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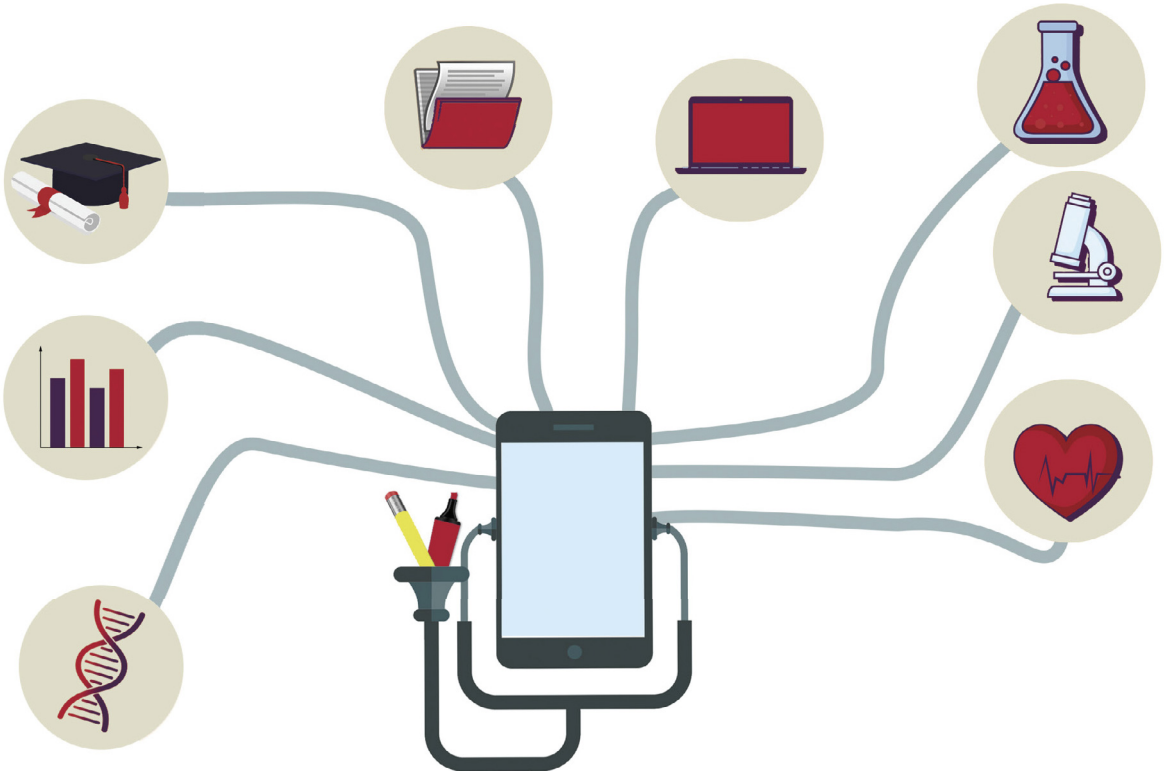
EDITORS

Innovative Medical Education in the Digital Era



eBook

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Table of contents

Introduction

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Universities have traditionally aimed to instill in their students the ability to interpret information as well as the joy of learning. However, today's universities are challenged with the need to also incorporate technological advances without forsaking the solid principles at their foundation.

Furthermore, modern society's demand for a university-educated workforce is increasing, while the demand for unskilled jobs is decreasing. Universities now face the challenge of training many students with vast differences in background, previous knowledge, and study motivation.

Supporting student learning with digital resources

A huge amount of digital resources is now available for administrative as well as pedagogical support and enhancement in higher education. Today's students, who were born in the 2000s, now expect modern universities to provide an appropriate digital infrastructure for teaching and learning.

Medical education must adapt to many new and different healthcare contexts, including digitalized healthcare systems and digital-generation students in a hyper-connected world. Educational design needs to be adapted to the target learners, setting, and available resources. While the use of technology was already widespread in medical education, the Covid-19 pandemic accelerated the need for more flexible, personalized, and collaborative learning.

For this reason, educators and lecturers are expected to effectively incorporate digital tools into their teaching. Simply being an expert in a certain academic field is no longer sufficient. Today's lecturers need both pedagogical competence in order to help as many students as possible pass exams, as well as adeptness in the use of digital resources. This competence is referred to as technological, pedagogical, and content knowledge (TPACK). In order to achieve this goal, we must abolish (or at least adapt) some old-fashioned teaching methods, including chalkboards, practice groups, and lecture-based lessons.

The traditional format of the lecture may be enriched using live streaming or be made available on demand. Digital tools may be used to add interactive components to traditional lectures.

In the first chapters of this e-book, Liapi provides an overview of the technological tools available to modern teachers, such as multimedia approaches, simulation, gamification, artificial intelligence application, and virtual learning environments and augmented reality.

As discussed by Riggio and Durante, in-person traditional lectures may be enhanced by the availability of online resources (e.g., e-books, videos, podcasts) before the lecture, that may be transformed in a series of active learning, student-centered activities (the so-called flipped classroom). Digitalization further promotes interaction, thus boosting exchanges and educational collaboration between disciplines, professions, and universities worldwide. The Covid pandemic forced many courses to be moved online only and the experience of language teaching is explored by Markovina and Krasilnikova, looking at the experience of both students and teachers regarding tools, expectations, advantages, and limitations.

Another example of digital interaction is the modernization of the anatomical theater teaching tool. Tuebingens' Sectio chirurgica is a free interactive lecture produced by the Department of Anatomy at Tübingen University, which is targeted to both students and professionals. Surgeries are broadcast live via the internet. Surgeons of different disciplines explain and perform various procedures on anatomical specimens with the aim of applying anatomical knowledge to a clinical context while demonstrating the importance of theoretical knowledge. One of Sectio chirurgica's most important features is viewer interaction. Viewers are invited to contribute to the live stream by chat, by completing a quiz, via "second stream screens" or by contacting the dedicated hotline. Viewers actively influence surgical activity by digital means, thus representing a digital reinvention of traditional teaching methods ("chalk and talk") still practiced at universities today. However, as compared to a traditional lecture, Sectio chirurgica has proven to be more easily understandable and entertaining. It also transmits the same anatomical knowledge and more clinical insights. It is discussed in detail by Shiozawa and Hirt.

Digital instruments have the general aim to simplify the application of *active learning*. Research has shown that active learning, supported by effective use of pedagogical digital resources, can both improve student results and support inclusiveness. The flipped classroom, active learning classroom (also in combination with the traditional classroom), problem-based learning (PBL), student response systems, and digital exams are some examples of common resources/methods that may benefit from digital support.

In particular, PBL, a constructive, self-directed, collaborative, and contextual learning method, has been shown to be effective when students are on campus and study full-time, but entirely online courses may be provided for master-level courses or adult learners who are working professionals. Many online courses resort to a teacher-led traditional design. However, while there is no one-size-fits-all solution for student-centered online learning, successful examples include small-scale blended courses with synchronous online discussions, middle-scale fully online courses with individual project work and no synchronous communication, and large-scale massive open online courses (MOOCs) based on PBL principles. Verstegen and De Nooijer report three examples of these different-scale courses, along with their actual application and results.

Virtual reality and virtual flipped classroom may be applied successfully both in pre-clinical and clinical teaching. Cytometry and cell culture basics may be delivered using a virtual reality environment (which also reduces costs and plastic waste), both for students and for professionals needing continuing professional development (as reported by Baus and colleagues in their chapter).

On the other hand, clinical training may be particularly benefitted by the application of new technologies. As reported by Pecoraro and colleagues, artificial intelligence is able to improve the teaching of radiology (providing diagnostic clues on real CT and MRI scans, suggesting anatomical segmentation, reporting discrepancies and inter-observer variability among trainees).

Simulation is useful for the initial training of clinical abilities as well as for the maintenance of lifelong professional competence throughout one's career. Medical simulation can use equipment (e.g., high-fidelity mannequins), virtual reality (serious games), or standardized patients. In recent years, technological progress has made simulation-based teaching one of the most appealing educational resources. As discussed by Lubrano, Bloise and Bertazzoni, simulation provides a safe environment for emergency medicine training (the first time is never on the patient), and offers proactive, controlled, reproducible, and standardized training based on feedback and debriefing. The human impact brought by teachers and coordinators is needed to create real medical histories to immerse learners in the simulation scenario. A skilled instructor should guide the scenario and evaluate performance. This educational technique has several advantages: it allows learners to play an active role, its use of debriefing stimulates cognitive efforts, and it promotes the learning of correct clinical case management in the long term. Simulation in teams also allows students to develop team-working skills, practice leadership roles, and optimize group dynamics in order to achieve the best possible outcome, thus also effectively practicing multitasking.

Furthermore, simulation training can also be a major factor in reducing work stress. Simulation may also be enhanced by team-based competition, which promotes the natural instinct of teams to excel, and may motivate students to study and prepare harder before the competition. A team-based competition organized by Sapienza showed a marked improvement in standard of care and technical knowledge over time. This was due to the sharing of knowledge between students who had participated in previous editions and their younger colleagues.

Teaching humanities

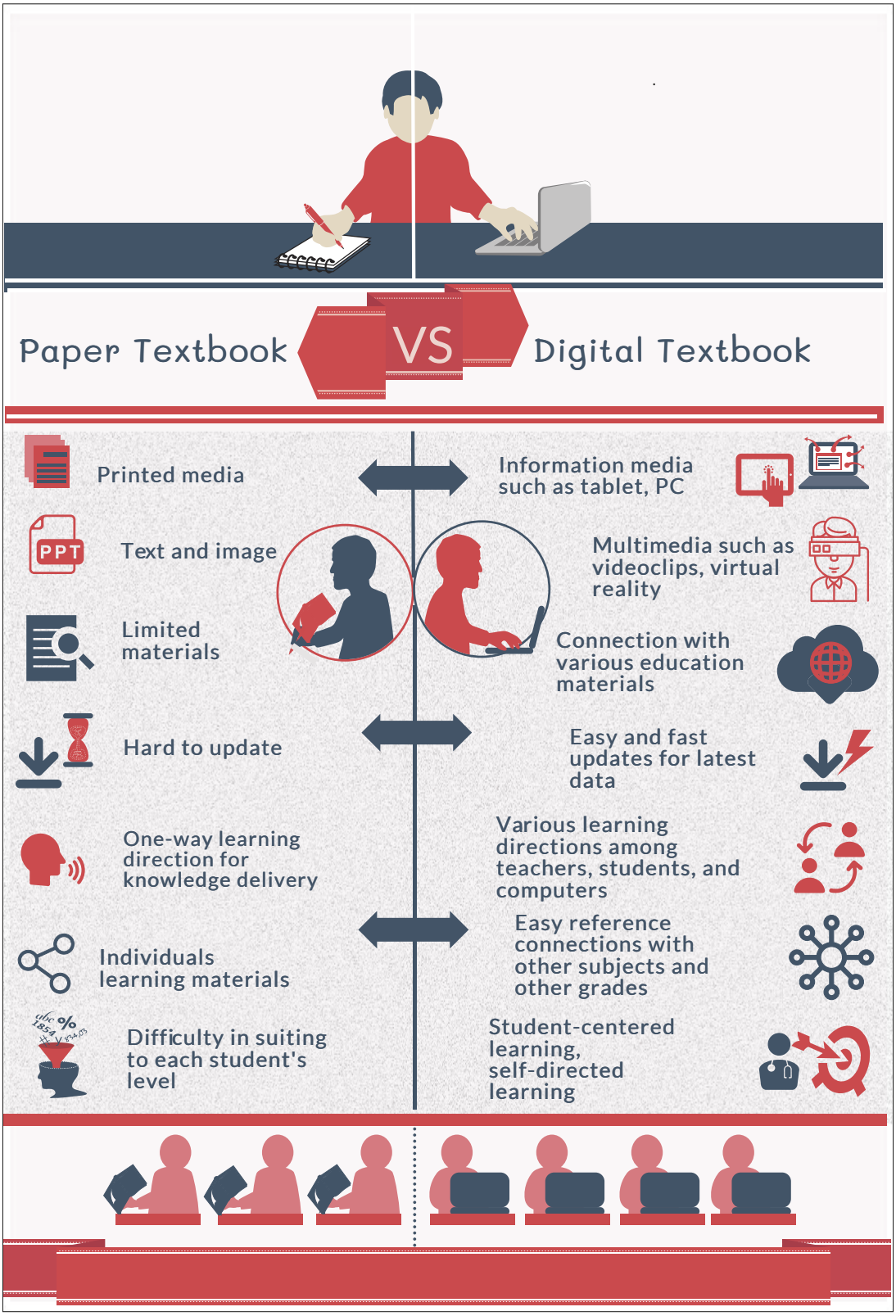
The decision to pursue medical studies is often influenced by humanitarian considerations that are formulated in moral terms (e.g., duty of helping others). Digitization may help shape and enhance the moral intuitions and judgments of medical students. Critics maintain that online education cannot be compared to the instant feedback and sense of community provided by face-to-face courses, and that the use of simulation reduces human interaction. Medical education in the digital era will pose important challenges in building empathy in medical practice. McFarland proposes to restore the role of the humanities in the medical curriculum, also proposing *why* and *how*. Socaciu and Gibea explain how the issue of ethics may be addressed using new technologies: students may be immerged in clinical scenarios posing ethical dilemmas, applying some of the tools we have already discussed, such as virtual reality, group activities, and gamification.

