



**Trinity College Dublin**  
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Academic Practice, Trinity Teaching & Learning

# Digital education in the disciplines:

*A snapshot of digital teaching, learning & assessment practices in the Health Sciences*

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## Purpose of this report

This report has been written as part of Trinity College's Digital by Design project, funded by the Irish National Forum for the Enhancement of Teaching and Learning. The Digital by Design project aims to build capacity for digital education across the disciplines within Trinity College, building on what we have learned from our pandemic experiences of digital learning.

The purpose of this report is to provide a snapshot overview of digital teaching, learning and assessment practices within the Health Sciences disciplines, including those within Trinity and across the broader national and international higher education sector. By profiling and disseminating these practices, this report aims to support and inspire academics and those with teaching responsibilities at third level to enhance digital teaching and learning practices within their disciplines.

## Definition of Terms

For the purpose of this report, we have taken commonly used terms to have a particular meaning as follows:

**Blended learning** refers to learning that integrates complementary face-to-face learning experiences with online learning experiences.

**Digital assessment** is an assessment approach or process which is enabled by digital technologies. This includes:

- assessments which are fully enabled by digital technologies and often defined by their use of technology—such as blogs, wikis, online discussion fora, virtual simulations, multimedia artefacts.
- more traditional assessment types, elements of which are now often enabled using digital technologies—such as essays, annotated bibliographies, presentations.
- assessments which have moved into a digital context due to Covid-19, but may also be undertaken in traditional face-to-face formats—such as performances or debates (Academic Practice, 2021).

**Digital learning** refers to the use of digital technologies to enable and/or facilitate learning and teaching experiences, activities and processes. Digital learning encompasses a wide variety of learning models and approaches including blended, hybrid, hyflex or online learning.

**Hybrid learning** refers to modules or programmes that can be taken simultaneously by online and on-campus students working together as a single cohort. Also called "hybrid-flexible" or "hyflex" learning.



**Hyflex learning** combines the terms ‘hybrid’ and ‘flexible’. Often used interchangeably with the term ‘hybrid learning’, students have a choice in how they participate in the module—in the classroom or online or both.

**Online learning** is any form of learning which is facilitated wholly via the internet, encompassing both asynchronous and/or synchronous activities.

**Pedagogy**, defined broadly, refers to the practice of teaching and its associated discourse of educational theories, values and evidence (Alexander, 2009).

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## Foreword

The enforced closure of university campuses in response to the Covid-19 pandemic have placed digital learning at the heart of higher education. For many it has led to the re-invention of teaching, learning and assessment practices across the disciplines, taking advantage of the affordances of digital technologies. In a short period of time, educators across the sector have developed core pedagogic competences in digital teaching and learning, competences which have long been deemed essential for a digital age (National Forum, 2015).

However, while the pandemic led to significant pedagogical innovation in some programmes, it has also presented many challenges. For many educators, time pressures and limited experience of digital pedagogies resulted in a “quick-fix” whereby long-standing pedagogies (often dominated by the traditional lecture delivery) were rapidly moved online (Academic Practice, 2022). In addition, the necessity to deliver programmes remotely presented challenges for educators and students, with particular difficulties emerging for pedagogies supportive of experiential, laboratory, and work-based learning.

Recognising these ongoing challenges and the clear need to build digital pedagogic capacity at personal, disciplinary and organisational level, the Digital by Design project was crafted with the intention of:

- equipping educators with core pedagogic competences for digital learning, teaching and assessment;
- enabling the development of differentiated digital learning strategies which address discipline-specific competences;
- building and supporting disciplinary Communities of Practice focussed on digital education within cognate fields.

Authored by Kathleen Hannon—Research Assistant within the Digital by Design project team— this report was written as part of the initial research phase of the project and is one of three research reports, each of which focuses on disciplinary pedagogies within the three Faculties at Trinity College: Arts, Humanities & Social Sciences (AHSS), STEM and Health Sciences. With a focus on Health Science disciplines, this report provides a snapshot overview of digital education practices, particularly in the context of the emergency “pivot” to online delivery during the pandemic.

I would like to thank our Research Assistant, Kathleen, for her commitment and professionalism while researching and writing this report. We are more convinced than ever that if we are to build on what we have learned during the pandemic, guidance and support on the effective design and development of blended and digital learning is essential. Providing an insight into the practices and experiences of other Health Science educators during the pandemic, we hope that you find this report useful in informing your own pedagogic practices as we move beyond emergency delivery towards a post-pandemic “normal”.

