of student radiographers has shown to yield improved patient positioning outcomes as compared to conventional laboratory practicum.[36] This was supported by a systematic review by Tang et al.,[37] where it was concluded that such immersive technologies can be widely adopted and used for medical practice and education to reduce drawbacks of traditional teaching formats and practical training.

Usage of Microsoft HoloLens includes allowing medical students to learn by interacting with a holographic patient via VR and AR as part of telemedicine innovation[38,39] and learning of new practical tasks such as catheter placement where MR technology is seen as a cost-effective method to facilitate practical medical education.[40]

Examples that are more closely related to us are also illustrated by Uppot et al.[41] where both VR and AR tools are used in radiology education for training communication and clinical care. This includes using AR to help learners conceptualise complex anatomy, experiencing a 3D conceptual model of a physical environment and interactive lectures. Such technologies have the potential for supplementing radiography training in anatomy and pathology and for procedural simulation.[41]

As opposed to textbooks or online learning modules, immersing the learner in a virtual world is associated with a higher level of active learner participation because of increased social, environmental, and personal presence within the learning activity.[42] In addition, the use of such technology allows students to integrate lectures into practice sessions, where previously they would have to wait for lectures to refresh their understanding. In fact, holographic technology has recently been officially integrated into the curriculum for training medical and nursing students in Singapore.[43] Evidently, this is a shift in paradigm from our traditional mode of learning and such sight of students wearing headset will soon be much more common.

Especially in this COVID-19 pandemic, many had to challenge the status quo. In a recent commentary by Hayre and Kilgour,[44] the authors put forward the possibility of a paradigm shift within radiography education through use of technology including VR. The authors rounded up by concluding that VR does not offer a 'one size fits all' model but its current use and success for maintaining student progression should not be overlooked.

Application of VR in radiography education has been around for a while and models that have surfaced include Shaderware (Shaderware Ltd, Darlington, UK). The use of Shaderware for radiography training using 3D interactive simulation provides a cost-effective simulation training for radiographic equipment handling, receptor placement, collimation, side marker placement, exposure factor selection, control of scatter, and image quality assessment.[45] In fact, when available fully to learners, it facilitates asynchronous learning and acts as evidence of acquired competency prior to learners commencing their clinical placements.[46]

In 2016, Monash University developed a VR simulation clinic to facilitate the training of medical radiation science students and reported improvement of student perception scores for clinical and technical skills.[47] Also in 2016, Shanahan[48] from the Royal Melbourne Institute of Technology investigated the students' perspective on using virtual radiography simulation. Her findings have been promising. Students feedback that the virtual radiography simulations have a valuable role to play in developing technical and cognitive skills. And this could be due to the strength of such a model where students can repeat activities and could quickly see images and understand if changes needed to be made without being burdened by the use of ionising radiation on actual patients. The value of VR simulation was also echoed in other studies which include Sapkaroski, Mundy and Dimmock's[49] study which illustrated the benefit of repetition afforded by the use of VR simulation. This has implications on radiography education as VR could potentially be used to augment practicum or laboratory session while having the benefits of being easily accessible and the ability to allow students to correct their mistakes at their own pace.[49]

A similar picture was also painted in a recent study published by University College Dublin[50] on the use of 3D VR simulation in radiography education reported that the students "enjoyed" the VR simulation. Additionally, virtual immersion bolstered students' confidence in a number of areas including beam collimation, anatomical marker placement, centering the X-ray tube, and selecting radiation exposure parameters. Their findings were in alignment with Gunn et al.[51] who concluded that the integration of VR computed tomography simulation has the potential to increase both student confidence and preparation for the clinical environment.

For radiography educators, it is reassuring to know that students exposed to VR performed better than those in the traditional education group as suggested in a systematic review and meta-analysis published by Zhao et al.[52] Additionally, in another meta-analysis by Chernikova et al., simulation-based learning offers a wide range of opportunities to practice complex skills and allows a variety of scaffolding to facilitate effective learning.[53] However, in a recent study conducted on radiologic technologists in Japan, the authors found that VR can be less effective than real-world training in radiographic techniques which often emphasises patient interaction and palpation skills.[54]

Therefore, it is important to note that while such technology is scalable, reusable, and suitable for many students with limited patient access, the tasks should be meaningful and transferrable to the real world. Educators would also have to consider many factors including the ergonomic design and development of the applications; the financial and technological assistance in developing the VR environment and the requirement of a highly creative and educated workforce.[55] Nonetheless, these immersive technologies have enormous potential in medical practice and education.

Gamification: driving engagement through game-based learning (GBL)

Another technique that can promote student learning is in the form of gamification which is increasingly being adopted by educators to optimise students' learning outcomes. In a systematic review by van Gaalen et al.,[56] it was suggested that gamification, when used appropriately, improves learning behaviors and attitudes towards learning in health professions education. A similar picture was also painted in another systematic review by Gentry et al.,[57] where they further concluded that gamification or serious gaming is more effective for improving knowledge, skills, and satisfaction in health professions education. In alignment with the systematic reviews, Arruzza and Chau[58] in their scoping review of randomised controlled trials concluded that gamification may be advantageous for health science undergraduates. In addition, they also suggest educators supplement conventional teaching methods with gamification rather than replace them and to also consider group-based gamification, employed at irregular intervals.