Finally, the organization of clinical learning activities may also be updated, as shown by the experience of Operemos, a managing platform explained by Guadalajara, Esteban, Lopez-Fernandez and García-Olmo. Even mobility programs may be rethought and reorganized to include a preparatory online session and a shorter time in person, as proposed by Calés Bourdet. The publisher's role must also undergo a complete rebuild. As medical publishers, Allison and Grillo discuss the evolution of the e-book from 1971 to date. To support case-based learning and problem-based learning, content also needs to be refreshed. Students now need to engage with the content, with video and audio support, and to receive instant feedback on activities. The McGraw Hill approach is detailed in the last chapter of this book.

Principles of modern medical education

Innovative medical education curricula may be developed according to the following principles:

- *Interactivity*. Active learning implies a shift from a teacher-centered class to a student-centered approach that will increase curiosity, boost engagement, and lead to better learning and comprehension. Educational technology should promote interactivity in all teaching settings.
- *Bidirectionality*. Students should be allowed to apply their knowledge to challenging problems in a setting that promotes collaboration with peers and continuous bidirectional feedback between educators and students and peer to peer.
- *Blendedness*. New technologies should be integrated with traditional methods. Online lectures, VPs, and online games must integrate traditional lectures, bedside teaching, and group simulations in a comprehensive curriculum.
- *Transnationality*. Since web-based platforms allow for international cooperation, medical curricula should be transnational and promote contributions from different universities. This would enable homogeneity of training across European countries. It will also improve understanding of cultural diversity.
- *Up-to-dateness*. The ability to record and broadcast lectures that learners may attend from their own home at their chosen time should not encourage material recycling from year to year. Materials should be accurately checked for up-to-dateness and refreshed continuously.


Paper Textbook
VS
Digital Textbook
Printed media
Information media such as tablet, PC
PPT
Text and image
Multimedia such as videoclips, virtual reality
Limited materials
Connection with various education materials
Hard to update
Easy and fast updates for latest data
One-way learning direction for knowledge delivery
Various learning directions among teachers, students, and computers
Individuals learning materials
Easy reference connections with other subjects and other grades
Difficulty in suiting to each student's level
Student-centered learning, self-directed learning

1 Innovation in medical education: benefits and limitations

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Since the 1990s, technology[1] has been gradually implemented into medical education, and has generated a wealth of innovative approaches to pre-clinical and clinical medical training through the adoption of asynchronous learning, simulation, game-based instruction, and even the use of social media as a mode of collaborative and peer-to-peer learning (Tudor Car *et al.* 2019). The benefits of technology-enhanced learning have been widely appreciated over the last year due to the Covid-19 pandemic, which saw e-learning become the major component of academic medical education (Rajab *et al*. 2020).

In the last quarter of the 20th century we experienced an explosion of information in medical sciences in relation to advances in information technology that enables faster, more reliable and more comprehensive data collection. At the same time, an increasing amount of irrelevant information has become a limiting factor, leading to a growing gap between medical knowledge on the one hand, and the ability of doctors to follow the evolution of information on the other. The current explosion in health technology procedures, tools and techniques has improved healthcare in the simplest and the most effective ways: an artificial pancreas (Boughton and Hovorka 2020), a glucose monitor built in to smartphone cases (Yang *et al.* 2020), the mySugr program (Debong *et al.* 2019) allowing for customized digital population health, artificial narrow intelligence (ANI) in surgery (Namikawa *et al.* 2020), a cloud-based deep learning algorithm for cardiac imaging (El-Askary *et al. 20*17), and a digital ingestion tracking system to measure drug adherence (Van Biesen *et al*. 2019), are just some examples of the digitalization of health.

Innovation has become an extremely important part of the healthcare landscape, and permeates many areas of clinical medicine. To respond to these challenges, students must be prepared for the Medicine

[1] The term "technology" is of Greek origin (τεχνολογία) deriving from the words "τέχνη" and "λόγος"; "τέχνη" means a skill and "λόγος" implies a science. Thus, "technology" refers to the applied knowledge or the applied science.

of the Digital Era and aware of the new technologies that are being introduced (i.e., simulation, virtual worlds, game-based instruction, social media use). It should also be taken into account, however, that healthcare and medicine are fundamentally different from physical sciences and that the practice of medicine is complex.

Apart from the evolution of medical information and research, education itself drives the need for renewal and changes to the curriculum (Han *et al. 20*19); according to the *NMC Horizon Report* (2016), the current generation of students must have various skill sets (i.e., digital literacy, complex thinking, creativity) to be successful. Thus, in medical schools, in addition to formal knowledge and clinical experience, the integration of innovation strategies is necessary to prepare students for the growing complexity of medical practice; these strategies are consistent with emerging needs in the field and, including interdisciplinary learning experiences, will allow students to develop multi-institutional expertise on the best processes and best practices (Bullard *et al*. 2019).

Medical educators must encourage student inquiry, feed their curiosity, and deepen their understanding of scientific concepts (Dyche and Epstein 2011). At the same time, they must be equipped with the necessary knowledge, skills, and attitudes that will enable them to adopt creative approaches in identifying innovative solutions to complex issues in medical education. Medical educators should consider new media suited to training students in the modern healthcare settings of the digital era and permit students to practice in real-world situations (e.g., using computer simulation that allows the student to try out different strategies) (Lateef 2010). Thus, towards a learner-centered approach (Cullen *et al.* 2019), it makes sense to consider involving students in the selection and design of tools to stimulate their interest in solving complex healthcare problems.

But what does "innovation" really mean? It is difficult to define since innovation is not a positive performance in itself. One possible definition is "the application of selected new key practices in education that will lead to an overall improvement." For example, in a 2018 survey on innovation in medical education methods, involving students at Concordia University's Portland College of Education (https://resilienteducator.com/classroom-resources/educational-innovations-roundup/), the following aspects were highlighted:

- Finding any way you can to reach all of your students, by being willing and flexible to adjust what you teach and how you teach;
- Stepping outside of the box, challenging our methods and strategies in order to support the success of all students as well as ourselves;
- Keeping yourself educated about new trends and technology in education and being creative with the resources you are given;
- Allowing imagination to flourish and not be afraid to try new things; sometimes these new things fail but it's awesome when they are a success; without the right attitude, innovation would just be a word and the art of education would miss out on some great accomplishments.

Technological innovations for teaching and learning in higher education provision that aim to promote the practice of skill development and optimize educational experience are classified into four main groups: (i) systems based on computer support for the learning of basic medical sciences; (ii) computer simulation systems for training and testing of clinical competency; (iii) systems-based computer consulting; and (iv) systems based on computers for data management and quality assurance.

Although the benefits of technology cannot be denied, and constitute a challenge in the education of medical students, there are also limitations in their use. Thus, the benefits and limitations of some important technological innovations applied in education will now briefly be discussed.

1.1 Digital teaching aids and multimedia

A wide range of digital technologies is reported in relation to their use for teaching allied health professionals. The technologies that are most frequently related to practice-based learning are the following: (i) video-based lectures enabling trainees to harness repetition, self-paced practice, and active learning (Dominguez *et al.* 2018; Liu *et al.* 2019); (ii) mobile devices enabling the collection of data related to experience/accommodation of the numerous demands of the highly mobile clinician and trainee;[2] (iii) audio response systems that offer an innovative approach to teaching and learning, which shows positive acceptance and increased attentiveness (Beaumont *et al.* 2017; Hussain and Wilby 2019). These tools stimulate more active learning in the classroom, facilitate student in-classroom participation, encourage group problem solving, and enhanced engagement and enjoyment of the lecture experience. However, results in terms of long-term knowledge retention and learning outcomes are weak or equivocal (Atlantis and Cheema 2015).

1.2 Simulation

Simulation[3] has recently been incorporated in medical schools, with simulation-based education a rapidly developing discipline that can provide a safe and effective learning environment for students, lead to improvements in understanding of the basic concepts of medical sciences (e.g., pharmacology, physiology), improvement in medical knowledge, familiarity with procedures, improvements in performance and clinical skills during retesting in simulated scenarios (diagnosis, treatment, resuscitation, etc.), and a reduction in medical errors, benefitting patient safety (Khan et al. 2011, McCoy et al. 2017).

[2] Smartphone and mobile device applications offer trainees the ability to multitask, instantly refreshing knowledge on diagnoses, medical management, patient health information, medical calculations, accessibility to the most contemporary clinical literature, faster clinical communication and subsequent response times to patients' needs, continued medical education, and error prevention. However, the possibility of malware risks, potential privacy breaches, and erroneous information in searches cannot be excluded. Furthermore, trainees express concern about smartphone usage appearing disrespectful to patients, other attendees, and co-workers (Latif 2019). Cell phones in particular seem to be a big hindrance to learning in class, even for those using them for note taking, and according to recent studies students that multitask or are distracted by multitaskers performed worse on exams (students on their phones caught 62% less of the information given in class than their peers using pen and paper); no current studies exist regarding mobile devices improving actual patient outcomes (Kuznekoff and Titsworth 2013).

[3] Simulation is derived from the Latin word simulare, which means "to copy" (Sinha *et al.* 2009).

Simulation began with the first life-size mannequin pelvis for midwives training in childbirth in the 9th century, developing right up to the late 1990s and early 2000s, where versatile human-patient simulators were introduced and eventually a high-fidelity simulator "patient" who talks, breathes, blinks, and moves like a real patient. Simulation leads to a reduction in teaching time, coupled with an improvement in speed of knowledge uptake, but is also helpful in cases of depleted resources (e.g., unavailability of animals for experimentation). Examples of simulation include: (i) SimMan as a tool for training and examination (Swamy *et al.* 2014; Liu *et al.* 2019); (ii) ventriloscope to assess clinical examination skills among undergraduate medical students (simulates auscultatory findings) (Verma *et al.* 2011); (iii) simulation techniques to teach intravenous catheter placement (McWilliams and Malecha 2017); (iv) three-dimensional tool for teaching human neuro-anatomy (Estevez *et al.* 2010); (v) audience response systems to evaluate performance and digital tools used in combination with simulation (Hussain and Wilby 2019); (vi) telesimulation as an innovative tool for teaching intraosseous insertion techniques in developing countries (Mikrogianakis *et al.* 2011); and (vii) a web-based learning program combined with simulation for critical care ultrasonography (Sekiguchi *et al.* 2013).

Patient safety constitutes a major reason for using medical simulation in order to avoid harm caused by inexperienced trainees, and ethical concerns (e.g., circumventing the need for patient consent and confidentiality) (Sørensen *et al.* 2017). A high-fidelity simulator patient provides a better teaching modality as a blended learning approach for certain tasks, while simulation offers an ideal tool for assessment and evaluation of the clinical skills of students, and the possibility of retraining boosts student confidence.

However, the limitations of simulation also need to be recognized. Among others, these include incomplete mimicking of the human system (which is very complex), defective learning (physical signs are missing, omission of safety procedures, patient consent, etc.), the cost factor (initial purchase and ongoing maintenance costs), time factor, lack of infrastructure, technical difficulties and lack of full-time staff (Qayumi *et al.* 2014). Although there is no evidence to support the notion that simulation-based learning helps to produce better doctors than traditional teaching methods (Bradley and Bligh 2005), residents trained on simulators were more likely to adhere to the advanced cardiac life support protocol than those who had received standard training for cardiac arrest patients, and residents trained using laparoscopic surgery simulators showed improvement in procedural performance in the operating room (Okuda *et al.* 2009). Hence, future studies should help in elucidating the utility and value of simulation in medical education, and in assessing the effects of simulation teaching on patient outcome rather than just assessing short-term goals like acquisition of knowledge, skills, and student satisfaction (Okuda *et al.* 2009; Sørensen *et al.* 2017).

1.3 Virtual learning environments and augmented reality

Virtual reality (VR) is a modern technology that creates a simulation environment. It enhances the user experience by convincing the human brain that it is in a different environment (Riva *et al.* 2019). VR is useful in, among others, distance learning, special education, training students to perfect their skills in handling patients in different environments, and it has been used by universities as a way of disseminating informa-

tion about a campus to prospective students before they enroll. Examples include: (i) virtual reality-based training system to teach about spinal anesthesia (Lövquist *et al.* 2012); (ii) computer programs to strengthen knowledge related to anatomy (digital cadaver) (Darras *et al.* 2019); and (iii) virtual patients for the online interactive approach to medical education (Cendan and Lok 2012; Baumann-Birkbeck *et al.* 2017).

A virtual field trip (VFT), used as a stand-alone activity, offers a guided exploration through the World Wide Web that organizes a collection of pre-screened, thematically based web pages into a structured online learning experience. VFTs have been shown to enthuse and excite students, encouraging and supporting the development of a collaborative environment in which both teacher and students take responsibility for the learning that takes place. However, VFTs are less beneficial than real-world experience and learning opportunities are downgraded if interaction with the real world is limited (Robinson *et al.* 2009). Moreover, one cannot neglect the fact that VR, in a sense, undermines human interaction, lacks the flexibility offered by live teacher–student collaboration, and calls for high expenditures that only a few can afford, thus exacerbating educational inequalities rather than erasing them.