**Dr. Pauline Rooney**, Digital by Design Project Lead



## Introduction

The COVID-19 pandemic necessitated higher education institutions to transition to remote programme delivery (Crawford, Butler-Henderson et al., 2020), with Trinity College making the move to remote teaching in March 2020 (Trinity College Dublin, 2020). As time progressed, many institutions implemented a blended learning model, offering both online and in-person instruction (Brown and McCall, 2021). The implementation of what has been referred to as Emergency Remote Teaching (ERT) has highlighted the varied levels of preparedness for online learning and the different approaches taken by institutions to an ongoing crisis (Hodges, Moore et al., 2020). The need for a swift transition did not allow for the usual time spent planning or developing modules (Porter, Barbagallo et al., 2020), which has been a cause of concern for educators (Hill, Murphy et al., 2020). Prior to COVID-19, early reviews of the introduction of digital education into higher education have stressed that digital learning is not simply a replacement of traditional means of education and requires its own specific curriculum development and instructional design (Chumley-Jones, Dobbie et al., 2002, Ruiz, Mintzer et al., 2006). As institutions continue to incorporate online learning into formal curricula, it is important to reflect on what digital teaching, learning and assessment (TLA) practices have already been enacted.

This report provides a snapshot review of digital teaching, learning and assessment in Health Science disciplines, particularly in the context of the emergency “pivot” to online delivery during the pandemic.

This report aims to:

- identify current and emerging practices in digital teaching, learning and assessment within Health Sciences disciplines at Trinity, nationally and internationally, inclusive of in-person, blended, hybrid/hyflex and online approaches;
- gain an insight into the effectiveness of digital TLA approaches, and their limitations and challenges;
- explore student and staff perspectives on, and experiences of, digital teaching, learning and assessment, particularly in the context of the pandemic period;
- reflect on implications for teaching, learning and assessment over the longer term, and, in particular, how institutions might support staff to develop and innovate in digital education provision.

## Methodology

A desktop research methodology was adopted for the purposes of this report, with a focus on research-intensive national and international universities and institutions. Due to the emerging and evolving nature of many of digital TLA practices, university sources constituted the primary focus of investigation, including institutional repositories, websites and institution-affiliated news sources (for example, blogs and online newspapers). For consistency during the research process, information was collected for those disciplines within the Health Science Faculty at Trinity College



Dublin which includes Medicine, Nursing and Midwifery, Dental Science, and Pharmacy and Pharmaceutical Science.

A search string was composed using key terms relating to digital TLA within Health Science disciplines. The inclusion criteria were limited to articles and/or digital projects conducted after 2015 that were available in English. Sources were included if they related to digital TLA practices implemented in higher education Health Science disciplines, inclusive of in-person, blended, hybrid/hyflex and online approaches. Journal databases such as PubMed and Elsevier were also consulted. All examples of digital TLA practices were compiled within a Microsoft Excel spreadsheet and sorted according to the pedagogical strategy underpinning the activity (for example, problem-based learning, team-based learning, etc.). The sections that follow provide an overview of our key findings.

## Teaching & learning practices/signature pedagogies in Health Sciences

When exploring digital TLA practices within any discipline, it is useful to consider underpinning teaching and learning practices or signature pedagogies. The term ‘signature pedagogy’, coined by Shulman (2005), refers to the forms or styles of teaching that are common to specific disciplines, areas of study, or professions. Signature pedagogies are defined as “the types of teaching that organise the fundamental ways in which future practitioners are educated for their new professions” (Schulman, 2005, p. 52).

There are a number of pedagogical approaches commonly used in the Health Science disciplines. While didactic lectures (DL) are commonly used (Challa, Sayed et al., 2021), learner-centred methodologies utilised in Health Sciences include problem-based learning, case-based learning, simulation-based learning, and team-based learning (Challa, Sayed et al., 2021).

### Problem-based learning

Problem-based learning (PBL) is a student-centred pedagogical approach that facilitates opportunities for students to learn through problem-solving activities, without receiving prior formal lectures relating to the subject material (Challa, Sayed et al., 2021). PBL was first introduced into medical education during the 1960s (Ju and Cho, 2017) and has since been adopted as a core pedagogical approach by many medical schools across the globe (Khoo, 2003, Neville, 2009). PBL is found within multiple different disciplines, including nursing, dentistry, and pharmaceutical sciences (Bassir, Sadr-Eshkevari et al., 2014, Galvao, Silva et al., 2014, Santos, Otani et al., 2019).

### Case-based learning

Case-based learning (CBL) is a teaching strategy aimed at promoting active learning, where students are given a case study to assess and manage. In the Health Sciences, CBL often materialises as patient case studies that incorporates clinically realistic data, such as a detailed patient history and accompanying laboratory data (Singhal, 2017). CBL and PBL are often compared, as the definitions



are used interchangeably in the literature. PBL 'involves open rather than guided inquiry, is less structured, and the educator plays a more passive role' (Yale Poorvu Centre for Learning & Teaching, 2021). PBL is focused more strongly on self-directed learning, with the problem often having multiple solutions that a learner can work towards, whereas case-based learning has a stronger emphasis on connecting theory to practice.

### Simulation-based learning

Simulation-based learning (SBL) provides experiential learning by utilising simulation aids to replicate real clinical situations and scenarios. SBL is often used in preclinical teaching as a solution to barriers restricting students' access to clinical settings (Challa, Sayed et al., 2021). SBL provides students the opportunity to make and learn from mistakes without risk to a real patient (Mulugeta, Drach et al., 2018) and to guide their own learning experience through interactivity (Stapleton, 2004).