Gamification can also be used in tandem with VR for teaching and learning. For example, gamification and VR have been used for teaching mobile radiographic imaging. Leveraging on the benefits of both simulation-based learning and gamification, it provides learners with a user-friendly and sufficiently realistic training tool with a high educational value for mobile imaging.[59] In radiology, the incorporation of gamification is able to improve learners' diagnostic confidence, reducing errors rates in training for pneumothorax detection and offering the element of fun in the learning process.[54] The fun factor of the learning tool encourages continuous utilisation of such learning aids and helps keep the learners motivated.[60]

GBL in virtual worlds such as Second Life™ is also widely published in literature. Second Life™ has been used for health professional learning where learners from various health profession disciplines, including medical radiation sciences, to develop their communication and history taking skills in a fun and safe learning environment of Second Life™ - enhancing learning outcomes.[61] In fact, the radiology profession has been using Second Life™ to teach medical students undergraduate radiology[62,63] including core radiological anatomy and radiological signs content. Furthermore, experiences from the use of Second Life™ by radiology[64] further

supported Arruzza and Chau's[58] findings of group-based gamification where competing in teams has the advantages of promoting collaborative learning and responsibility in collective work.

Despite GBL gaining momentum in education, there are also critics. It has been suggested that GBL tends to address lower-level learning goals rather than higher-level goals.[58] Additionally, Sánchez-Mena and Martí-Parreño[65] further highlighted the lack of resources, classroom dynamics and students' apathy towards GBL as barriers to widespread adoption in education. Cultural differences may also affect the effective use of gamification as a teaching and learning methodology.[65] Educators will have to consider and address these elements before implementing this as a new teaching methodology in their course.

Technology-enhanced learning (TEL): innovating teaching and learning practices

TEL is now commonplace and widely accepted in teaching and learning in health professions education following the influx of new technology in education.[66] Some of the TEL tools include the use of digital learning objects such as videos, mobile, and learning management systems (LMS). While such tools delivered online learning adequately, many learners experienced superficial learning.[67] Thus, it is imperative to adopt an innovative pedagogy approach in tandem with digital learning objects to deliver quality and inclusive education in online environments.[67] TEL tools facilitate flipped classroom models which yields many advantages such as: allowing learners to learn at their own pace, frees up contact time for more effective, creative and active learning activities and facilitating learners' control, focus and responsibility for their own learning.[68,69] Such a combination of technology and teaching approach can also increase learners' motivation and engagement.[70]

The pandemic mandated social distancing, thus reducing interactions between people and avoiding physical gathering including academic institutions**.** The use of digital learning objects has helped to "overcome the distance", while facilitating remote learning and education. LMS were leveraged at the onset of the pandemic to facilitate knowledge transfer across the globe. A LMS can be defined as an all-in-one organisation software that automates the administration, tracking, reporting, and delivers accessible contents rapidly.[71] The dissemination of mobile radiography knowledge through a global collaboration was an exemplar of LMS usage during a pandemic.[72] A narrative review by Konstantinidis et al.[73] concluded that e-learning is an attractive training method, equally or occasionally more effective than the conventional educational methods for the lifelong training of healthcare professionals in the field of medical imaging and radiation therapy. In alignment, a systematic review by Naciri et al.[74] concluded that health professions students demonstrated a positive response to e-learning in domains such as perceptions, acceptance, motivation and engagement. Furthermore, such asynchronous e-learning has shown to be effective in improving knowledge acquisition in radiology (chest radiology suggestive of COVID-19) while being a flexible tool to adapt to complex situations caused by the pandemic.[75] This may be of value for training of radiographers in image interpretation or preliminary clinical evaluation delivered through asynchronous online learning/distance learning.

Other examples of innovations in TEL is the curation of 10 min video lectures called voice annotated presentations (VAPs) by Duke-National University of Singapore. The curated digital library consists of various Learning in 10 videos from radiology and radiography.[76] Such approaches allow greater accessibility to medical information by learners globally which ultimately contribute to a better health system for all. Like many TEL tools, video lectures can also be used with flipped classrooms. Vavasseur et al.[77] illustrated blended learning using video-based lectures. In fact, they also suggest that low achievers take the best advantages from this approach, with overall higher student engagement. This can be attributed to the empowerment of these low achievers in terms of gaining more opportunities to reflect and learn at their own pace rather than being afflicted by the more challenging and fast-paced traditional lectures.[69]

Educators could also use dynamic eLearning authoring tools to create responsive, learner-focused structured courses for any device. It is no surprise that radiology adopted this new method for teaching medical imaging since radiology itself consists of highly visual content.[78,79] Experiences from the University of Southampton,[80] has suggested that a well-designed and integrated TEL solution can be an efficient approach for facilitating the application, integration, and contextualisation of anatomy and radiography - one that radiography can take a leaf from.

The emergence and increased deployment of mobile learning is well suited for our learners, many of whom are technologically digital natives. Mobile technology has become an intrinsic part of everyday life and the use of mobile learning as an educational method would facilitate delivery of educational content which is readily accessible, up to date, and technology enriched.[81] Moreover, it is also a good source of information for "just-in-time" learning.

In fact, the role of mobile electronic devices in radiographer education has been explored for some time. In 2010, Applegate[82] illustrated in a literature review the potential use of mobile electronic devices in radiography education and concluded that such mobile electronic devices are valuable as an information delivery tool. Another more recent 2019 systematic review and meta-analysis by the Digital Health Education Collaboration[83] suggested that mobile learning is as effective or even better than traditional learning. Makary et al.[84] further supported the use of mobile electronic devices and concluded that such devices have the potential to remarkably transform content delivery in the education of residents. In alignment with radiology, radiography has also adopted mobile learning in the training of radiographers. Alsharif et al.[85] validated the educational effectiveness of a mobile learning app in improving radiographer knowledge about magnetic resonance image quality optimisation and artefact reduction. Their findings were positive and underpin the potential of mobile applications as an effective educational tool.