Augmented reality (AR) is a technology that superimposes a computer-generated image onto a user's view of the real world, thus providing a composite view. In an era of collaboration and sub-specialization, AR, in the future, may provide a much needed contribution to educational advancement. AR is used to evaluate dynamic anatomy in real time through the use of digital ultrasound; it allows visualization of structures and blood flow that can enhance the performance of invasive procedures; it can supplement anatomy education by superimposing radiological (CT or MRI) images on to a body and by creating a direct view of spatial anatomy for the learner; furthermore, with the complementary use of haptic technology, it provides the user with tactile feedback that aids appreciation of the consistency of different tissue components (Kim *et al.* 2017).

Overall, this represents an exciting area for VR and AR development in anatomical education. The traditional method usually involves use of an anatomical atlas, time spent in the dissection room, and fixed prosections, while AR and VR deliver a better appreciation of structures in virtual or real space (e.g., Microsoft Kinect produces an interactive digital mirror that visualizes the structures/musculature, superimposed on the user's own arm); Dassault Systèmes and Anatomage Table are typical examples that allow clinical scientists to immerse themselves in the patient's anatomy; however anatomic dissection and prosection remain the best and most realistic 3D experiences, while all other systems are complementary methods in the study of anatomy.

AR plays an important role in image-based augmentation of the surgical environment; virtual interactive presence and augmented reality (VIPAR) has developed a support solution that allows remote surgeons to project their hands into the display of another surgeon wearing a headset (Shenai *et al.* 2011). In fact, according to the Lancet Commission on Global Surgery, 5 billion people do not have access to safe, affordable surgery (Alkire *et al.* 2015). In addition, live operations using AR have been broadcast to a global community, with feasibility demonstrated for basic procedures both in Paraguay and Brazil (Khor *et al.* 2016). Proximie (a collaborative platform) allows surgeons to visualize real-time or recorded operations being performed by experts in other parts of the world (El-Asmar *et al.* 2021).

Although AR and VR appear to be powerful tools, and the literature reveals their versatile emerging applications in medicine, they also give rise to new challenges (Yeung *et al.* 2021). Furthermore, the limitations of AR, which include (i) the need for increasingly powerful microcomputers to drive AR, (ii) devices that must be a natural extension of the surgeon's senses (light, mobile, comfortable and functional for potentially long periods of time), and (iii) ethical concerns and legal pitfalls or issues (e.g., electronic patient records, confidentiality and data management), are some of the factors that could be a major hurdle in the integration of this new technology in education (Khor *et al.* 2016).

1.4 Cloud technology

Cloud technology is probably the future of technology in education since it hosts apps and services on the internet instead of a user's computer, enabling information to be stored, shared, and accessed on any device connected to the internet (Mell and Grance 2011). In education, the cloud is used to store and share digital textbooks, lesson plans, videos, and assignments, giving students the opportunity to have easy access with their instructors and other classmates through live chat options; it enables "flipped classrooms" (where students can watch a lecture before class and then spend the class time engaged in discussion), group work, and analytical activities (Liu *et al.* 2015); it reduces the chances of homework getting lost between school and home. A major limitation to full adoption of the cloud—apart from inadequate access to the internet—is security, however almost every network in the cloud has a security system in place to protect its information (Liu *et al.* 2015).

1.5 Gamification

Over the past 20 years "gamified training platforms" for both pre-clinical and clinical medical education have been developed (Kron *et al.* 2010, McCoy *et al.* 2016). The use of gaming in the classroom aims to bring together the fun part of play with the content and concepts that students must learn; gamification increases student engagement, creates enthusiasm for the lesson, provides immediate feedback, and in general students learn better when they are having fun (Hamari *et al.* 2014). However, not every fun game is effective at teaching a given concept, not every concept is fun, and it takes time and training to learn how to use games effectively for learning (Gentry *et al.* 2019).

1.6 Artificial intelligence

Artificial intelligence (AI) is all about creating machines that can think like humans; it is making its way in to the educational sphere by means of automating grading and feedback, and providing personalized learning opportunities. It can save teachers time by doing the grading and giving feedback on their behalf, and by providing greater insight into a student's learning patterns. On the other hand, teachers can learn a lot about a student's learning patterns by doing the grading themselves, while the personal element of care, when a teacher gives personalized feedback (rather than letting a machine generate it), should not be underestimated. Despite the fact that AI algorithms are more cost-efficient than conventional methods, awareness is rising among health experts and managers as to the particular disadvantages of utilizing these technologies; after all, personal involvement and interaction

between doctor and patient are of great importance in building trust and successful treatment (Davenport and Kalakota 2019). Although the impressive results of AI cannot be disregarded, apart from increasing concerns about the ethical and medico-legal impact, clinical safety questions must be considered (Challen 2019).

1.7 Problem-based learning

Problem-based learning (PBL) in medical education has been characterized as the most significant educational innovation of the past 35 years (Lim 2012). It is defined as "an instructional (and curricular) learning, student-centered approach, that empowers learners to conduct research and students to develop a collaborative spirit." PBL is a peer tutoring activity and a very effective learning technique by which students undergo brainstorming, and integrate and retain theory and practice in the application of knowledge and skills, to develop a viable solution to a defined problem. It instills many different kinds of skills, such as problem solving and argumentation rules. A limitation of the method is that student contact hours are four times greater for educators in a PBL curriculum than for educators in a traditional curriculum, thus the economic viability of problem-based learning is a major concern (Hoidn and Kärkkäinen 2014).

The implementation of evidence-based medicine (EBM), which as a concept developed from PBL, is rightly considered a revolution compared with classical empirical medical practice. Recent technological, scientific, and social developments are likely to transform EBM into precision medicine (König *et al.* 2017). The high-resolution, high-throughput data-generating technologies that continue to emerge facilitate the cost-effective generation of huge datasets (Cirilo and Valencia 2019), sophisticated new algorithms and methodologies, and high-capacity computation facilities, giving rise to medicine-based evidence (MBE). MBE is able to build and archive profiles that emerge from all known types of studies and data sources (Knottnerus and Dinant 1997).

1.8 A matter of perspective: what kind of medical education do we seek to deliver?

Appreciating the miracles of technology is one thing, making appropriate use of them is another. A key component of contemporary innovation in medical education is undoubtedly delivered via technology, but the educator still has to play the key role of deciding how to use it appropriately in order to enhance medical students' critical thinking and problem-solving skills, and not to substitute him/herself as a teacher. In view of this fact, the question is, "What kind of medical education do we seek to deliver?" In essence, this could be rephrased as, "What kind of doctors do we need?"

Technology already plays a huge role in delivering everyday healthcare, but it should be kept in mind that using it effectively should neither undermine the doctor–patient relationship (Chipidza *et al.* 2015) nor compromise the patient's right to life-saving and cost-effective care. In this respect, although e-learning offers immense opportunity for high-quality and universally standardized medical training, it will never be able to replace all aspects of real-life, experience-based learning gained with respect to the patient.

1.9 Conclusion

Future physicians will undoubtedly benefit from innovative, technologically enriched, blended medical training (Vallée *et al.* 2020); the latter will certainly prepare them for the clinical practice they will be called to deliver as professionals, and facilitate their adaptation to the dynamically evolving e-learning pathway they will have to follow throughout their postgraduate clinical training and CPD (Bloice *et al.* 2014). However, certain aspects of technology-enhanced medical learning remain underexplored and require a systematic review in order to ensure that: (i) understanding of the value of efficient patient–physician communication is not undermined (Alexandraki and Mooradian 2013); (ii) medical students are not deprived of the benefits of face-to-face instruction (Korman *et al.* 2019); and (iii) assessment of innovative approaches to medical education is undertaken more rigorously, with wider inclusion criteria and more learning outcome endpoints (Lewis *et al.* 2014). In this respect, now more than ever, high-profile medical schools should encourage interdisciplinary collaborative research toward the continuous development and rigorous assessment of innovative interventions in their curriculum.

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2 Teaching basic clinical skills to medical students in the classroom: the flipped model

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2.1 Achieving educational objectives through the use of diversified methodologies

An educational objective is what the recipient of our pedagogical intervention should acquire and does not already possess. An educational goal is traditionally expressed by an action verb and by an object that may be contextualized. For example, at the end of the educational activity the learner should be able to *diagnose* (action verb) *ulcerative colitis* (object) *in the video of an endoscopic examination* (condition, context). Educational objectives fall into various fields of knowledge (cognitive objectives) and knowledge of how to do (gestural objectives or skills) and how to be (communicative/relational objectives). List, describe, define, interpret, and choose are examples of verbs for cognitive purposes; performing, practicing, administering, applying, regulating, and measuring describe gestural goals; inform, explain, make people think, encourage, reassure, and motivate are examples of verbs that can be used for communicative/relational objectives. Educational objectives are also characterized by levels of progressive complexity, the achievement of which makes it possible to pass from simple knowledge to competence, defined as the ability to use knowledge to solve problems and make decisions in an autonomous and responsible way. For example, first-level cognitive objectives imply only the memorization of the topic, while higher levels require students to be able to interpret (second level) (e.g., laboratory investigations, symptoms) and make decisions (third level) (e.g., establishing a therapy after evaluating a set of clinical and instrumental data).

Once a specific educational goal has been identified, the first thing to ask is whether it is possible to verify its learning. This allows the quality of the objective itself to be evaluated. In practice, for each educational objective, we must always ask ourselves:

- Can I make the student do what the verb expresses? How?
- Can I observe what the student is doing? How?
- Can I measure the result of what the student has done? How?

If we are able to answer each of the above questions in the affirmative, the educational goal is likely to be of good quality.

It is clear that to achieve objectives of different quality (cognitive, practical skills, and communicative/relational skills) and complexity, it is not possible to use the same teaching method. Even remaining within the scope of the cognitive objectives, the achievement of higher-level skills may be a difficult task for students. A decision-making objective can be achieved only through specific teaching methods, which differ from those used to achieve cognitive objectives that involve simple memorization.

In summary, for a coherent educational intervention relevant to the needs of learners it is necessary to:

- Identify the learning goals and formulate a list (program);
- Evaluate the quality of each goal (type and level of complexity) and the possibility of verifying learning;
- Evaluate the teaching methodology (lesson, small group work, tutorial activity, etc.) and the most suitable environment (classroom, department, teaching laboratory, etc.) to achieve each goal.

2.2 Notes on the practical application of learning theories and choice of educational environment

Andragogy, the discipline that studies individual adult learning, is based on five assumptions (Misch 2002). When adults learn:

1. They are independent and self-directed;
2. They have already accumulated a large amount of knowledge that can be used for further learning;
3. They tend to learn better when answering questions arising in the context of their daily experience;
4. They are more interested in problem-based, methodological approaches;
5. They are more motivated to learn as a result of internal rather than external stimuli.

On the basis of the aforementioned principles, adult learning takes place when learners have the opportunity to increase self-directed learning by identifying the limits of their knowledge and skills, asking questions, and reflecting critically on the new information acquired and on their own learning process. The learning process is also guided by judgment of one's abilities, which although this may be inaccurate

or influenced by psychological states or confrontation with colleagues, is generally reinforced positively by success and negatively by failure. Finally, the learning process is constructive. Once students have gained a significant amount of knowledge, good learning takes place when this knowledge, recalled with appropriate stimuli, leads to a new and active elaboration through which experience and theory are linked. This is achieved when, following a stimulus, students reflect (experiential learning) on pre-existing theoretical knowledge and/or when students, starting from their knowledge, can program their new behaviors in relation to a potential future stimulus. In essence, students actively learn by processing information based on their actual knowledge. Actual knowledge influences (constructs) new learning. Accordingly, new knowledge depends mainly on how pre-existing knowledge is processed in relation to the stimulus.

Therefore, the role of teachers is not to transmit knowledge but to facilitate active student learning by promoting appropriate experiences to bridge the gap between theoretical knowledge and practice, and building new knowledge based on experience. In this regard, the meta-cognitive function of the teacher becomes paramount, and entails:

- Encouraging the student to make hypotheses, reflect, and make decisions;
- Stimulating, directing, and correcting students;
- Managing educational resources;
- Supporting, appreciating, advising, and serving as a reference for students.

Another relevant aspect is the so-called educational environment, i.e., the context that can make learning interesting, stimulating, and attractive for learners. In adult learning theories, the teacher's ability to create an appropriate context is as important as the ability to convey knowledge and experience. Since teachers become a model for learners, their actions can result in appropriate educational messages.

The ability to establish positive feedback toward the learner is known to favor the learning process. Positive feedback is able to enhance progress by stimulating awareness. Positive reinforcements stimulate learner involvement, and motivate learners to put their own responsibility and autonomy into play. Through positive criticism, learners reflect on the objectives achieved and begin to plan the next steps in relation to the evaluation of their success or difficulty.

The flipped classroom described below is an example of an educational environment that aims to apply the aforementioned educational theory.

2.3 The flipped classroom model

Moving toward active learning strategies requires a shift in learning paradigms. This implies a deliberate shift from a teacher-centered to a student-centered approach, where in-class time is dedicated to exploring topics in greater depth, addressing the needs of individual students, and, most importantly, enabling more active and engaged learning. The flipped classroom model uses this approach (Figure 1).