### Team-based learning

Team-based learning (TBL) is a learning strategy where a small group of students work on individual and team-based activities. TBL increases communication skills, which are required in patient care (O'Daniel and Rosenstein, 2008). TBL was first piloted in medical education in 2000 and has grown rapidly since (Searle, Haidet et al., 2003).

## Moving signature pedagogies online in Health Sciences: exemplars

While digital learning has become increasingly common in Health Science education (Regmi and Jones, 2020), the role of digital learning varies across Health Sciences disciplines and across national and international institutions.

During the pandemic transition to online learning, educators across all Health Sciences disciplines availed of both synchronous and asynchronous learning formats. Synchronous learning was conducted using videoconferencing and webinar platforms, while asynchronous formats primarily involved pre-recorded lessons made available through institutional virtual learning environments such as Moodle or Blackboard (Academic Practice, 2022). From March to April 2020, Quinn et al. (2020) gathered information on the impact of COVID-19 on non-clinical and clinical education in both members and non-members of the European Academic Dental Institutions. Sixty nine of the 153 institutions responded, with 90% reporting using online learning tools such as live or streamed videos (72%), links to online resources (48%) and virtual meetings (65%). Only 19% of respondents planned to hold in-person examinations.

For some institutions, clinical placements were substituted with daily lectures, small group sessions, virtual reading rooms, curated case discussions, with weekly review meetings (Buckley, 2020). Many educators intentionally avoided providing only online lectures, by using a variety of digital tools for students to conduct peer-led and self-directed learning, such as breakout rooms (Buckley, 2020). A number of institutions implemented a flipped classroom model, which allows students to





watch online content at their own pace and frees classroom time for discussion and interactive learning. One such institution created whiteboard style videos with integrated quizzes, using Camtasia, Blackboard and Re/Play (University of Bristol, 2019). The educator noted that students were able to watch lessons in advance of laboratory work, with the objective of introducing students to concepts while saving time. A meta-analysis of 28 studies found a positive outcome of the use of flipped classrooms within the health professions education compared to traditional classrooms, and recommended the use of quizzes at the beginning of each in-person session (Hew and Lo 2018).

In relation to assessments, many institutions implemented a pass/fail system, replacing traditional grading systems (Morin, 2020). Examinations still went ahead, often by using online open-book examinations (Birch and De Wolf, 2020, Tapper et al., 2020). For example, at Imperial College London, online open-book examinations replaced a practical assessment of clinical examination skills for medical students (Damania, Sharma et al., 2021). Other assessment practices included take-home exams, peer review and evaluation via VLEs, assessed online discussions, online submissions, synchronous/asynchronous presentations, and quizzes (Brown, 2021). A survey conducted at the University of Queensland found a common approach to delivering online assessments across the institution's various departments, was to simply use an alternative delivery mode (Slade, Lawrie et al., 2021). For example, Dentistry assessments were adapted from invigilated, on-campus examinations to online time-restricted tests via the University's VLE (Slade, Lawrie et al., 2021). Maintaining academic integrity in online assessment was a repeated concern of teaching staff, who employed a range of preventative methods, such as plagiarism detection software, online invigilation, and strict time limits on assessments (Ng, 2021). As implementing online assessment proctoring comes with its own unique challenges, Currie et al. (2020) suggested that replacing traditional invigilated examinations with authentic assessments would be a better solution.

Often, universities with a track record of investing in digital learning and delivering blended modules and programmes reported quick delivery of online learning during the first lockdown in 2020 by implementing digital tools already in use within the institutions (Eastman Dental Institute, 2020). For example, Imperial College London had previously introduced the use of augmented reality (AR) headsets into medical teaching and student examinations (MacKay, 2019). The AR headsets were used during the pandemic to deliver virtual ward rounds, which will be discussed further in the "Simulation-based learning" section of this report.

Some institutions have incorporated experimental digital TLA practices to reach their intended learning outcomes. The following section highlights exemplars of innovative digital TLA approaches within the Health Sciences. Several of these digital approaches were implemented during the emergency move to online learning, however some are pre-COVID teaching methods.



## Problem-based learning

Educators adapted problem-based learning practices from in-person to online platforms.

At the University of New South Wales (UNSW) Sydney, educators used online knowledge maps to facilitate PBL for medical students (Ho, Harris et al., 2018). Knowledge maps are visual aids that are used frequently in brainstorming activities. Students were given a clinical case to assess and manage. The answers they provided in their knowledge maps were assessed against the educator's own map and through the use of weighted scores. The scores generated from the mapping tool were compared to the traditional Modified Essay Question (MEQ), which demonstrated students showed better understanding of the studied topic when using the maps. An evaluation survey was circulated to students, where most students reported that the mapping tool improved their learning and motivation. Other strengths reported included the tool's ease of use and the ability to link concepts to each other. However, educators were hesitant about incorporating the exercise into the education programme for senior students, who had already established knowledge on those topics addressed by the mapping tool.