While the benefits of mobile learning are undeniable, it also exposed the digital poverty position. Beyond any doubt, learning in a digital environment is not compatible with digital poverty. Substantial investment is required while developments need to be well-calibrated to address the specific needs of the most deprived; mitigating the digital exclusion while supporting technology-enhanced learning into the future.[86]

Digital assessment and feedback

Prior to the pandemic, digital assessment was gaining traction and popularity in medical education with the trajectory of digital transformation and digitalisation.[87] During the pandemic, with the transition to online teaching, assessment of the learners also moved online. One example is the MammographyOnline,[88] where high quality academic components are delivered with assessment embedded at the end of each module. Almeida et al.[89] further spotlighted Modular Object-Oriented Dynamic Learning Environment (Moodle) utilisation as an LMS to assess learning, collect, assess and provide feedback in medical imaging education and training. While many medical schools have implemented such platforms for their learners prior to the pandemic, medical schools in low and middle-income countries experienced obstacles in the development and adoption.[90] However, the current pandemic has forced many to

adopt it for education; institutions that were previously resistant had to now accept the new transformation or be excluded.[22,90,91]

Another transformation to assessment could be the use of screencasts for assessment. Jones and Wisniewski[92] used screencast video assignments to replace multiple-choice quizzes and such an approach was proven to be an innovative way to assess pharmacy students' knowledge and to provide feedback on their assignments. Indeed, screencasts can also be used to provide feedback to learners.[93] A qualitative literature review by Killingback et al.[94] concluded that alternative feedback modes, including screencast, aids learners to achieve a greater level of comprehension of feedback through more personalised feedback.

Objective structured clinical examinations (OSCEs) are another important component in the summative assessment of medical students.[95] Indeed, OSCEs are recognised by radiography as a valuable form of assessment in evaluating clinical competence of student radiographers since it targets the 'Shows How' level of Miller's pyramid of assessment.[96] Due to the COVID-19 pandemic, many face-to-face OSCEs were converted to an online or hybrid format.[97–101] Experiences from Nurse Practitioner students[102] were positive and it highlighted that the interactive Virtual OSCE was deemed an extremely effective tool for virtual evaluation of various clinical competencies. Similar positive findings were also echoed by Farrell et al.[103] where students rated telehealth OSCE positively while adequately assessing the students' foundational clinical skills performance. It is no surprise that practical tips from various authors' experience[104] are gradually emerging and contributing to the small but developing body of literature on VOSCE - one where radiography educators could potentially contribute.

The role of technology in clinical settings

Experiences of student diagnostic radiographers transiting into the workforce during the pandemic[105] spotlighted the concern regarding training for competencies during their induction period. The lack of formal training compounded with the inadequate support from mentors due to increased workload and manpower shortage have implications for their early career as a radiographer. Though it remains to be seen, video conference technology may be a solution to the current challenge posed. Rawle et al.[106] illustrated a teleradiography pilot project which presented positive results - improvement of image quality of radiographers through the introduction of video conference supervision. Similarly, Cameron et al.'s qualitative study also supported the use of remote supervision through video conference where trainees are provided with readily available guidance and well supported in their delivery of care to patients.[107]

In a commentary by Singh,[108] various examples and features of emerging technologies that were deemed beneficial to radiography education were highlighted. It was suggested that technology advancement could be a game changer in the way tracking of clinical competency for both students and newly graduated staff under supervision is done. Alismail et al.[109] illustrated a clinical education tracking system that overcomes the challenge of tracking student competency while supporting the provision of immediate student feedback on their progress, thus improving student outcomes. Another model could be the use of electronic clinical tracking systems. Bakers and Dubose[110] in 2009 published electronic systems for medical sonography student clinical records where the electronic systems enabled rapid collection and analysis of clinical education data while eliminating problems associated with paper forms - a common scene in radiography education. In a similar vein, an integrative review by Branstetter et al.[111] concluded that electronic clinical tracking systems are increasingly being utilised in advanced practice registered nurse education.

In radiography education, Monash University is an exemplar of introducing technology in all aspects of clinical placement. In fact, being the first undergraduate radiography course in Australia to implement such technology, their experiences were a timely reminder for us to enculturate positive attitudes towards technology and associated pedagogical change.[112] Clearly, such models could be studied further by the radiography educators on its feasibility and appropriateness for radiography education.

Conclusion

While advances had been made in technology-enhanced radiography teaching and learning prior to the COVID-19 pandemic, the significant disruption to learning due to the pandemic accelerated the transformation of digital teaching and learning in radiography education around the world. Most importantly, it provided a unique window for fundamentally transforming approaches to teaching and learning within radiography as radiography education "recovers" and moves on from the pandemic. To achieve a better outcome for learners, radiography educators must act jointly and swiftly to revamp various aspects of radiography education. This will enhance radiography education and strengthen the future of the profession.

Conflict of interest statement

None.