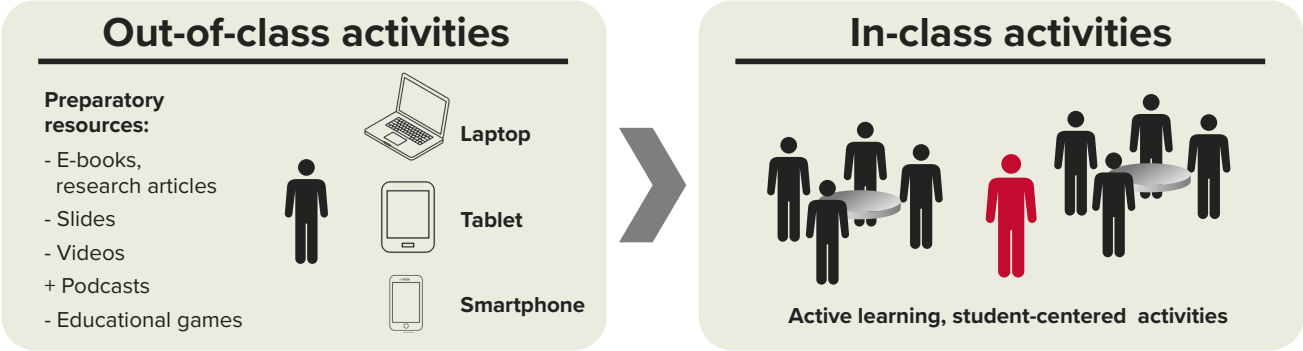

Figure 1. The flipped classroom model. The flipped learning pathway starts with pre-class preparation of students, who are asked to explore the didactic electronic resources selected by educators (*left panel*). Digital documents can be made available through computer, tablet, or smartphone. In-class time becomes available for teachers to implement a variety of student-centered, active learning strategies (*right panel*).

Students are introduced to content at home so that when they get to group learning spaces (i.e., classrooms) they can practice activities that force them to reflect upon their knowledge and ideas, and how they can use their knowledge and ideas. This allows students to apply their knowledge to challenging problems in a setting that promotes collaboration with peers and feedback from educators. Direct learning takes place outside the classroom and moves into the individual learning space (e.g., at home, on the bus, in the library, at the park) with the help of several technologies. Digital tools allow students to access teaching resources whenever and wherever convenient. Pre-class preparatory resources usually include text-based resources (e.g., e-books and research articles) (Ramnanan and Pound 2017). However, to increase students' curiosity and boost their engagement, they are frequently provided with electronic resources. These can range from slide presentations with accompanying narration to videos, podcasts, and educational games (Ramnanan and Pound 2017). Based on this educational pathway, the role of "flipped" teachers is more important than ever and, to some extent, more demanding than in a traditional class. In addition to selecting didactic materials that students should explore on their own outside of class, educators should:

- Implement a variety of student-centered classrooms activities;
- Observe, facilitate, and assess the application of these activities during class;
- Provide students with feedback.

2.4 Medical student perception and impact on student learning

On the whole, evidence in the literature indicates that medical students perceive flipped classroom activities as beneficial to both knowledge and the learning process (Rotellar and Cain 2016; Ramnanan and Pound 2017). The main strengths reported in published surveys include an increased "motivation to learn" and an enhanced level of "engagement, investment, and interest" in the subject matter. Limitations were

mainly related to how the flipped classroom was conducted, rather than "inverted" learning itself. Students questioned the selection of content delivered through this approach, which they found was overly complex for self-directed learning. They occasionally also found a mismatch between out-of-class and in-class activities, and reported some educator difficulties in keeping students engaged in the task and managing the discussion without dominating it.

While students mostly favored the "inverted" learning approach, current evidence has failed to demonstrate whether the flipped classroom actually improves medical student knowledge and learning. Conflicting results have emerged from published studies (e.g., Chen *et al.* 2017). Although these inconsistent findings may arise from limitations in the study designs, special emphasis should be placed on the assessment tools used in these studies, which predominantly measured student achievement in terms of learning outcome rather than competence level. This is in conflict with the Qualifications Framework of the European Higher Education Area, which defines the ordinary outcomes students should achieve after completing a curriculum of studies, known as the Dublin Descriptors (van Lankveld *et al.* 2020). These include the following components:

- Knowledge and understanding;
- Applying knowledge and understanding;
- Making judgments;
- Communication;
- Lifelong learning skills.

Active learning and student-centered teaching activities (including the flipped classroom) are expected to enhance these competences in undergraduate medical students. While waiting for high-quality, tailored trials to address these learning outcome issues, a growing number of medical schools and teachers are likely to adopt a flipped classroom approach.

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3 Teaching languages for medical purposes in times of the pandemic: transfer to a digital classroom

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3.1 Introduction

The pandemic of 2020 transformed tertiary education practices all over the world and made educational institutions look closer at online teaching options. An overnight transition from traditional classroom face-to-face teaching to total online communication with the students involved a number of challenges in terms of the ability to use electronic devices, choosing an online platform, content delivery, assessment, shifts in role models, etc. However, it was even more of a challenge in the case of language teaching, which requires constant feedback on the student's activity on the part of the teacher and on the part of the group.

The issue has already received a lot of attention from language teachers, ranging from reviews of online training courses for teaching English online (Codreanu 2020), to the use of technologies by ESP practitioners in specific countries (Constantinou and Papadima-Sophocleous 2020), to suggestions for professional development (Constantinou and Papadima-Sophocleous 2020), to challenges of online language learning (Krishnan *et al.* 2020), the effect of the developed blended learning model on learning outcomes (Syahri *et al.* 2020), motivation for online language learning (Prasangani 2020), and the attitude of students to online language learning (Tamayo-Maggi and Cajas-Quishpe 2020).

The papers mentioned here cover a spectrum of attitudes to online teaching and learning, varying across the nations and probably from university to university, but the authors generally agree that: (i) online methodology and resources should be well integrated with traditional classroom learning to fit students' needs; (2) teachers need more training on using technology in teaching language for medical purposes.

3.2 Setting

This article describes the experience of online foreign languages teaching at Sechenov University (Moscow, Russia), which lasted from April to December 2020.

Sechenov University has a long tradition of educating healthcare specialists in a variety of spheres, ranging from general medicine, nursing and dentistry to clinical psychology, pharmacy and related fields such as biotechnology, and so on. For any of its degree programs, foreign language is compulsory and forms an integral part of training. It is aimed specifically at professional communication, in both oral and written form. Besides this, there is an additional educational program, Translation for Medical Purposes, for students, residents, and medical practitioners, which takes three and a half years and is aimed at the development of skills of professional communication in a foreign language, interpreting, and written translation.

3.3 Aim

The research aims to obtain a clear and detailed picture of medical students' and teachers' attitudes toward online learning and teaching languages for medical purposes. The transfer to online classes occurred overnight, revealing sensitive gaps in teachers' competences and students' readiness to study all subjects of the university curriculum online.

3.4 Materials and methods

The study mainly employed a quantitative methodology for gathering and analyzing data.

The tool used for the data collection was two separate online questionnaires, one for teachers and one for students, administered using Google Forms. Each questionnaire contained 11 open-ended questions compiled based on literature review and interviews with faculty members. The questions were worded differently for teachers and for students but aimed to obtain similar information. For details, see Appendix.

We surveyed students and teachers who participated in the Translation for Medical Purposes program in January 2021. The questionnaires were completed in Russian. By January 30 2021, 125 completed questionnaires had been returned (100 students and 25 teachers).

The questions were centered around the software used for online classes, including digital tools, the scope of classwork and homework, the suitability of online classes for the acquisition of communication skills, the advantages and limitations of online language classes, changes in students' attitude to learning the language, conclusions about the feasibility of online learning of the language, and preferred course structure and mode of communication. Respondents were offered several options to choose from and could also leave their own comments.

3.5 Results

The absolute leader among the applications, used for communication by 100% of students and teachers, was Zoom. As for optional applications tried a single time, students mentioned Google Meet and Skype (6% either), Yandex Telemost (3%), Google Hangouts and Google Classroom (1% each) (Figure 1). Teachers admitted also using Moodle (20.8%), and MS Teams (4.2%) (Figure 2).

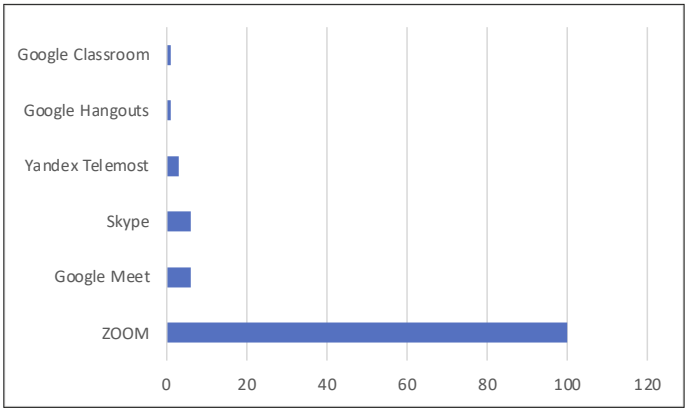

Figure 1. Applications and services: students.

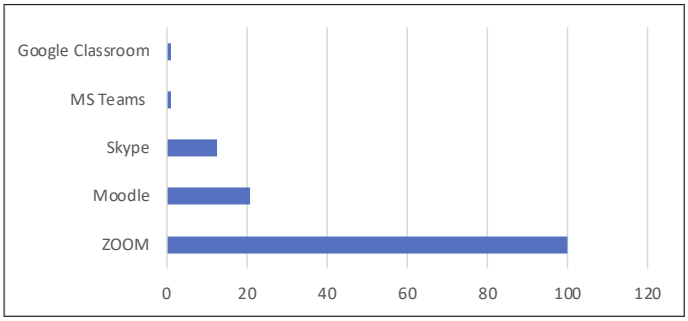

Figure 2. Applications and services: teachers.

As for the digital tools used during an online lesson, students selected screen-sharing function 92%, chat room 70%, Google Classroom 68%, listening to recordings during the conference 67%, watching video during the conference 62%, breakout rooms 56%, using whiteboard 44%, and Google Documents 38% (Figure 3). Identifying the least useful/never used tools, teachers gave the priority to whiteboards (45.8%), closely followed by breakout rooms and Google Classroom (41.7%); 12.5% said they had not played voice recordings or showed videos during the conference but in their comments added Kahoot! and Quizlet to the list (Figure 4).

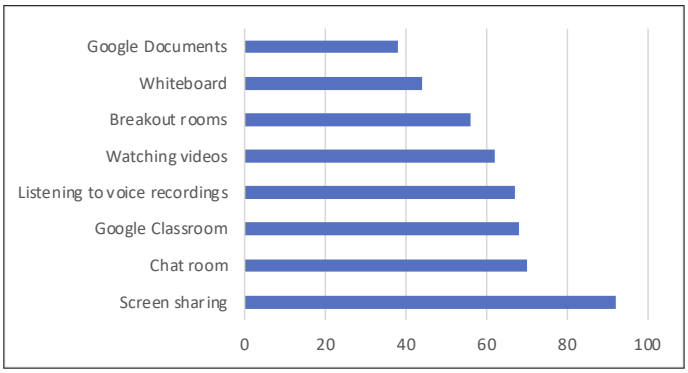

Figure 3. Digital tools: students.

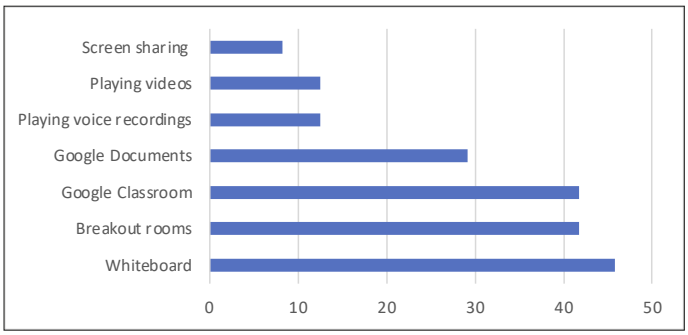

Figure 4. Useless digital tools: teachers.

When asked about the changes in the amount of face-to-face online learning, more than half of the students believed that the number of oral (63%) and written (57%) assignments done in class remained unchanged as compared to offline learning (Figure 5), and this was confirmed by 75% of teachers, who also reported no changes (Figure 6).

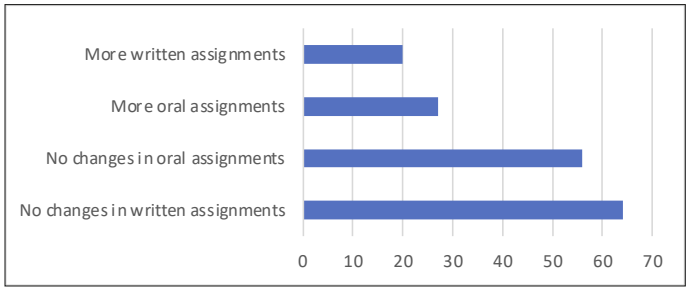

Figure 5. Face-to-face work: students.

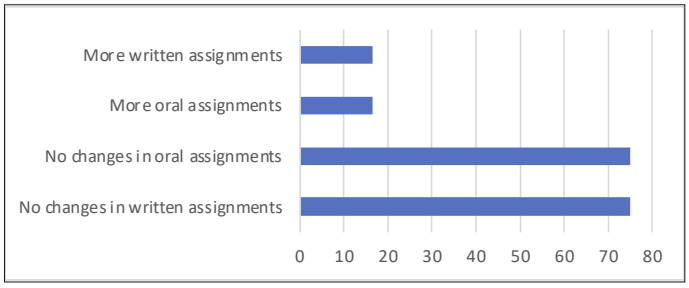

Figure 6. Face-to-face work: teachers.