In 2016, the University of Hong Kong collaborated with Chengdu University of Traditional Chinese Medicine (CDUTCM) to provide an online problem-based learning (PBL) environment via Moodle and Panopto (Yum, Zou et al., 2016). A case scenario was presented in a face-to-face session with students in a Chinese Medicine course. Working in groups of six to seven, students were expected to define and analyse the problem presented in group discussions. Students would conduct further research individually, consulting journal databases and other online resources. Students would present their findings as a group in an online meeting. Online discussions were started asynchronously, with students questioning each other's work or responding to questions through Moodle. Students at both institutions responded positively, commenting on the usefulness of the tool and the constructivist approach of PBL. Students demonstrated exploratory learning behaviour through use of the PBL environment (Yum, Zou et al., 2016).

Within the Health Care Management and Policy programme at KU Leuven, the defence of a master's thesis no longer takes place via traditional jury presentations and has been replaced by a poster fair (KU Leuven Learning Lab, 2020). Due to COVID-19 public-health measures, the poster fair was moved online. Students submitted their posters via Toledo and presented through Blackboard Collaborate. After an introductory welcome, the audience were split into several moderated break-out rooms, where eight posters were presented in each room. A final Q&A round brought the session to a close. While the posters were assessed by supervisors, they were examined by professionals and researchers attending the poster fair, and by fellow students who also partook in peer evaluation (20% of the final score). One issue identified was the reduced ability to network and interact in comparison to an in-person event.

## Case-based learning

Educators within the Health Sciences have reported higher levels of student engagement with a case-based curriculum due to the transition to online learning. Digital case-based learning offered students the opportunity to gain experience in managing patient cases when COVID-19 public health measures restricted access to clinical settings. For instance, tutors used a series of Zoom-



based simulations for Dentistry students where tutors would act as the patient, based on the tutor's own professional experience with patients (Technology Enhanced Learning and Design, University of Manchester 2021). Case studies were built from previous patients' referral letters to the dental clinic and supplemented with a detailed medical history and relevant photos. Zoom lectures were perceived by students and staff as not allowing for the same level of involvement as in-person clinical sessions, however it was reported that weaving in difficult or 'fun' factors (for example, imitating typical patients' reactions to diagnoses and interactions with their healthcare provider), increased student engagement with the simulated patient sessions.

Telehealth is a term used for the delivery of healthcare through technology and telecommunications systems (NEJM Catalyst, 2018). Telehealth services offer remote patient consultations, which have been helpful in providing continuity of patient care and reducing anxieties relating to delayed medical care (Elangovan, Mahrous et al., 2020, Villa, Sankar et al., 2021). Additionally, telehealth services can also provide students with access to clinical education in a remote setting. At the University of Chicago, third and fourth year medical students staffed a triage telehealth service for COVID-19 patients (Server et al., 2020). With the support of an on-call attendant, students aided patients and their families until their health improved. By facilitating the involvement of students as frontline healthcare workers during the pandemic, this allowed students to expand on their studies and to build their professional experience.

### Simulation-based learning

Virtual Reality (VR) or Augmented Reality (AR) tools have increasingly played a significant role in SBL (Lee Chin et al., 2014). For example, educators at Imperial College London employed the use of headsets to create 'virtual ward rounds' for medical students (Gallagher and Alford, 2020, Bala et al., 2021). A physician wore a HoloLens headset while conducting a ward round, as students watched remotely. Virtual images of clinical material (for example, blood results and x-rays) were presented alongside the streamed video. The technology allowed students to view a doctor-patient interaction in real time. The virtual ward rounds could be recorded, which allowed the institute to build a digital library of clinical scenarios for students, within the university and beyond.

At Yale University, medical students were provided with a livestream operating room (LOR) (Ottinger et al., 2021). Students logged into Zoom sessions and watched a live streamed operation where they were able to listen to the surgeon and their team and learn from their actions. A television was used in the operating room enabling the surgeon to communicate with the class. The students reported that this provided them with access to a real surgical experience that wouldn't be possible through other means, such as pre-recorded videos. However, it was noted that the availability of a LOR is dependent on an institution's technical resources and the consent of involved patients.

Some educators sampled mixed reality tools in their teaching practices. Mixed reality is the merging of virtual reality and real-life environments. The use of mixed reality tools allows student to enact doctor-patient social interactions. The University's Singapore Centre for 3D Printing and LKC Medicine collaborated to create 3D-printed specimens mimicking the anatomical structure of humans. The Medicine School is exploring additional pedagogical approaches for providing



innovative digital education, such as a medical tutor powered by AI and a mobile App where more virtual 3D animations can be accessed by students. Some institutions used online learning platforms specifically developed to provide virtual access to activities carried out in a laboratory setting (Harrison, 2020, Kong et al., 2020, Universite Paris-Saclay, 2020, Teaching & Learning, University College London, 2021). These platforms allowed students to work either remotely or within labs to analyse data. In other institutions, telehealth visits were developed so students could remotely conduct patient visits virtually, with some educators joining the sessions virtually for the purposes of student assessment (Buckley, 2020, Server et al., 2020). Some institutions have stated their willingness to implement virtual clinical experiences for students in the future (Server et al., 2020).