References

1. World Economic Forum. *The great reset*. 2020. Available from, https://weforum.org/focus/the-great-reset.
2. World Health Organization. *WHO coronavirus (COVID-19) dashboard*. 2022. Available from: https://covid19.who.int/. Date.
3. Zarefsky M. *How we will know when COVID-19 has become endemic*. 2022. Available from, https://www.ama-assn.org/delivering-care/public-health/how-we-will-know-when-covid-19-has-become-endemic. Date.
4. Ng CKC. A review of the impact of the COVID-19 pandemic on pre-registration medical radiation science education [published online ahead of print, 2021 Aug 4] *Radiography (Lond)* 2021. https://doi.org/10.1016/j.radi.2021.07.026. S1078-8174(21)00106-1.
5. Lawson Jones G, York H, Lawal O, Cherrill R, Mercer S, McCarthy Z. The experience of diagnostic radiography students during the early stages of the COVID-19 pandemic - a cross-sectional study. *J Med Radiat Sci* 2021;**68**(4):418–25. https://doi.org/10.1002/jmrs.544.
6. Ofori-Manteaw BB, Dzidzornu E, Akudjedu TN. Impact of the Covid-19 pandemic on clinical radiography education: perspective of students and educators from a low resource setting [published online ahead of print, 2021 Nov 19]. *J Med Imag Radiat Sci* 2021;**S1939-8654(21)00245-9**(21). https://doi.org/10.1016/j.jmir.2021.11.002.
7. Buléon C, Caton J, Park YS, Eller S, Buyck M, Kardong-Edgren S, et al. The state of distance healthcare simulation during the COVID-19 pandemic: results of an international survey. *Advances in Simulation* 2022;**7**(1).
8. McNulty J, England A, Shanahan M. International perspectives on radiography practice education. *Radiography (Lond).* 2021;**27**(4):1044–51. https://doi.org/10.1016/j.radi.2021.04.004.
9. Bridge P, Shiner N, Bolderston A, Gunn T, Hazell L, Johnson R, et al. International audit of simulation use in pre-registration medical radiation science training. *Radiography (Lond).* 2021;**27**(4):1172–8. https://doi.org/10.1016/j.radi.2021.06.011.
10. Ng P. Timely change and timeless constants: COVID-19 and educational change in Singapore. *Educ Res Pol Pract* 2021;**20**:19–27. https://doi.org/10.1007/s10671-020-09285-3.
11. Jahan N, Naveed S, Zeshan M, Tahir MA. How to conduct a systematic review: a narrative literature review. *Cureus* 2016;**8**(11):e864. https://doi.org/10.7759/cureus.864.
12. Ciena. *Why broadband is the new electricity for rural communities*. 2022. Date, https://www.ciena.com/insights/articles/2022/why-broadband-is-the-new-electricity-for-rural-communities.
13. Organisation for Economic Co-operation and Development. *The potential of online learning for adults: early lessons from the COVID-19 crisis*. 2020. Date, https://www.oecd.org/coronavirus/policy-responses/the-potential-of-online-learning-for-adults-early-lessons-from-the-covid-19-crisis-ee040002/.
14. Chandrasiri NR, Weerakoon BS. Online learning during the COVID-19 pandemic: perceptions of allied health sciences undergraduates [published