Much in the same way, more than half of the students reported no changes in the scope of oral or written homework (57% and 56%, respectively) (Figure 7). A total of 70.8% of teachers said the scope of oral homework assignments remained unchanged, 58.3% reported the unchanged scope of written assignments; 37.5% of teachers gave more written assignments than offline, and 12.5% gave more oral assignments (Figure 8).

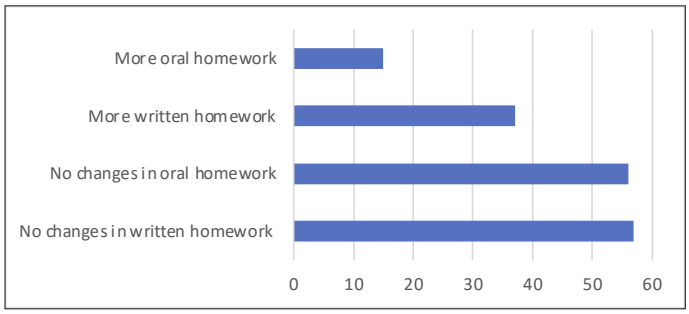

Figure 7. Homework: students.

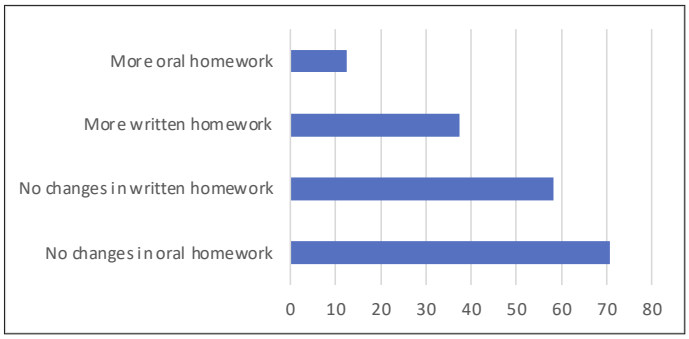

Figure 8. Homework: teachers.

The skills more easily acquired online are ranged by the students the following way: first comes active listening (36%), then writing (34%), speaking (23%), and reading (7%) (Figure 9). Teachers find writing the most suitable skill to be taught online (33.3%), while next come speaking (25%), active listening (20.8%), and reading (20.8%) (Figure 10).

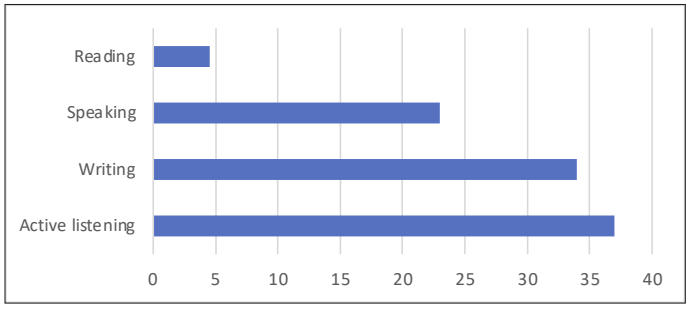

Figure 9. Skills: students.

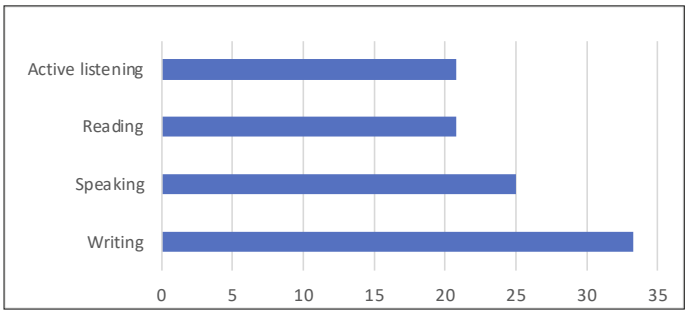

Figure 10. Skills: teachers.

Changes in attitudes toward learning after the online experience are described by the students in the following way: 64% admit they can manage their time better now, 46% feel more responsible as the result depends entirely on themselves, 27% feel less responsible as there is no immediate contact with the teacher, while only 6% feel that online classes keep them from managing their time properly (Figure 11). The students also comment that learning became more comfortable as they could join the class from any spot with an internet connection, their attendance improved, they have less fear of speaking the foreign language. There is also an alarming comment, however, that "some teachers have started to be less responsible about marking the students' papers."

The teachers assess the changes in students' attitude differently: 45.8% reported that without immediate contact with the teacher, the students show less responsibility, 25% admitted that attendance had improved, 20.8% stated that attendance had decreased, 20.8% felt the students became more responsible, 8.3% reported no changes (Figure 12). Here are some quotations taken from the teachers' comments: "if there is no motivation and ability to learn the language technology won't help"; "the students often get disconnected and say it is a technical problem but it is difficult to say whether it is true or not"; "the students have more freedom for self-expression and enjoy more functionality to show the results of their effort and take part in groupwork"; "there are more opportunities on condition that the teacher is also motivated"; "the result depends entirely on the students."

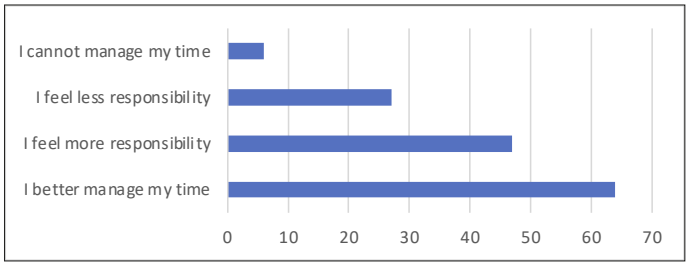

Figure 11. Attitude: students.

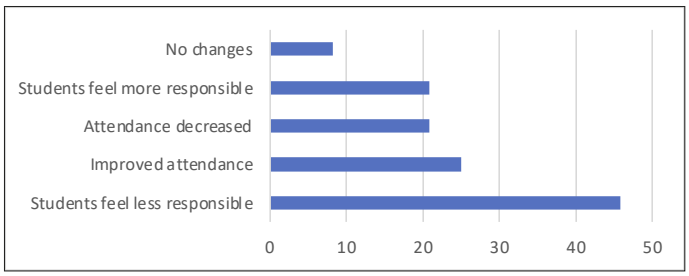

Figure 12. Attitude: teachers.

The most important advantage of learning/teaching the foreign language online is seen by both students and teachers as the opportunity to make a screenshot of the assignment and use it while preparing for the next lesson (78% and 62.5%, respectively) (Figures 13 and 14). The next valuable option, in the students' opinion, is seeing immediately on the screen the corrections to their papers (46%). This is also valued by 54.2% of the teachers. A total of 43% of students see as an advantage the opportunity to compare their own papers with the papers of other students (37.5% of teachers), 39% welcomed the opportunity to simultaneously edit the same document and see the alterations (37.5% of teachers), 35% see as an advantage the opportunity to record a part of a lesson or the whole lesson (62.5% of teachers), 34% the opportunity to learn the language with a native speaker, 19% value the opportunity of marking out the text for reading directly on the screen (37.5% of teachers), while 5% admitted that they had never done any of the above.

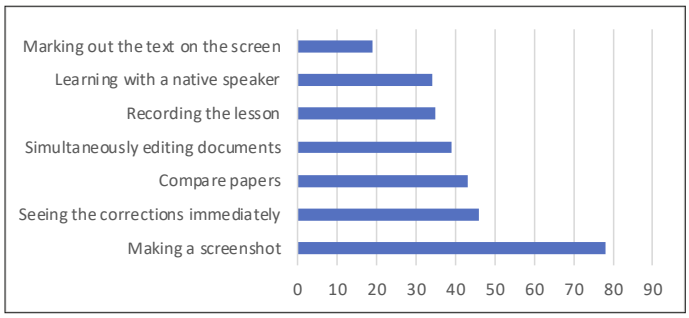

Figure 13. Advantages: students.

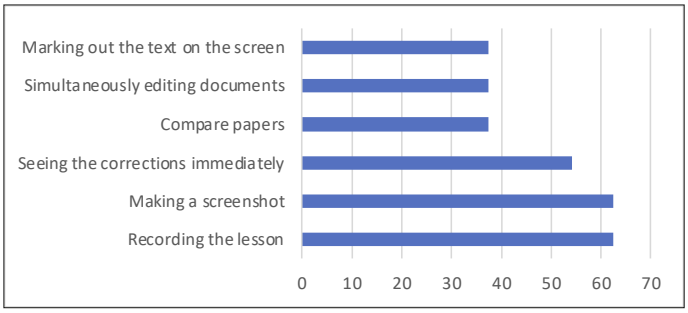

Figure 14. Advantages: teachers.

Students' comments on the advantages of online learning included: "I don't have to waste time commuting"; "I can quickly make a summary of the lecture on my computer"; "I can join the class at any time whereas when I had to come to the lecture room I was always late and often missed classes."

As for the limitations of online learning and teaching, the students believe that the principal one is bad connection (42%); this is closely followed by inability to concentrate at home (37%) and having to concentrate more on the technical side of preparation (35%) (Figure 15). A total of 26% point out that it is rather difficult to ask the teacher questions or ask for explanation, while 15% point out the inability of their counterparts to use digital tools properly and 5.1% believe a foreign language cannot be learned online. Among the comments, there were regrets that some teachers used free Zoom accounts, with all their limitations, but the majority of comments stated that the shortcomings could be overcome.

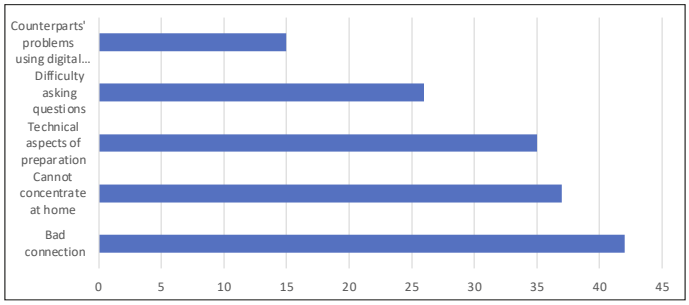

Figure 15. Limitations: students.

The teachers also selected bad connection as the principal limitation in 62.5% of cases, while 54.2% saw as a limitation the need to think more about purely technical aspects of preparation, and 45.8% the need to think more about planning the lesson. A total of 33.3% found it difficult to communicate with the student, for instance it is difficult to ask questions, and 4.2% mentioned the inability of some students to use digital tools (Figure 16). In their comments teachers mentioned that "it was difficult to speak to people in the absence of immediate contact," "we can never say if the students were completely honest while doing assignments," and "there were no problems that couldn't be settled."

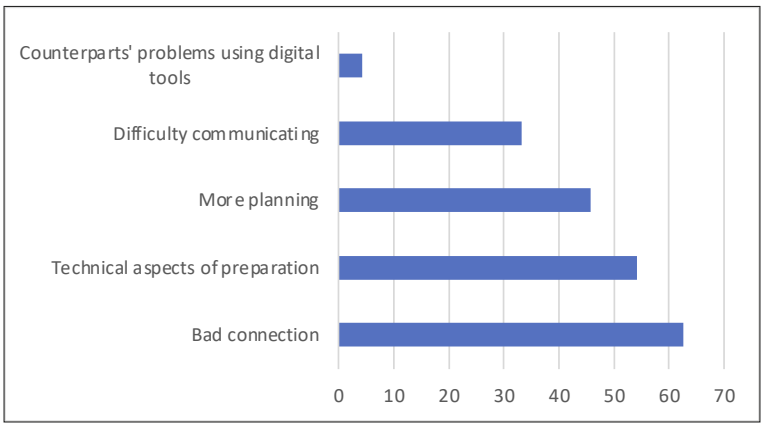

Figure 16. Limitations: teachers.

When asked to select true statements about learning the foreign language online, 61% of students chose "learning the language online is naturally determined by the development of technology," 55% "learning the foreign language online gives a lot of new exciting opportunities," 35% "it is more difficult to learn the foreign language online than offline," an almost equal number (33%) believe that "it is easier to learn the foreign language online than offline," and only 5% consider that "the foreign language cannot be learned online" (Figure 17).

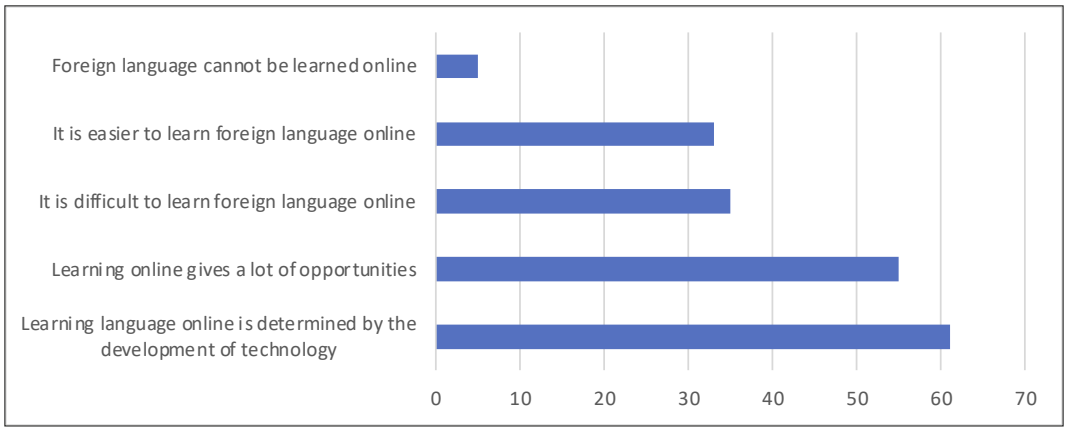

Figure 17. True statements: students.