## Team-based learning

Certain digital tools were optimal for facilitating team-based learning, such as Zoom's breakout-room function for group discussions and debriefs. Digital tools allowed for 'virtual students exchanges' when COVID-19 public health restrictions prevented travel (Cowls et al., 2019). Some educators found ways to replace individual projects with team-based activities. For example, in one institution, Dentistry students were typically expected to complete an individual library project. However, tutors were concerned that students had completed a similar project and previously had not received adequate feedback and support. Instead, students were asked to undertake a collaborative project, working in small groups on a specific topic. Students were expected to contribute to a wiki as they progressed with their research, allowing tutors to track students' progress. Two issues emerged: students faced difficulties familiarising themselves with the software and tutors found that certain individuals within groups were doing most of the work. To resolve these issues, the wikis were redesigned to include a clear pre-set structure and students now receive individual grades for contributing to the wiki. In addition, groups are now required to give an oral presentation, with all members receiving the same mark for this presentation (Digital Education Office, University of Bristol, 2021).

Nursing and midwifery students at Monash University took part in Obstetric and Neonatal Simulation (ONE-Sim) synchronous workshops. Students were asked to identify aspects of care that could be improved in three streamed simulations depicting realistic clinical emergencies. Following streaming of the emergency scenarios, students would debrief in Zoom breakout groups of six. Educators noted that as the session progressed, students began to become more vocal and engaged as they interacted with each other more. While the live sessions replicated a 'real-life' emergency, educators found it to be time and resource intensive. For future workshops, the educators intend to use a pre-recorded video to ensure an optimal viewing experience for students (Prasad et al., 2020).

During 2020, some institutions presented opportunities for students to create their own digital resources, either individually or as a group. Several of these projects have since been incorporated into formal curriculum. One such instance is SOLViT (Student-led Online Virtual Team-based learning), an 11-week programme of group 'pub-quiz style' medical teaching sessions developed by a team of graduated University College London Medical School students for final year students (Casalotti, 2020). Following a pilot of SOLViT, academic staff worked to integrate it into the existing curriculum, which was evaluated on a weekly basis (Casalotti et al., 2020). SOLViT incorporated



team-based learning with clinical case studies and gamification, formatting traditional questions into quizzes. Seventy nine students responded to a survey evaluating SOLViT, of which 64% stated they preferred the peer-sessions, in comparison to a clinician-led lecture and 93% found that gamification made the sessions more enjoyable. The project highlighted the ability of students to generate peer learning with minimal staff intervention (Casalotti et al., 2020).

Other student-led projects have led to the creation of resources aimed at future students. For instance, students from University College Dublin and the Royal College of Surgeons in Ireland collaborated with clinicians based in the National Maternity Hospital to design and develop a free Multiple Choice Question (MCQ) bank for future students, providing specialist knowledge and assessment preparation (Le Blanc et al., 2021).

## Opportunities & challenges of digital/remote delivery in Health Sciences

A recent systematic review identified the key challenges of digital learning in Health Sciences education, including low motivation and expectations of learners; the resource-intensive nature of developing, delivering and engaging with digital learning; the limitations of digital approaches for experiential or practice-based learning; and a lack of IT skills across both users and educators (Regmi and Jones, 2020). Poor learner motivation was linked to both internal factors (for example, poor engagement between learners and facilitators, or high levels of stress and anxiety) and external factors (including poor pedagogical design and/or inadequate institutional support) (Regmi and Jones, 2020). Some learners faced personal challenges transitioning to online learning, such as restricted access to childcare and increased care responsibilities (Renfrew et al., 2021), unstable internet connectivity or a lack of a quiet place to study (Bliss, 2020).

It can be challenging for educators to integrate digital approaches into their teaching, which was reflected in the literature (Mackay et al., 2017, Müller et al., 2021). The reliance on online assessments during the COVID-19 pandemic generated concerns regarding academic integrity and the potential for cheating during examinations. The urgency to move modules to online forms of delivery posed time-constraints on educators (Porter et al., 2020). Within Health Sciences, the emergency move to online and remote teaching created barriers in facilitating essential curricula components, such as clinical placements and laboratory work (Buckley, 2020, Hodges et al., 2020). Several institutions' partner hospitals and clinics were unable to provide clinical placements to students. A lack of clinical experience can impact on the skills required for undertaking clinical internships (Ross et al., 2020). Many dental colleges reported that essential requirements for graduation were not met as a result of campus closures, causing delays in graduation for some students, and leading to others completing their courses without full clinical training (Alkadi, 2021). Health Sciences disciplines faced the additional challenge of academic staff working as frontline healthcare workers, causing staffing shortages.