online ahead of print, 2021 Nov 30]. *Radiography (Lond)* 2021;**S1078-8174(21)00187-5**(21). https://doi.org/10.1016/j.radi.2021.11.008.
15. Alhasan M, Al-Horani Q. Students' perspective on the online delivery of radiography & medical imaging program during COVID-19 pandemic. *J Med Imag Radiat Sci* 2021;**52**(4S):S68–77. https://doi.org/10.1016/j.jmir.2021.07.009.
16. Alvin MD, George E, Deng F, Warhadpande S, Lee SI. The impact of COVID-19 on radiology trainees. *Radiology* 2020;**296**(2):246–8. https://doi.org/10.1148/radiol.2020201222.
17. Burns D, Dagnall N, Holt M. Assessing the impact of the COVID-19 pandemic on student wellbeing at universities in the United Kingdom: a conceptual analysis. *Front. Educ.* 2020;**5**:582882. https://doi.org/10.3389/feduc.2020.582882.
18. Baticulon RE, Sy JJ, Alberto NRI, Baron MBC, Mabulay REC, Rizada LGT, et al. Barriers to online learning in the time of COVID-19: a national survey of medical students in the Philippines. *Med Sci Educ* 2021;**31**(2):615–26. https://doi.org/10.1007/s40670-021-01231-z. Published 2021 Feb 24.
19. Astirbadi D, Lockwood P. COVID-19: a literature review of the impact on diagnostic radiography students [published online ahead of print, 2021 Sep 29] *Radiography (Lond)* 2021. https://doi.org/10.1016/j.radi.2021.09.009. S1078-8174(21)00136-X.
20. Jen E, Mathijssen S, Hoogeveen L. Supporting professional development for educators during the pandemic: lessons from an international blended learning diploma program. *Prospects* 2022;**51**(4):583–7.
21. Wu S-Y. How teachers conduct online teaching during the COVID-19 pandemic: a case study of taiwan. *Front. Educ.* 2021;**6**:675434. https://doi.org/10.3389/feduc.2021.675434.
22. Zalat MM, Hamed MS, Bolbol SA. The experiences, challenges, and acceptance of e-learning as a tool for teaching during the COVID-19 pandemic among University Medical Staff. *PLoS One* 2021;**16**(3).
23. Stoehr F, Müller L, Brady A, Trilla A, Mähringer-Kunz A, Hahn F, et al. How COVID-19 kick-started online learning in medical education-The DigiMed study. *PLoS One* 2021;**16**(9):e0257394. https://doi.org/10.1371/journal.-pone.0257394. Published 2021 Sep. 21.
24. The Society of Radiographers. *Virtual education: a reality for radiography?*. 2007. Available from. http://www.shaderware.com/distrib/etc/p20-21_SynNews_Aug07.pdf.
25. Tabatabai S. Simulations and virtual learning supporting clinical education during the COVID 19 pandemic. *Adv Med Educ Pract* 2020;**11**:513–6.
26. Torres A, Domańska-Glonek E, Dzikowski W, Korulczyk J, Torres K. Transition to online is possible: solution for simulation-based teaching during the Covid-19 pandemic. *Med Educ* 2020;**54**(9):858–9.
27. Stoehr F, Müller L, Brady A, Trilla A, Mähringer-Kunz A, Hahn F, et al. How covid-19 kick-started online learning in medical education—the DigiMed study. *PLoS One* 2021;**16**(9).
28. Zaragoza-García I, Ortuño-Soriano I, Posada-Moreno P, Sánchez-Gómez R, Raurell-Torredà M. Virtual simulation for last-year nursing graduate students in times of covid-19: a quasi-experimental study. *Clinical Simulation in Nursing* 2021;**60**:32–41.
29. Obrero-Gaitán E, Nieto-Escamez FA, Zagalaz-Anula N, Cortés-Pérez I. An innovative approach for online neuroanatomy and Neurorrehabilitation teaching based on 3D virtual anatomical models using leap motion controller during COVID-19 pandemic. *Front Psychol* 2021:12.
30. Tay YX, Chow HC, Ooi CC. Impact on clinical learning during coronavirus disease 2019 pandemic: from disruption to recovery and the new norms. *Korean J Med Educ* 2020;**32**(4):297–305. https://doi.org/10.3946/kjme.2020.176.
31. Teo LW, Pang T, Ong YJ, Lai C. Coping with COVID-19: perspectives of student radiographers. *J Med Imag Radiat Sci* 2020;**51**(3):358–60. https://doi.org/10.1016/j.jmir.2020.05.004.
32. Lateef F, Suppiah M, Chandra S, Yi TX, Darmawan W, Peckler B, et al. Simulation Centers and simulation-based education during the time of COVID 19: a multi-center best practice position paper by the World Academic Council of Emergency Medicine. *J Emergencies, Trauma, Shock* 2021;**14**(1):3.
33. Pears M, Yiasemidou M, Ismail MA, Veneziano D, Biyani CS. Role of immersive technologies in healthcare education during the COVID-19 epidemic. *Scot Med J* 2020;**65**(4):112–9.
34. Kluwer Wolters. *Mixed reality in medical education: virtual patient interactions in real-world settings*. 2021. Available from, https://www.wolterskluwer.com/en/expert-insights/mixed-reality-in-medical-education-virtual-patient-interactions-in-real-world-settings.
35. Raith A, Kamp C, Stoiber C, Jakl A, Wagner M. Augmented reality in radiology for Education and training—a design study. *Healthcare* 2022;**10**(4):672.
36. Sapkaroski D, Baird M, Mundy M, Dimmock MR. Quantification of student radiographic patient positioning using an immersive virtual reality simulation. *Simulat Healthc J Soc Med Simulat J Soc Simulat Healthcare* 2019;**14**(4):258–63.
37. Tang YM, Chau KY, Kwok AP, Zhu T, Ma X. A systematic review of immersive technology applications for medical practice and education - trends, application areas, recipients, teaching contents, evaluation methods, and performance. *Educ Res Rev* 2022;**35**:100429.
38. Microsoft. *Azure mixed reality - mixed reality for every developer and every business*. 2022. Available from, https://azure.microsoft.com/en-us/topic/mixed-reality/#demystifying.