A total of 58.3% of the teachers admit that "to teach the foreign language online, I need more digital skills," 41.7% are of the opinion that "teaching the language online is naturally determined by the development of technology," 41.7% agree that "teaching a foreign language online gives a lot of new exciting opportunities," 37.5% believe that "to teach the foreign language online, I need more skills related [to] organization and methodological support," 29.2% think "it is more difficult to teach the foreign language online than offline" (in contrast with the students' opinion, not a single one says it is easier), and 25% identify with the idea that "the foreign language cannot be taught online" (Figure 18).

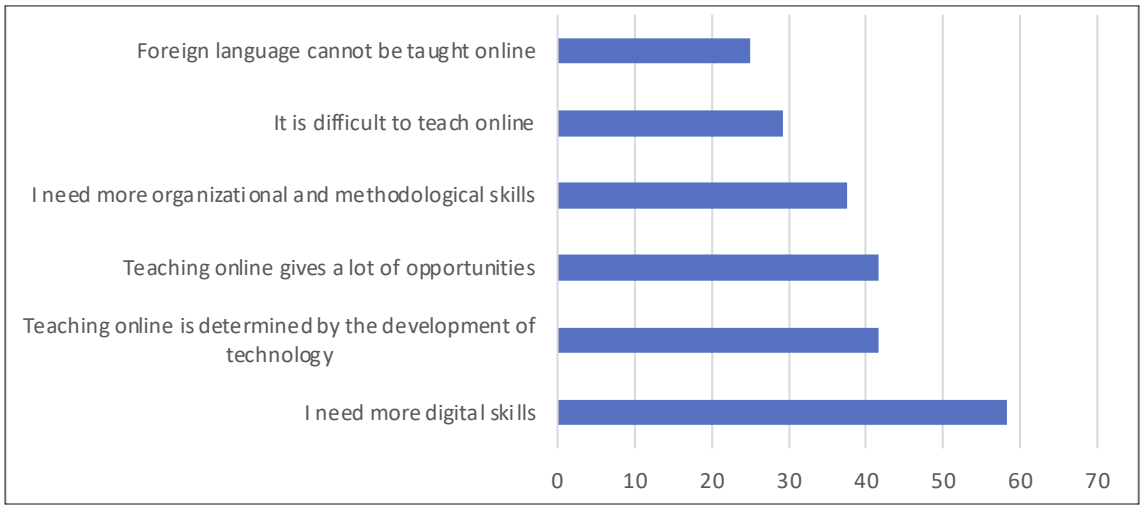

Figure 18. True statements: teachers.

In the teachers' questionnaire there was an additional question, not presented in the students' questionnaire, about the skills they need to acquire to teach the foreign language online effectively. To this, 37.5% responded "I do not need any new skills," 8.3% mention proctoring, among single answers there is "being able to involve the whole group," "a library of sample lessons," "understanding more online platforms," "playing voice recordings in Zoom conferences," "I'm ready to learn about new digital tools," "to learn more about the functions of Zoom and Google Meet," "we need a special seminar for all teachers," "to get new skills related to my needs" (Figure 19).

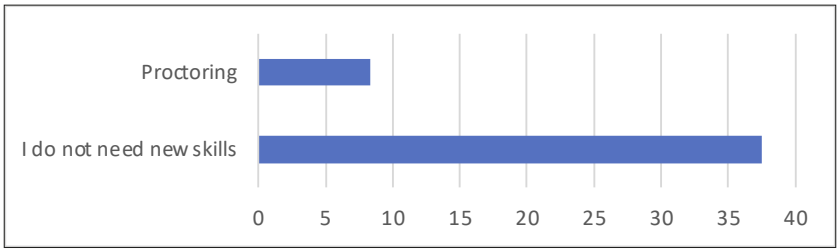

Figure 19. New useful skills: teachers.

As the preferred mode of learning the foreign language 27% of the students choose MOOC + doing assignments in Google Classroom + learning online with a teacher; 22% preferred MOOC + doing assignments in Google Classroom + learning offline with a teacher; 20% preferred Google Classroom + learning online with a teacher; and 13.1% Google Classroom + learning offline with a teacher. The options learning the language offline with a teacher, learning the language online with a teacher, MOOC + learning the language online with a teacher were preferred by 5% of students each (Figure 20).

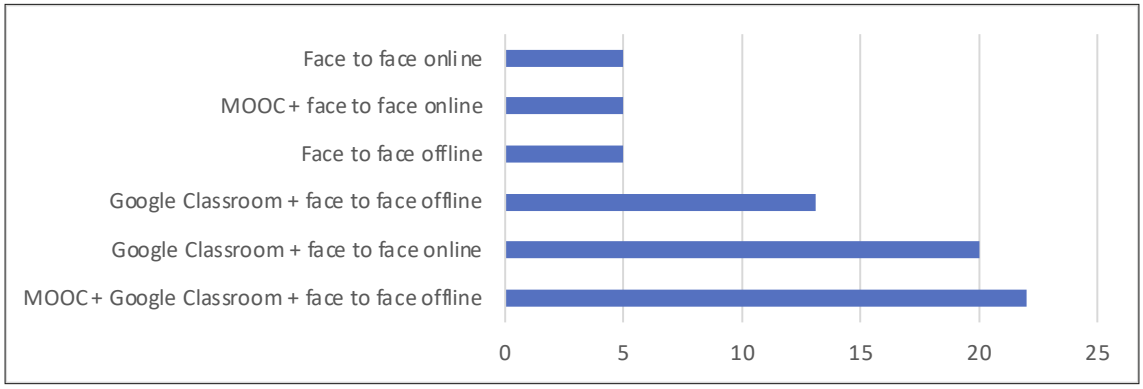

Figure 20. Preferred mode of learning: students.

As for the teachers, 54.2% preferred MOOC + assignments in Google Classroom + offline group lesson, 25% offline group lesson, 8.3% assignments in Google Classroom + offline group lesson, 8.3% MOOC + assignments in Google Classroom + online group lesson, and 4.2% MOOC + online group lesson (Figure 21).

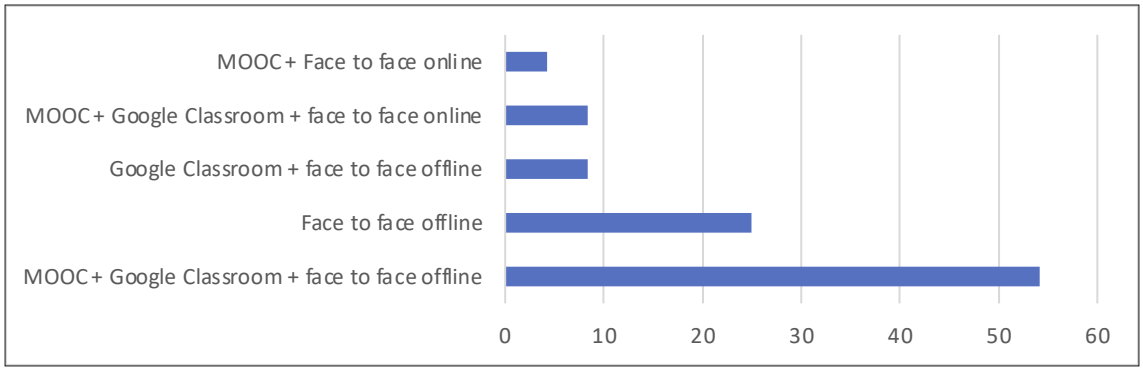

Figure 21. Preferred mode of teaching: teachers.

3.6 Discussion

The questions offered to the participants on the long-term online teaching/learning experience mainly covered three domains: academic content, venue, and attitudes of the participants to the experience.

In terms of **academic content**, the majority of the respondents agreed that there was not much change in the scope of work done in class or homework, either orally or in written form: 75% of teachers admit not giving more oral or written assignments online face to face than offline and only 25% give either more oral or more written assignments. As for homework, 37.5% of teachers give more written home assignments than offline, and 12.5% give more oral assignments, with the students admitting getting most use from active listening, and the teachers feeling they are getting the best results in writing and speaking. In the majority of cases this implies adaptation of the existing content to the new form of presentation. On the part of the students, there is an expectation of multicomponent (blended) learning, with a strong preference (60%) for online learning. As for the teachers, there is also a strong conviction that more versatile and authentic content is needed, but only about 12% are prepared to stay online.

The **venue** for face-to-face communication with the students was not the choice of the department but rather dictated by the effects of the pandemic. Each teacher was free to choose any accessible online service to interact with their students. All chose Zoom (either the free or Pro plan) due to its wide functionality and user-friendly interface. The most widely used of digital tools was the screen-sharing function, but only a little over half of the students had an opportunity to listen to the voice performing recordings or watch the video during the conference, though they value online classes mainly for their suitability for the acquisition of active listening skills. Likewise, only 70% of students used breakout rooms (indispensable online when role playing or performing any individual task in a small group). Online face-to-face communication was supplemented with Google Documents or Google Classroom as tools for assessing the written assignments.

The main difference between the two groups (students and teachers) is seen in their **attitude** toward online learning. The students generally feel more responsible for their own progress and better management of their time. In their comments they mainly stress the common comforts of online learning: not wasting time commuting, the ability to join the conference from home or from work, improved attendance, not being afraid to speak the language. They see online learning as a new opportunity, although there is no common opinion as to whether it is easier or more difficult to learn the foreign language online. The teachers, on the contrary, do not think online teaching an easier option, partly because they find it difficult to adapt to the lack of immediate contact with their students, feeling they are not in control of the situation, ready to be cheated. Though they understand that teaching online is a natural development, that it should have been expected, that it gives new opportunities, they would still prefer to continue offline. The majority of teachers feel the need for more skills to continue online teaching, but only two out of the 25 know exactly what they need (proctoring), others name the skills not directly related to online teaching (involving the whole group), are ready to use their colleagues' experience rather than create their own (a library of sample online classes, a seminar for all teachers), name the skills they can easily acquire on their own exploring the interface (understanding more online platforms, playing voice recordings in Zoom conferences), or use a vague expression "skills related to my needs."

3.7 Conclusions

Since online teaching seems to have become a permanent component of the university educational process, we find the data obtained in this survey both important and useful. Based on the data, we are designing professional development programs for the faculty that focus on particular digital skills mentioned by the survey participants. This will help to bridge the gaps that hinder online activities at language classes. Another idea is that some of the subjects of the Translation for Medical Purposes program will be digitalized, as the students find this form of learning more efficient. This is a clearly positive outcome of the changes brought about by the pandemic.

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Appendix

Questionnaires for teachers and students

Students	Teachers
Which year are you in?	Which skills do you need to acquire to effectively teach the foreign language online?
Which applications, web services or web-based platforms have you been using during the pandemic to learn the foreign language?	Which applications, web services or web-based platforms have you been using during the pandemic to teach the foreign language?
Which digital tools have you been using to learn the foreign language?	Which digital tools do you think useless/have never used while teaching the foreign language?
How did the scope of face-to-face work change after going online?	How did the scope of face-to-face work change after going online?
How has the scope of homework assignments changed after going online?	How did the scope of homework assignments changed after going online?
Which skills are more easily acquired online?	Which skills is online teaching optimal for?
What are the advantages of learning a foreign language online?	What are the advantages of teaching a foreign language online?
How did your attitude toward learning change after online experience?	How did the attitude of the students to the classes change during online learning?
What are the limitations of learning a foreign language online?	What are the limitations of teaching a foreign language online?
Which statements about learning a foreign language online are true?	Which statements about learning a foreign language online are true?
In which mode would you prefer to learn the foreign language?	In which mode would you prefer to teach the foreign language?

4 Lecture 4.0: digital and interactive enhancement of a traditional teaching method

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4.1 Introduction

The medical education landscape has been changing rapidly over the past 25 years. New technologies emerge, and new teaching formats claim equivalence to traditional courses, seminars, and lectures. New digital trends may also fall as fast as they arise. This chapter shall put a spotlight on the transformation—not the revolution—of a long-established teaching method: the lecture.

4.2 Historical perspective

Lectures are the oldest and most traditional form of conveying knowledge at university, and are as old as the institution itself. The didactic format dates back to the time when books were handwritten and rare, and a knowledgeable professor would actually read from them ("to lecture").[1]

Arguably, the format is even older, as in the Ancient Greek philosophical academies students would gather under the proverbial "olive tree"[2] and listen to the scholarly disquisitions of their mentors.

The insight, that solely verbal facilitation may not be the only way, followed in the Middle Ages. Anatomical dissections, for example, were also a visually (and probably olfactorily) enlightening experience for students (Figure 1).