Some aspects of Health Sciences curricula, such as learning amongst peers, role modelling and traditional mentoring, can be challenging to replicate or replace in an online environment (Torda, 2020). Additionally, there are significant differences in educational requirements across the Health



Sciences. For example, dental education traditionally involves a considerable proportion of in-class/on-campus teaching and learning: this can be difficult to replace with digital education interventions (Quinn et al., 2020) although it is acknowledged that various strategies have previously been successfully implemented in other Health Science disciplines, such as Medicine (Goh and Sandars, 2020).

Online teaching poses a range of benefits and opportunities for both educators and students. Some educators reported the transition to online learning as improving class attendance and dynamics, and student access and equity (Morin, 2020). Both students and educators found that the flexibility of online teaching allowed students to learn independently, and prompted the interest of educators in engaging with innovative digital teaching methods (Müller et al., 2021). A review of eleven institutions who had used virtual medical education for vascular surgery rotations found that as a result of the availability of virtual electives, students were able to engage with a larger variety of programmes, better preparing them for the professional field (Ottinger et al., 2021). Virtual education offered students increased access to Faculty, as students were able to meet all Faculty members through virtual skills sessions, which wouldn't occur in an in-person elective. Institutions collaborated and shared their resources to provide education to students who did not have access to integrated residencies within their own institutions. The virtual rotations benefited the involved programmes, with increase collaboration and networking, leading to cohesion of content and goals across the programmes (Ottinger et al., 2021).

During 2020, several educators rapidly upskilled in using online platforms and digital tools to facilitate synchronous and asynchronous learning (Torda, 2020). Digital learning can potentially facilitate the learner-centred education that is required in Health Sciences curricula. The wide variety of digital tools available allows for greater flexibility and convenience, however this is often dependent on the financial resources of an institution. Identified enablers of successful digital learning include the facilitation of contextualised learning, using digital tools for teaching clinical skills, the improvement of educational quality through the integration of theoretical contexts into practice, and the integration of digital learning into existing curricula (Regmi and Jones, 2020).

## Moving forward

The COVID-19 pandemic necessitated a re-evaluation of teaching and learning strategies in the Health Sciences, leading to educators adopting creative solutions to address learners' needs. As access to physical campuses resumes, universities and institutions are in a transitional stage of education delivery (Alkadi, 2021) and it is unclear whether online TLA approaches employed under COVID-19 restrictions will be continued in the future. While the online delivery of didactic curriculum components was viewed as successful (Kim et al., 2020), delivering practical skills and training was viewed as an ongoing challenge for the Health Sciences disciplines (Alkadi, 2021). Many Health Science disciplines, such as Dentistry, require close contact with other people (Yu-Fong Chang et al., 2021), and it can prove difficult to replicate the tactile interaction that face-to-face consultations provide in an online environment (Sharka, Abed et al., 2020). Educators employed a range of different approaches, such as VR and AR tools, to provide continuity of clinical teaching and assessment practices (Elangovan, Mahrous et al., 2020). While VR tools have provided



some students with access to clinical settings, these tools are not always portable and may not be readily available across some institutions (Alkadi, 2021).

Digital learning in Health Sciences offers an array of opportunities to innovate and enhance traditional education methods in Health Sciences disciplines. However, as outlined above, it also provides its own unique challenges. Some have suggested that a blended learning approach, combining both physical and online components will characterise the future of learning within the Health Sciences (Chang et al., 2021). However the implementation of effective blended learning approaches relies on a number of factors: purposeful design underpinned by robust pedagogies (which takes time and pedagogical expertise), availability of relevant academic professional development, provision of adequate online learning support and access to current and up-to-date digital tools (Goh and Sandars, 2020, Iyer et al., 2020).

Reflecting on their pandemic experiences, Health Sciences lecturers have highlighted the need for 'deliberate, premeditated and planned' digital learning approaches (Renfrew et al., 2021). There is an understanding that developing such higher education modules and programmes will involve not only the 'teaching educator', but also a team of experts including educational/learning designers, learning technologists, technical support staff etc. (Torda, 2020). If institutions are to build on the learnings of the past two years and sustain pedagogical gains, institutional commitment to, and guidance on, the effective design, development and implementation of blended and digital learning will be essential.



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## Appendix 1: Digital teaching, learning and assessment practices in the Health Sciences disciplines