39. Martin G, Koizia L, Kooner A, Cafferkey J, Ross C, Purkayastha S, et al. Use of the HoloLens2 mixed reality headset for protecting health care workers during the COVID-19 pandemic: prospective, observational evaluation. *J Med Internet Res* 2020;**22**(8):e21486. https://doi.org/10.2196/21486. Published 2020 Aug 14.
40. Schoeb DS, Schwarz J, Hein S, Schlager D, Pohlmann PF, Frankenschmidt A, et al. Mixed reality for teaching catheter placement to medical students: a randomized single-blinded, prospective trial. *BMC Med Educ* 2020;**20**:510. https://doi.org/10.1186/s12909-020-02450-5.
41. Uppot RN, Laguna B, McCarthy CJ, De Novi G, Phelps A, Siegel E, et al. Implementing virtual and augmented reality tools for radiology education and training, communication, and clinical care. *Radiology* 2019;**291**(3):570–80. https://doi.org/10.1148/radiol.2019182210.
42. Christopoulos A, Conrad M, Shukla M. Increasing student engagement through virtual interactions: How? *Virtual Real* 2018;**22**:353–69. https://doi.org/10.1007/s10055-017-0330-3.
43. *The Straits Times. Holograms to help NUS medical and nursing students get more practice from April*. 2022. Available from: https://www.straitstimes.com/singapore/health/holograms-to-help-nus-medical-and-nursing-students-get-more-practice-from-april.
44. Hayre CM, Kilgour A. Diagnostic radiography education amidst the COVID-19 pandemic: current and future use of virtual reality (VR). *J Med Imag Radiat Sci* 2021;**52**(4S):S20–3. https://doi.org/10.1016/j.jmir.2021.09.009.
45. Cosson P, Willis RN. *Comparison of student radiographers' performance in a real x-ray room after training with a screen based computer simulator*. 2012. Available from, http://www.shaderware.com/distrib/etc/WhitePaper-ComparisonOfStudentRadiographersPerformanceInaRealXrayRoomAfterTrainingWithAScreenBasedComputerSimulator.pdf.
46. Council of Deans of Health. *Implementation of a radiographic simulation solution to undergraduate training*. 2022. https://www.councilofdeans.org.uk/case-study/implementation-of-a-radiographic-simulation-solution-to-undergraduate-training/.
47. Sapkaroski D, Baird M, McInerney J, Dimmock MR. The implementation of a haptic feedback virtual reality simulation clinic with dynamic patient interaction and communication for medical imaging students. *J Med Radiat Sci* 2018;**65**(3):218–25. https://doi.org/10.1002/jmrs.288.
48. Shanahan M. Student perspective on using a virtual radiography simulation. *Radiography (Lond)* 2016:217–22. https://doi.org/10.1016/j.radi.2016.02.004.
49. Sapkaroski D, Mundy M, Dimmock MR. Virtual reality versus conventional clinical role-play for radiographic positioning training: a students' perception study. *Radiography (Lond)* 2020;**26**(1):57–62. https://doi.org/10.1016/j.radi.2019.08.001.
50. O'Connor M, Stowe J, Potocnik J, Giannotti N, Murphy S, Rainford L. 3D virtual reality simulation in radiography education: the students' experience. *Radiography (Lond)*. 2021;**27**(1):208–14. https://doi.org/10.1016/j.radi.2020.07.017.
51. Gunn T, Rowntree P, Starkey D, Nissen L. The use of virtual reality computed tomography simulation within a medical imaging and a radiation therapy undergraduate programme. *J Med Radiat Sci* 2021;**68**(1):28–36. https://doi.org/10.1002/jmrs.436.
52. Zhao G, Fan M, Yuan Y, Zhao F, Huang H. The comparison of teaching efficiency between virtual reality and traditional education in medical education: a systematic review and meta-analysis. *Ann Transl Med* 2021;**9**(3):252. https://doi.org/10.21037/atm-20-2785.
53. Chernikova O, Heitzmann N, Stadler M, Holzberger D, Seidel T, Fischer F. Simulation-based learning in higher education: a meta-analysis. *Rev Educ Res* 2020;**90**(4):499–541. https://doi.org/10.3102/0034654320933544.
54. Kato K, Kon D, Ito T, Ichikawa S, Ueda K, Kuroda Y. Radiography education with VR using head mounted display: proficiency evaluation by Rubric Method. *BMC Med Educ* 2022;**22**(1).
55. Javaid M, Haleem A, Singh RP, Khan S. Understanding roles of virtual reality in Radiology. *Internet of Things and Cyber-Physical Systems* 2022;**2**:91–8.
56. van Gaalen AEJ, Brouwer J, Schönrock-Adema J, Bouwkamp-Timmer T, Jaarsma ADC, Georgiadis JR. Gamification of health professions education: a systematic review. *Adv Health Sci Educ Theory Pract* 2021;**26**(2):683–711. https://doi.org/10.1007/s10459-020-10000-3.
57. Gentry SV, Gauthier A, L'Estrade Ehrstrom B, Wortley D, Lilienthal A, Tudor Car L, et al. Serious gaming and gamification education in health professions: systematic review. *J Med Internet Res* 2019;**21**(3):e12994. https://doi.org/10.2196/12994. Published 2019 Mar 28.
58. Arruzza E, Chau M. A scoping review of randomised controlled trials to assess the value of gamification in the higher education of health science students. *J Med Imag Radiat Sci* 2021;**52**(1):137–46. https://doi.org/10.1016/j.jmir.2020.10.003.
59. Sünncksen M, Bendig H, Teistler M, Wagner M, Bott OJ, Dresing K. Gamification and virtual reality for teaching mobile x-ray imaging. In: *2018 IEEE 6th international conference on serious games and applications for health (SeGAH)*; 2018. p. 1–7. https://doi.org/10.1109/SeGAH.2018.8401364.
60. Winkel DJ, Brantner P, Lutz J, Korkut S, Linxen S, Heye TJ. Gamification of electronic learning in radiology education to improve diagnostic confidence and reduce error rates. *AJR Am J Roentgenol* 2020;**214**(3):618–23. https://doi.org/10.2214/AJR.19.22087.
61. James JP, Sim J, McDonald M, Ryan T. Using second life for health professional learning: informing multidisciplinary understanding. *Int J Monetary Econ Finance* 2012;**1**(1):27–39.