[1] As a reference, please see the image depicting Henry of Germany delivering a lecture to university students in Bologna, Italy, in the mid-14th century: https://www.cabinet.ox.ac.uk/iv1-lectures#/media=3552. (Accessed November 29, 2021)

[2] As a reference, please see image of the mosaic of Plato's Academy, from the Villa of T. Siminius Stephanus in Pompeii, Italy: https://upload.wikimedia.org/wikipedia/commons/4/48/Plato%27s_Academy_mosaic_from_Pompeii.jpg. (Accessed November 29, 2021)

Figure 1. Rembrandt Harmenszoon van Rijn, 1632: "The Anatomy Lecture of Dr. Nicolaes Tulp." Mauritshuis, den Haag, Netherlands. Courtesy of Mauritshuis, The Hague.

The modern age advanced the lecture format further. With the launch of television, distance education became possible (Hensley and Palmer 1975; Bates 1988). In the 1970s, the introduction of videotapes made lecture capture possible (Paegle *et al.* 1980). Other notable quantum leaps in technology were projectors, mounted slides, computers (Wofford *et al.* 2001), and of course the internet. Now, the digital landscape of the 21st century opens up even more possibilities.

4.3 Didactical concept

The didactical premises for lectures have scarcely changed over the centuries. The lecturer is an expert, a source of knowledge, who delivers systematic and organized information to a number of students. The format is highly economic because one lecturer can teach many students simultaneously. Being a traditional and "old-fashioned" method, the concept of lectures was questioned more and more by educationalists at the end of the last century. The main criticism is that students are degraded to passive recipients and learning as an active process is not fostered through this format (Deslauriers *et al.* 2011). There is, however, enough evidence that lectures are as effective as other methods in conveying knowledge to students (Bligh 1998). Lectures' efficacy in promotion of thought, change in attitude, or behavioral skills is very questionable (ibid.). "Modern" lectures now more and more incorporate active learning strategies to foster knowledge acquisition (Butler 1992).

4.4 Lecture 4.0: digital possibilities

The transformation of the lecture continues in the 21st century. Although lecture capture is actually older than one may think, the consistent use of computers for teaching, learning management systems (LMS), the massive price drops of hard drive memory, and the accessibility of data via the internet, have contributed to advancing lectures to the next level. The new digital possibilities have made lecture capture a common feature in many universities (Tang *et al.* 2018). Video lectures, or video podcasts, present advantages and disadvantages: students appreciate the possibility to stop, review, repeat, and accelerate the video, but they still prefer live lectures (Cardall *et al.* 2008; Schreiber *et al*. 2010). From a didactical point of view, the premises for instructional design may change with online lectures. Mayer's Theory of Multimedia Learning (2020), being probably the most common and best known, is however rarely applied to online lectures (Tang *et al.* 2018).

With many advancements, the entertainment industry anticipated the innovations in teaching. Preceding the proliferation of lecture capture, the mid-2000s saw the upsurge of video-on-demand (VoD) services like Sky, Hulu, Netflix, and later Amazon Prime. Higher-education institutions adapted and introduced learning platforms, which contained video lecture repositories (da Graça Pimentel *et al.* 2001). Video-on-demand and YouTubeTM paved the way that led to the upsurge in success of MOOCs (massive open online courses) in 2012 (Pappano 2012). The hype was real at that time: MOOCs were said to revolutionize higher education by making lectures and even universities obsolete. Over time, however, problems unfolded: personal address and a connection to the teacher were lacking, students were more reliant on self-motivation and self-discipline (Littlejohn *et al.* 2016). The same principles apply to a pandemic, where teaching has to be transferred to online settings. The factual problems marking the decline of MOOCs were worse student performance (Bettinger *et al.* 2015) and huge dropout rates, which averaged at over 90% (Jordan 2014; Israel 2015). Our own institute was fortunate to host the first medical MOOC in Germany. The response was huge, with more than 7,000 subscribing participants; however, less than 1% successfully completed the course. MOOCs still retain a place in higher education: in postgraduate training, where the flexibility of the programs is important, and the intrinsic motivation is high.
The next evolutionary step in entertainment followed in 2014 with live streaming, whereby "live" means a synchronous broadcast. Affordable hardware and broadband internet enabled seemingly everyone to produce live content, which led to the striking success of Twitch.tv around the globe. Other platforms, like Mixer (Microsoft), Facebook, and YouTube, followed with similar services. University teaching has yet to adapt on a larger scale, but there are already lighthouse projects employing live streaming for education (Bridge *et al.* 2009; Rossouw 2020). One of these is Tuebingens' Sectio chirurgica (Hirt *et al.* 2010).

4.5 Tuebingens' Sectio chirurgica as a best-practice example

Tuebingens' Sectio chirurgica is an interactive, interdisciplinary live-stream lecture accompanying the dissection course. Following an upsurge in curricular reform approaches for more horizontal and vertical integration at the beginning of the 2000s, Tuebingens' Faculty of Medicine opted out of a fully reformed, problem-based curriculum. In contrast, multiple alternative and novel teaching strategies were developed to assure teaching of interdisciplinary and interprofessional interrelations. One of the results

was Tuebingens' Sectio chirurgica (TSC), a surgical-anatomical prosection, contextually in parallel to the dissection of the traditional gross anatomy course (Hirt *et al.* 2010). Arranged like a lecture, the Sectio chirurgica presents clinical cases of varying (mainly surgical) disciplines, presented by an anatomist.

The key concept of the lectures is to link the basic science knowledge of the topographical anatomy to its clinical application in surgery. To achieve this, each episode is framed by a (virtual) patient case. In every episode, different aspects from history taking, diagnostics, the actual surgical treatment, of course, up to post-op procedures and follow-up care are presented. This is supplemented by anatomical presentations or live prosections. The centerpiece is a surgical procedure, which is simulated on an anatomical specimen. The anatomical setting leaves the surgeons much more time to explain the surgical approach, as there is neither bleeding, time pressure nor an impatient anesthesiologist.

Following the high demand of local students at its launch in 2008, the TSC was transferred to the internet. Since 2009, it is streamed live on a specially created website (https://www.sectio.digital). The platform requires registration, as access is limited to medical and paramedical students and practitioners (nurses, midwives, physiotherapists, paramedics, etc.). The closed access is necessary for ethical reasons and personal rights, as anatomical specimens are shown.

The technical requirements for TSC were created with a custom-built TV studio, where the interactive lecture is produced. The production site includes a digital OR, a green screen studio, and a control room (Figure 2).

Figure 2. Digital OR, green screen studio, and control room at the Institute of Clinical Anatomy and Cell Analysis, Tuebingen.

In more than 17 seasons and way over 100 episodes, the teaching concept matured and incorporated more and more features. Several special episodes were produced, including robotic surgery, virtual reality (Figure 3), and complex emergency scenarios (Figures 4 and 5).

One of the main characteristics of TSC is that it is produced (and viewed) live. This opens up the possibility to interact with the viewers—a feature that is valued by students in on-campus lectures and that cannot be provided in videos. The live-stream platform not only provides the live transmission, it also includes interactive features. Participants are able to chat with one another, and can direct questions to the moderator or the operating surgeon. Live online voting tools are in place, even enabling interactive surgery—students can, for example, vote on different surgical approaches.

Additional information is provided via a "second stream screen"; this may include additional camera views, peeps behind the scenes, annotated pictures from surgery, secondary literature, or anatomical drawings.

Figure 3. Sectio chirurgica episode with surgical planning via virtual reality (VR).

Figure 4. Sectio chirurgica episode on intensive care treatment of Covid-19 infection (season 17, episode 1).

Figure 5. Sectio chirurgica episode on emergency rescue training.

At the time of launch, Sectio chirurgica immediately hit the nerve of the medical student population. In no time, the platform registered up to 30,000 participants, which equals about one-third of all medical students in Germany. Following demand, English live commentary was added a few years later, to allow access from other countries in the world. In winter term 2020/21 the first season aired with contributions from universities of the CIVIS university alliance.

4.6 Educational research on live-stream lectures

The innovative format called for research questions to analyze if students can actually benefit from the live stream. For education research, "live" means synchronous—recorded lectures sometimes are also labeled as video streams, but these are asynchronous (Bridge *et al.* 2009).

A first study in Tuebingen compared the exam results of students who viewed TSC to those of students who did not view TSC. The final exam was two-fold, comprising basic anatomy multiple-choice questions as well as clinically applied multiple-choice questions. While there was no difference in basic anatomy knowledge, students who viewed TSC performed significantly better in answering questions that required transfer (application) of knowledge (Shiozawa *et al.* 2017).

These results could also be reproduced in a multicenter study, with participants from universities employing either a traditional or a reformed (integrated) curriculum. In a study design with two measurements (pre-/post-test) participants from all universities showed a significant performance increase in clinically applied anatomy knowledge (preliminary data). This effect was independent of the curricular model, although there were notable differences between the different institutions. Arguably, these may stem from differences in prior subject knowledge, as the TSC topic used in this study (female pelvic organs) was placed differently in each curriculum. Thus, students from each institution had different immersion and preliminary knowledge.

Streamed via the internet, it is to question if (and how) a live-stream lecture is different from a recorded lecture video. A subsequent lab study compared the TSC live-stream lecture with a lecture capture of a traditional lecture providing the same information. The live-stream format was perceived better in terms of comprehensibility of the presentation, conceivability of the surgical procedure, and entertainment. Again, the participants of the live-stream lecture acquired more clinical knowledge. Analyzing the learning increase with a mediation analysis, the results show that entertainment is the main factor conducive to academic achievement (Grosser *et al.* 2019).

With the patient-centered episode design, TSC can also open up a holistic view on patient care. This allows to include allied health professions in introducing undergraduate students to interprofessional education. Interprofessional collaboration may not be learned through videos (it must be experienced), but the live-stream lecture can convey attitudes and values with role models. In a study with medical and physiotherapy students observing an interprofessional TSC episode, participants' attitude toward interprofessional learning improved in both groups (Grosser *et al.* 2020). Interprofessional live-stream lectures can provide an introduction to interprofessional collaboration in undergraduate education and pave the way for interprofessional education in the clinical setting.

4.7 Proposed success factors for live-stream teaching

Live-streaming lectures are still a new format, so is it a venture that is worthwhile to embark on? And how can lecture live streaming be successful? From current research and experience, several success factors can be discussed.

The most obvious success factor for live streaming might be interaction, as this is the most distinguishing point compared to recorded video lectures. Also in traditional lectures, active learning and participation can modify a lecture to be an exciting, inspiring, and effective learning mechanism (Butler 1992). The moderator or lecturer in a live stream can communicate, answer questions from the audience, and ask for opinions or explanations from the students. First, preliminary study data on the interactivity of live-stream lectures suggests that interaction can be influenced by the moderator. This goes both ways: in a randomized setting, students were routed to one of two chat rooms, blinded to the fact that there were actually two. The moderator interacted with only one chat room, resulting in significantly more chat activity in this room, and ceased interaction in the other. Data from educational research confirms that interaction in lectures is beneficial for the academic outcome (O'Loughlin 2002; Ernst and Colthorpe 2007; Blasco-Arcas *et al.* 2013), however this is yet to be proven for a live-stream online setting like Sectio chirurgica.

The second putative success factor is entertainment. This is again not necessarily a characteristic of lecture live streaming, but the elaborate production setting lends itself to exploiting this possibility. With a relatively high production value, research data from our own experiments suggest that entertainment mediates the learning increase when comparing recorded lectures to live streaming (Grosser *et al.* 2019). Other authors also conclude that employing entertainment techniques in (video) lectures can foster student engagement and contribute to academic achievement (Choi 2018).

4.8 Future prospects

The lecture format has proven to be quite resilient to change. Although it is obvious that it may not serve all the purposes it was designed for, the digital era may further advance its strengths and hone notable features. The live-streaming lecture can be a part of the evolution, as it allows interaction with large groups of students in a digital setting, independent of lecture halls.

Nevertheless, digital live-stream lectures will probably not replace the traditional lecture. The current pandemic highlights vividly what students are missing: personal interaction with their fellows. The social value of the lecture should not be underestimated, although it may not (directly) contribute to the desired academic outcome.

Live-stream lectures do however have the potential to tackle several challenges, especially in a situation where digital teaching is more relevant than ever. Live streaming can go beyond lecture capture and open up the possibility to foster student–teacher interrelations in distance education. Interactivity in lec-

tures can contribute to engagement of students and active learning. Live streaming can be entertaining, which again leads to engagement and improved learning outcomes. The technological possibilities are there—we should not refrain from using them to our advantage.

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5 Online and blended learning for distance students: examples and lessons learned

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Abstract

Maastricht University has a strong history in problem-based learning (PBL), based on principles of constructivist learning. PBL has shown to be effective when students are on-campus and study full-time, but how do we cater for master-level or post-academic students who are working professionals and live far away? Many online courses fall back on teacher-led "old-fashioned" instructional designs.

We present three successful examples of student-centered online learning:

1. A small-scale blended course that features synchronous, online discussions;
2. A middle-scale completely online course without synchronous contact;
3. A large-scale MOOC about PBL.

The examples illustrate that there is no one-size-fits-all solution for student-centered online learning. The instructional design needs to be adapted to characteristics of the target learners, the setting and the available resources. Lessons learned are summarized in the conclusions.