Pedagogical Approach	University	Discipline	Aims	Method	Observations (Challenges/Strengths)
Problem-based learning	UNSW Sydney	Medicine	To develop and assess the abilities of an online knowledge map as an assessment tool (Ho, Harris et al., 2018).	<p>The answers that students provide in their maps are assessed through comparison with the educator's own map and through the use of weighted scores.</p> <p>Scores generated from the mapping tool were compared to manual grading of a modified essay question (MEQ) on the same topic. An online survey was circulated to students for feedback.</p>	<p>While comparisons of the maps to the MEQ showed similar 'knowledge gaps' in low, mid-, and high performing students, students showed better understanding of the studied topic when using the maps.</p> <p>25% of eligible students (n=35) responded to the survey. Most reported that the mapping tool improved their learning and motivation. Other strengths reported included the tool's ease of use and the ability to link concepts to each other.</p> <p>Educators reported that the mapping tool may not be as useful for senior students, who already have developed their own knowledge on the topic and may find it difficult adapting this to 'pre-constructed maps'.</p>
Case-based learning	University of Manchester	Dentistry	Zoom based simulations for Oral Health students to replace cancelled clinical placements	The tutor created a series of Zoom-based patient scenarios, where the tutor acted as a patient requiring treatment. Each 'case' included a detailed medical history and photos, based on the tutor's own professional experience of interacting with	Although the online simulations did not allow for the standard level of involvement that clinical placements provide, the educator reported that including 'fun' factors increased student participation.

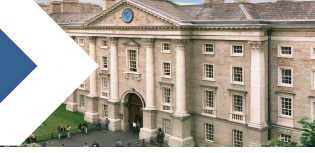


Pedagogical Approach	University	Discipline	Aims	Method	Observations (Challenges/Strengths)
			(Technology Enhanced Learning and Design, University of Manchester 2021).	students and previous patients' referral letters to the dental clinic.	
Case based learning	Cardiff University	Medicine	Using an e-learning resource to develop student's skills in interpreting chest x-rays (Sait and Tombs, 2021).	Xerte Online Toolkit was used to develop the resource. The design of the resource was based on andragogical principles, following the Overbaugh's guidelines and Mayer's 12 multimedia principles, in addition to use of the ADDIE (Analysis, Design, Development, Implementation and Evaluation) instructional model. The non-mandatory resource includes six cases for students to assess and diagnose.	94% of students reported agreeing or strongly agreeing that the learning outcomes were appropriate to their level of experience, that the resources were user-friendly and had high quality graphics and text content that met the stated learning outcomes.  Students identified areas for improvement, such as more challenging quizzes and a wider range of x-ray examples for diagnosis.
Case-based learning	University of Birmingham	Medicine	The use of a Technology Enhanced Learning (TEL) programme to improve trainee doctors prescribing competency. An aim of SCRIPT is to encourage self-directed learning in relation to prescribing (Brooks,	SCRIPT eLearning provides 48 modules covering a range of specialities related to prescribing and therapeutics. Developed by a team of health professionals, the modules are regularly updated. Each module is composed of MCQs, post-test questions, suggested further reading, in addition to the main body of learning content. Learners are required to maintain and complete an online ePortfolio during their 1st year. Assessment is not emphasised although it is optional to have a pass mark assigned.	Interviews were conducted with learners to explore their perceptions of using SCRIPT. While the content was acknowledged as relevant and useful, learners viewed SCRIPT as a 'tick-the-box- exercise due to its mandatory nature. Some interviewees perceived their clinical educators as not valuing SCRIPT.



Pedagogical Approach	University	Discipline	Aims	Method	Observations (Challenges/Strengths)
			Pontefract et al. 2016).	Review meeting are held between learner and clinical tutors bi-annually.	
Case-based learning	Monash University	Pharmacy	To transition in-person Objective Structured Clinical Examinations (OSCEs) to asynchronous and synchronous online formats (Pharmonash, 22 Sept 2020).	<p>Educators developed OSCEs into two formats:</p> <ol style="list-style-type: none"> <li>1) Pre-recorded videos for students overseas to complete asynchronously.</li> <li>2) Live Zoom calls with a simulated patient.</li> </ol> <p>In OSCEs, students demonstrate how to correctly use medical devices to patients.</p> <p>This was converted that patients would have the device and the students would observe and counsel. Students submit a recorded video of their interaction with the simulated patient for assessment.</p>	The pre-recorded video gives students time to practice multiple times, which will help them to achieve the intended learning outcomes through repeated practice. Students are learning specific skills which are needed by healthcare professionals for telehealth interventions.
Simulation-based learning	Monash University	Nursing and Midwifery	To report the move of an Obstetric and Neonatal Simulation (ONE-Sim) workshop from in-person learning to a synchronous remote learning approach (Prasad, Fernando et al., 2020).	Fifty nine medical and twelve midwifery students partook in the workshop. Three simulations were synchronously streamed, depicting realistic clinical emergencies: students were asked in advance to identify aspects of care that could have been improved. Following streaming of the emergency scenarios, students debriefed in Zoom breakout groups of six.	Results were compiled from observational findings. Midwifery students were more vocal than medical students. As the session progressed, students became more vocal and engaged. While live scenarios replicated a 'real-life' emergency, educators found it to be time and resource intensive. For future workshops, the educators intend to use a pre-recorded video to ensure an optimal viewing experience for students.