62. Lorenzo-Alvarez R, Rudolphi-Solero T, Ruiz-Gomez MJ, Sendra-Portero F. Game-based learning in virtual worlds: a multiuser online game for medical undergraduate radiology education within second life. *Anat Sci Educ* 2020;**13**(5):602–17. https://doi.org/10.1002/ase.1927.
63. Rudolphi-Solero T, Jimenez-Zayas A, Lorenzo-Alvarez R, Domínguez-Pinos D, Ruiz-Gomez MJ, Sendra-Portero F. A team-based competition for undergraduate medical students to learn radiology within the virtual world Second Life. *Insights Imaging* 2021;**12**(1):89. https://doi.org/10.1186/s13244-021-01032-3. Published 2021 Jun 29.
64. Ma Y, Williams D, Prejean L, Richard C. A research agenda for developing and implementing educational computer games. *Br J Educ Technol* 2007;**38**(3):513–8.
65. Sánchez-Mena A, Martí-Parreño J. Drivers and barriers to adopting gamification: teachers' perspectives. *Electron J e Learn* 2017;**15**(5):pp434–43. available online at, www.ejel.org.
66. Plch L. Perception of technology-enhanced learning by medical students: an integrative review. *Med Sci Educ* 2020;**30**(4):1707–20. https://doi.org/10.1007/s40670-020-01040-w. Published 2020 Aug 10.
67. Divjak B, Rienties B, Iniesto F, Vondra P, Žižak M. Flipped classrooms in higher education during the COVID-19 pandemic: findings and future research recommendations. *International Journal of Educational Technology in Higher Education* 2022;**19**(1).
68. Groff J. *Technology-rich innovative learning environments*. 2013. Available from, https://www.oecd.org/education/ceri/technology-rich%20innovative%20learning%20environments%20by%20jennifer%20groff.pdf.
69. Nouri J. The flipped classroom: for active, effective and increased learning – especially for low achievers. *International Journal of Educational Technology in Higher Education* 2016;**13**(1).
70. Chen F, Lui AM, Martinelli SM. A systematic review of the effectiveness of flipped classrooms in medical education. *Med Educ* 2017;**51**(6):585–97.
71. Back DA, Behringer F, Haberstroh N, Ehlers JP, Sostmann K, Peters H. Learning management system and e-learning tools: an experience of medical students' usage and expectations. *Int J Med Educ* 2016;**7**:267–73.
72. Hogg P, Holmes K, McNulty J, Newman D, Keene D, Beardmore C. Covid-19: free resources to support radiographers. *Radiography (Lond).* 2020;**26**(3):189–91. https://doi.org/10.1016/j.radi.2020.05.002.
73. Konstantinidis K, Apostolakis I, Karaiskos P. A narrative review of e-learning in professional education of healthcare professionals in medical imaging and radiation therapy [published online ahead of print, 2021 Dec 19] *Radiography (Lond)* 2021. https://doi.org/10.1016/j.radi.2021.12.002. S1078-8174(21)00193-0.
74. Naciri A, Radid M, Kharbach A, Chemsi G. E-learning in Health Professions Education during the COVID-19 pandemic: a systematic review. *Journal of Educational Evaluation for Health Professions* 2021;**18**:27.
75. Xiberta P, Boada I, Thió-Henestrosa S, Pedraza S, Pineda V. Asynchronous online learning as a key tool to adapt to new educational needs in radiology during the COVID-19 pandemic. *Med Educ Online* 2022;**27**(1).
76. SingHealth Duke-NUS Academic Medical Centre. *LITreviews learning in 10 - radiology*. 2022. Available from, http://www.learningin10.com/#/radiology/.
77. Vavasseur A, Muscari F, Meyrignac O, Nodot M, Dedouit F, Revel-Mouroz P, et al. Blended learning of radiology improves medical students' performance, satisfaction, and engagement. *Insights Imaging* 2020;**11**(1):61. https://doi.org/10.1186/s13244-020-00865-8. Published 2020 Apr 28.
78. Hoa D, Micheau A, Gahide G. Creating an interactive Web-based e-learning course: a practical introduction for radiologists. *Radiographics* 2006;**26**(6):e25. https://doi.org/10.1148/rg.e25.
79. Grunewald M, Heckemann RA, Gebhard H, Lell M, Bautz WA. COMPARE radiology: creating an interactive Web-based training program for radiology with multimedia authoring software. *Acad Radiol* 2003;**10**(5):543–53. https://doi.org/10.1016/s1076-6332(03)80065-x.
80. Webb AL, Choi S. Interactive radiological anatomy eLearning solution for first year medical students: development, integration, and impact on learning. *Anat Sci Educ* 2014;**7**(5):350–60. https://doi.org/10.1002/ase.1428.
81. André Viljoen Charle, Scott Millar Rob, Hoevelmann Julian, Muller Elani, Hähnle Lina, Manning Kathryn, et al. Utility of mobile learning in Electrocardiography. *European Heart Journal - Digital Health* 2021;**2**(Issue 2):202–14. https://doi.org/10.1093/ehjdh/ztab027. June.
82. Applegate JS. The role of mobile electronic devices in radiographer education. *Radiol Technol* 2010;**82**(2):124–31.
83. Dunleavy G, Nikolaou CK, Nifakos S, Atun R, Law GCY, Tudor Car L. Mobile digital education for health professions: systematic review and meta-analysis by the digital health education collaboration. *J Med Internet Res* 2019;**21**(2):e12937. https://doi.org/10.2196/12937. Published 2019 Feb 12.
84. Makary MS, Shah SH, Miller RJ, Doukides SP, King MA. Implementation of an innovative tablet-based curriculum for radiology resident education. *Acad Radiol* 2018;**25**(12):1653–8. https://doi.org/10.1016/j.acra.2018.05.018.
85. Alsharif W, Davis M, Rainford L, Cradock A, McGee A. Validation of the educational effectiveness of a mobile learning app to improve knowledge about MR image quality optimisation and artefact reduction. *Insights Imaging* 2018;**9**(5):721–30. https://doi.org/10.1007/s13244-018-0635-0.
86. Seah KM. COVID-19: exposing digital poverty in a pandemic. *Int J Surg* 2020;**79**:127–8. Jul.
87. Egarter S, Mutschler A, Tekian A, Norcini J, Brass K. Medical assessment in the age of digitalisation. *BMC Med Educ* 2020;(1):20. Mar 31.