Pedagogical Approach	University	Discipline	Aims	Method	Observations (Challenges/Strengths)
<b>Simulation-based learning</b>	Imperial College London; Leiden University	Medicine	The aim was to develop a virtual anatomy assessment using AR headsets and gain feedback from students and teachers on their experiences using the assessment tool (Bogomolova et al., 2021).	<p>The anatomy assessment was developed in two cycles of design and evaluation. Questions followed the Blooming Anatomy Tool (Bloom et al., 1956) and were focussed on subjects that are difficult to grade through paper assignments.</p> <p>The resulting test consisted of thirteen questions designed to assess students' spatial anatomical knowledge</p> <p>An AR HoloLens application was created 'to integrate the anatomy test and anatomical 3D model into a virtual 3D assessment scenario.'</p> <p>A standardised self-reported questionnaire collected feedback on the practicality of using the virtual assessment.</p>	<p>Feedback was positive, with students/trainees stating their preference for the virtual assessment in comparison to a specimen or cadaveric assessment scenario.</p> <p>Cited positives included the usefulness of the tool, its capacity to demonstrate student's knowledge and skills (particularly those with low visual-spatial abilities), and strong interaction with the educator.</p> <p>Challenges included technical and practical issues (for example, connectivity issues, and the need for two headsets for one assessment raising issues of high costs and time constraints).</p>
<b>Simulation-based learning</b>	Imperial College London	Medicine	To explore the feasibility of using Mixed Reality (MR) tools to deliver a remote teaching ward for medical students that is acceptable to students, educators and patients and provides effective	Patients were recruited from a London teaching hospital with eleven students and two patients taking part. The participating clinician wore a HoloLens2™ device while conducting a ward round, which students would stream and interact with remotely. Students could send messages, ask questions and discuss learning points.	<p>The technology enabled access to patients that students usually would not see. Positives reported by both Faculty members and students included its capacity for a large audience size to partake which would not be feasible in a physical setting.</p> <p>All students and involved patients found the virtual ward enjoyable, with most students finding the audio/visual content adequate (n=8) and reporting ease of interaction with the</p>



Pedagogical Approach	University	Discipline	Aims	Method	Observations (Challenges/Strengths)
			interaction between the three stakeholders (Bala, Kinross et al., 2021).		<p>clinician (n=9). The virtual tool did not hinder patient-doctor interaction.</p> <p>Challenges were identified by some students, such as disruptive background noise, intermittent poor image quality and a need for improvement in lighting.</p>
<i>Simulation-based learning</i>	University of Auckland	Pharmacy	To evaluate the use of a renal patient simulation through reflective questions embedded in the simulation and an evaluation survey for Pharmacy student (Martini, Bhargava et al., 2015).	A web-based 2D screen-based simulation, Ready to Learn, was used to test students' communication and decision-making skills. Case studies includes an interaction with a critically ill patient, a senior medical officer, and a medical handover. Each case had predetermined questions and answers, with additional aspects to mimic real-life scenarios, such as GP notes, patient's heart monitor, and distractors.	Nineteen out of ninety seven eligible students completed the simulation, of which eighteen answered the survey. Students reported finding the simulation immersive, 83.3% found the feedback useful and most (55.3%) found that they had to actively concentrate on their activities.
<i>Team-based learning</i>	King's College London	Medicine	To facilitate virtual tutor groups for medical students during the COVID-19 pandemic (Paul, Kohara et al., 2020).	Students met in small groups via a video conferencing app (Microsoft Teams) to participate in interactive scenario or simulation-based learning sessions, which involved patient consultations. With a lack of non-verbal cues and physical interaction, students had to adjust to the virtual consultation format appropriately.	<p>Students reported challenges in deciding if some patient cases merited in-person examinations or if the health issue could be self-managed at home. A lack of guidance regarding data protection and patient confidentiality was also reported.</p> <p>Patients involved in the initiative reported positively on the students' communication skills.</p>



Pedagogical Approach	University	Discipline	Aims	Method	Observations (Challenges/Strengths)
					The virtual group facilitated a sense of community amongst peers.
<i>Team-based learning</i>	University of Bristol	Dentistry	Replacing an individual library project with a group digital-based project (Digital Education Office, University of Bristol, 2021).	Students worked on a collaborative project, working in small groups on a specific topic. Students completed wikis as they completed their research, which allowed tutors to track students' progress.	Students faced challenges familiarising themselves with the software. Tutors found individuals within groups were doing most of the work. To resolve these issues, the wikis were given a clear pre-set structure and students now receive individual grades for contributing to the wiki. Groups are now also required to give an oral presentation, with all members receiving the same mark for this presentation.
<i>Team-based learning</i>	University of Auckland; University of Plymouth	Nursing	The study's aim was to facilitate a virtual 'student exchange', where students partake in weekly digital learning activities to gain a global perspective of nursing and healthcare practices through e-collaboration (Cowls, Young et al., 2019).	Senior nursing students from the UK and New Zealand took part in an eNetwork via audio/video-conferencing. For one month, students were given weekly discussion topics to discuss in small groups. The experience was evaluated using an anonymous online survey.	All participating students stated that the collaboration activity enabled them to engage purposefully with other students. Challenges experienced included time differences when attempting synchronous learning.