88. Kiegaldie D, Shaw L. MammographyOnline: an evaluation of an online mammography education program for radiographers. *J Med Imag Radiat Sci* 2020;**51**(4):579–89. https://doi.org/10.1016/j.jmir.2020.07.055.
89. Almeida RPP de, Silva CA da, Vicente BI da C, Abrantes AFCL, Azevedo KB. The paradigm shift in medical imaging education and training in europe. *International Journal of Information and Education Technology* 2022;**12**(4):326–32.
90. Thepwongsa I, Sripa P, Muthukumar R, Jenwitheesuk K, Virasiri S, Nonjui P. The effects of a newly established online learning management system: the Perspectives of Thai medical students in a public medical school. *Heliyon* 2021;**7**(10).
91. Mohammadi MK, Mohibbi AA, Hedayati MH. Investigating the challenges and factors influencing the use of the learning management system during the COVID-19 pandemic in Afghanistan. *Educ Inf Technol* 2021;**26**(5):5165–98.
92. Jones EP, Wisniewski CS. Video killed the multiple-choice quiz: capturing pharmacy students' literature searching skills using a screencast video assignment. *J Med Libr Assoc* 2021;**109**(4):672–6. https://doi.org/10.5195/jmla.2021.1270.
93. Inan-Karagul B, Seker M. Improving Language learners' use of self-regulated writing strategies through screencast feedback. *Sage Open* 2021. https://doi.org/10.1177/21582440211064895. October.
94. Killingback C, Ahmed O, Williams J. 'It was all in your voice' - tertiary student perceptions of alternative feedback modes (audio, video, podcast, and screencast): a qualitative literature review. *Nurse Educ Today* 2019;**72**:32–9. https://doi.org/10.1016/j.nedt.2018.10.012.
95. Craig C, Kasana N, Modi A. Virtual OSCE delivery: the way of the future? *Med Educ* 2020;**54**(12):1185–6. https://doi.org/10.1111/medu.14286.
96. Marshall G. A study of the role of an objective structured clinical examination (OSCE) in assessing clinical competence in third year student radiographers. *Radiography (Lond)* 2000;**6**(2):117–22. https://doi.org/10.1053/radi.1999.0229.
97. Blythe J, Patel NSA, Spiring W, Easton G, Evans D, Meskevicius-Sadler E, et al. Undertaking a high stakes virtual OSCE ("VOSCE") during Covid-19. *BMC Med Educ* 2021;**21**:221. https://doi.org/10.1186/s12909-021-02660-5.
98. Silverman JA, Foulds JL. Development and use of a virtual objective structured clinical examination. *Can Med Educ J* 2020;**11**(6):e206–7. https://doi.org/10.36834/cmej.70398. Published 2020 Dec 7.
99. Abraham JR, Foulds JL, Lee JA, Sonnenberg LK. vOSCEs 2.0: operationalising a universal low-cost virtual OSCE. *Med Educ* 2021;**55**(5):641. https://doi.org/10.1111/medu.14492.
100. Nusanti S, Dearaini, Bani AP, Kartasasmita AS, Ichsan AM, Virgana R, et al. Delivering a modified continuous objective structured clinical examination for ophthalmology residents through a hybrid online method. *Korean J Med Educ* 2021;**33**(4):419–30. https://doi.org/10.3946/kjme.2021.210.
101. Felthun JZ, Taylor S, Shulruf B, Allen DW. Empirical analysis comparing the tele-objective structured clinical examination (teleOSCE) and the in-person assessment in Australia. *J Educ Eval Health Prof* 2021;**18**:23. https://doi.org/10.3352/jeehp.2021.18.23.
102. Luke S, Petitt E, Tombrella J, McGoff E. Virtual evaluation of clinical competence in nurse practitioner students [published online ahead of print, 2021 may 24]. *Med Sci Educ* 2021;**31**(4):1–5. https://doi.org/10.1007/s40670-021-01312-z.
103. Farrell SE, Junkin AR, Hayden EM. Assessing clinical skills via telehealth objective standardized clinical examination: feasibility, acceptability, comparability, and educational value [published online ahead of print, 2021 May 17] *Telemed J e Health* 2021. https://doi.org/10.1089/tmj.2021.0094. 10.1089/tmj.2021.0094.
104. Hopwood J, Myers G, Sturrock A. Twelve tips for conducting a virtual OSCE. *Med Teach* 2021;**43**(6):633–6. https://doi.org/10.1080/0142159X.2020.1830961.
105. Blackburn NE, Marley J, Kerr DP, Martin S, Tully MA, Cathcart JM. Transitioning into the workforce during the COVID-19 pandemic: understanding the experiences of student diagnostic radiographers. *Radiography (Lond)* 2022;**28**(1):142–7. https://doi.org/10.1016/j.radi.2021.09.005.
106. Rawle M, Oliver T, Pighills A, Lindsay D. Improving education and supervision of Queensland X-ray Operators through video conference technology: a teleradiography pilot project. *J Med Radiat Sci* 2017;**64**(4):244–50. https://doi.org/10.1002/jmrs.229.
107. Cameron M, Ray R, Sabesan S. Remote supervision of medical training via videoconference in northern Australia: a qualitative study of the perspectives of supervisors and trainees. *BMJ Open* 2015;**5**(3):e006444. https://doi.org/10.1136/bmjopen-2014-006444. Published 2015 Mar 20.
108. Singh A. The role of technology in assessment, documentation, and tracking of clinical competencies in radiography education. *J Med Imag Radiat Sci* 2021;**52**(4S):S11–5. https://doi.org/10.1016/j.jmir.2021.05.015.
109. Alismail A, Tabisula BM, López D. Designing a clinical education tracking system: an innovative approach. *Adv Med Educ Pract* 2021;**12**:539–46. https://doi.org/10.2147/AMEP.S312734. Published 2021 May 26.
110. Baker AL, Dubose TJ. Electronic systems for student clinical records. *J Diagn Med Sonogr* 2009;**25**(5):277–81.
111. Branstetter ML, Smith LS, Brooks AF. Evidence-based use of electronic clinical tracking systems in advanced practice registered nurse education: an integrative review. *Comput Inform Nurs* 2014;**32**(7):312–21. https://doi.org/10.1097/CIN.0000000000000069.
112. McInerney J, Druva R. Clinical educators' attitudes towards the use of technology in the clinical teaching environment. A mixed methods study. *Journal of Medical Radiation Sciences* 2019;**66**(2):72–80. Apr 21.