5.1 Introduction

In higher education, there is a clear need to accommodate diverse learner populations, such as working professionals and students living at distance. This requires measures to increase flexibility and accessibility. To achieve this, many post-academic programs are offered online or largely online. Current learn-

ing theories, however, stress the importance of constructive, contextual, collaborative, and self-directed learning (Dolmans 2019). In face-to-face higher education, this has led to the adoption of small group learning formats, such as problem-based learning (PBL) (Barrows and Tamblyn 1980) or team-based learning (TBL) (Michaelsen *et al.* 1982). Given the benefits of cooperative learning (Johnson *et al.* 2014), there is a need to develop cooperative learning activities in online education. However, the combination with online learning is by no means self-evident.

Online PBL with synchronous tutor group meetings has been used successfully on a small scale with part-time students. Research shows that online synchronous PBL meetings can be similar to face-to-face PBL when students and tutors are motivated and prepared, and adequate technical support is available (De Jong *et al.* 2014; Barber *et al.* 2015; Verstegen *et al.* 2016; Edelbring *et al.* 2020). The Covid-19 pandemic has forced higher education institutions to move to large-scale online education, but there was not time for purposeful redesign of courses. Furthermore, simply moving PBL group meetings online is not possible when students are working professionals and/or live in different time zones.

Moving education online changes the way that students interact with one another and with teachers. Adapting to this requires careful reconsideration of learning activities, the structure of the course, and the roles of students and teachers. In this chapter, we present three examples of student-centered online solutions for different target groups of students. The examples illustrate that there is no one-size-fits-all solution. The instructional design needs to be adapted to characteristics of the target learners, the setting, and the available resources. Lessons learned are summarized in the conclusions.

5.1.1 Example 1: small-scale, blended, with synchronous online contact

The online course on Intervention Development at Maastricht University is an eight-week course that is part of a regular master's degree program in Health Education and Promotion (de Nooijer *et al.* 2021). This course is offered online to make it more accessible for part-time students. The rest of the program is face to face. The study load is 20 hours per week, and start and end dates are fixed. The general aim is to outline and justify a health promotion intervention. Participants are full-time or part-time students with a diversity of backgrounds. Groups of four or five students work online on a group assignment where they have to design a health promotion intervention based on the intervention mapping protocol (Bartholomew-Eldredge *et al.* 2016). This is an authentic task in the health education domain, and one that requires group work because it is too big for one student to accomplish alone.

Students introduce themselves in detail by completing a profile and recording a video. Students are explicitly invited to watch and respond to their fellow students' clips beforehand. At the start of the course, each group discusses how they want to collaborate and communicate. They fill in a team charter that specifies their roles, the task division and deadlines. They agree on when to meet and which tools to use. The team process is discussed explicitly every week, and groups are asked to submit two tops (things that went well) and two tips (areas for improvement) on collaboration as a team.

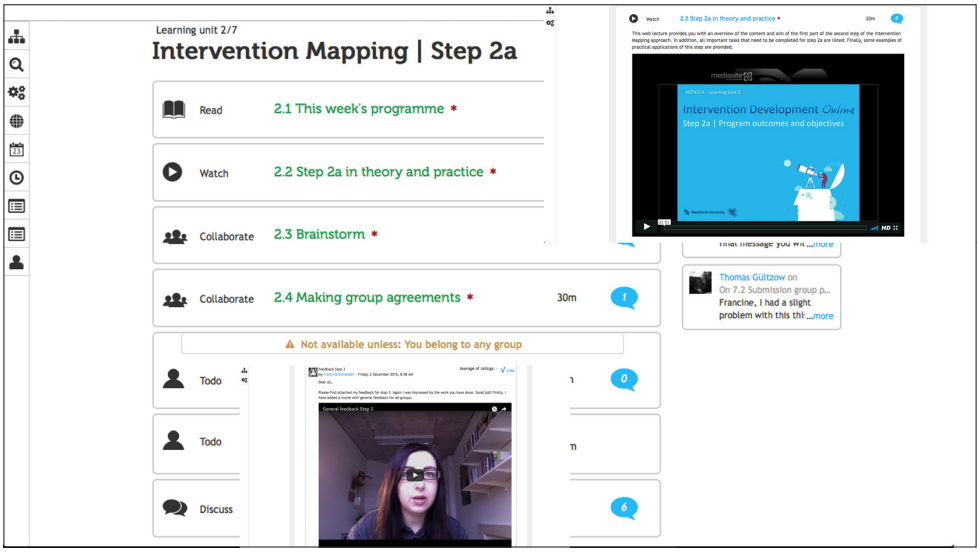

Figure 1. Learning environment for the online course on Intervention Development.

Based on the experiences with this course, de Nooijer and colleagues (2021) provide the following recommendations for the design, the students, and teachers with respect to online group work:

1. Construct learning tasks that force students to collaborate in order to attain a common goal.
2. Develop collaboration scripts that explicitly structure activities and communication.
3. Organize discussions about team processes and make expectations explicit.
4. Provide a range of communication and collaboration tools.
5. Ensure that teachers are present and visible in the online environment.
6. Provide feedback on task and group processes.
7. Stimulate students to invest in getting to know one another.
8. Ask students to reflect on their collaboration.
9. Stimulate students to put effort into creating a positive team atmosphere.

5.1.2 Example 2: middle scale, fully online and asynchronous

The Master of Health Professions Education (MHPE) is an accredited post-academic Master of Science program offered by the School of Health Professions Education (SHE) of Maastricht University (https://she.mumc.maastrichtuniversity.nl/). The two-year part-time MHPE program targets working healthcare professionals who are (going to be) involved in education in their own professional domain. The MHPE is offered as a blended, part-time program: there are two contact periods of three weeks in Maastricht,

or at one of the partner sites. The rest of the year students work at distance and part-time. Since all students are working healthcare professionals and live in different time zones, contacts during the year are mostly asynchronous.

Students mostly work on assignments that are representative of authentic problems in the health education domain. For example, in the third unit they perform a curriculum analysis on a curriculum that they are involved in themselves (usually as teaching staff or supervisor). They investigate stakeholder views, draw conclusions about strong and weak points, and propose a concept design for improvement. They also perform a mini-literature review on a topic that is relevant for their setting. In addition, they review the assignment of one of their fellows. To provide guidance and stimulate interaction, a number of measures are taken:

- Staff have recorded short, informal video clips to introduce themselves and to discuss important theoretical concepts of this unit (optional).
- Students post a short description of their curriculum in a blog (optional).
- Students are stimulated to contact peers working on similar curricula and/or similar problems (optional).
- There is a discussion forum to ask questions (optional).
- Teachers organize two or three question hours at different times to accommodate for time zones (optional).
- Students give peer feedback to one of their peers (obligatory).

At the end of the unit, students hand in their final curriculum analysis and concept redesign, a short reflection on their approach, the peer review, and the mini-literature review. Teaching staff grade these products and provide brief feedback.

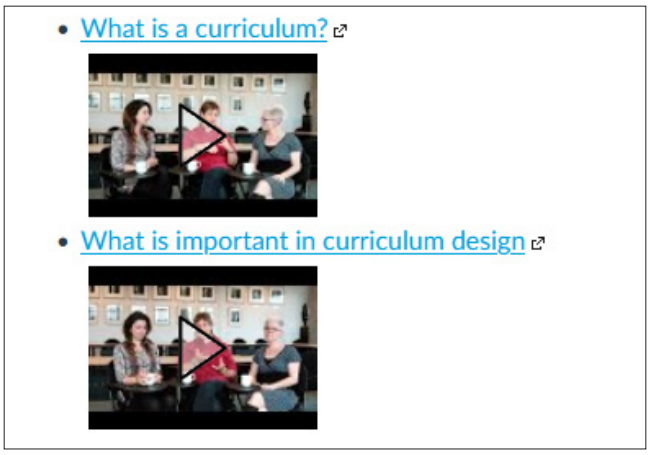

Figure 2. In short, informal clips, unit staff introduce themselves and discuss important concepts.

Student evaluations of this unit are quite consistent over the years, and show that students value the assignments and think they have learned a lot (scores >4.5 on 5-point scale). The workload is perceived as high, and the unit is seen as difficult, but also relevant. Since they are working with their own curriculum, many students can immediately use the results in their everyday work. The interaction with stakeholders—usually their own colleagues and students—is quite time-consuming. In their reflections, however, students often comment that this interaction was an eye-opener. They also report that the interaction with fellow students and teachers had been more important than they thought beforehand.

Experience shows that students have many questions at the beginning of the unit. The assignment is, purposely, a very open assignment and many students need support to interpret what is expected, which part of their curriculum they can use for the analysis and redesign, and how they can approach this task. Additionally, in this global audience not everyone is used to being asked to reflect and be openly critical toward their own curriculum, their own work, their fellow's work, and scholarly papers. The discussion forum, blog, and intermediate feedback help to address this. The experience of teaching staff is, however, that it is important to answer quickly, and to keep on stimulating students to ask more questions. The question hours are not much frequented, even though students regularly indicate that they miss synchronous contact moments, presumably due to scheduling problems.

5.1.3 Example 3: large-scale MOOC with little teacher support

The MOOC "Problem-based learning: principles and design. Students at the centre!" was designed to focus on interactive group work, while following PBL principles to enable constructive, contextual, collaborative, and self-directed learning (Dolmans 2019). The MOOC was free of charge and there were no entrance requirements. It was executed twice, in autumn 2015 and 2017 (see Figure 3).

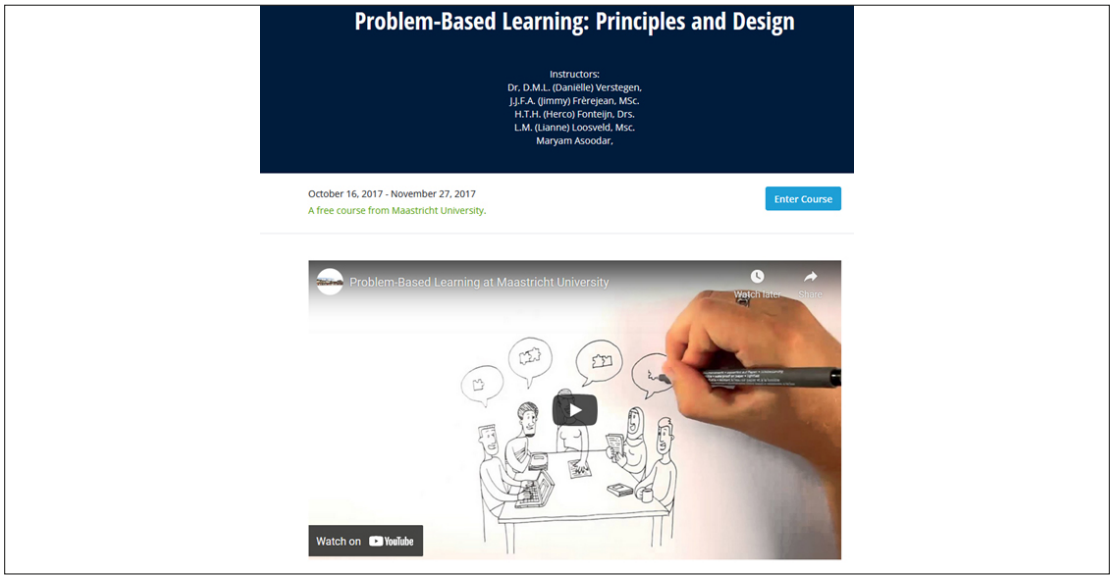

Figure 3. Start pages of the two runs of "Problem-based learning: principles and design. Students at the centre!" The 2015 run on the left and the 2017 run on the right.

Participants in the PBL MOOC were asked to form their own groups using the search facilities of the platform (NovoEd: https://novoed.com). After completing a team charter, they worked on four authentic PBL problems. The groups worked independently, without a tutor. Since participants were expected to vary widely in background and preferences, the MOOC design intentionally gave groups freedom in deciding what to focus on in more detail, and in how to interact and work together. There was no exam or assessment; participants who completed all assignments received a certificate of participation. The workload for participants was estimated at four to eight hours a week. (For a more detailed description, see Verstegen *et al.* (2019).) The first run of the MOOC had 2,799 participants and a completion rate of 9.4%. In the second run, there were 894 participants with a completion rate of 12.1%. Participants came from all over the world (see Figure 4).

The results of evaluation research showed that it is possible to apply, to a large extent, the principles of PBL in the context of a MOOC. Participants discussed authentic problem cases in groups and followed a similar structure as in regular PBL: a brainstorm phase in which they collaboratively generated their own learning questions; a self-study phase in which they individually searched resources to study; and a reporting phase in which they collaboratively discussed what they had found. In the absence of tutor guidance and feedback, participants learned with and from one another (Verstegen *et al.* submitted). Questionnaire results showed that participants who completed the MOOC were very satisfied with the design, the learning materials, and the learning process in the PBL MOOC. It seems that successful groups managed to collect insights from active group members, despite dwindling numbers of active participants and a large number of participants who were new to PBL, MOOCs, and virtual group work. Individual completion rates were comparable to those for other MOOCs or slightly better (9.4% in the first run and 12.1% in the second run, cf. Reich and Ruipérez-Va-

Figure 4. Google maps showing global participation in the MOOCs. The 2015 run on the left and the 2017 run on the right. (Note that not all participants pinned themselves on the map; this was a voluntary action.)

liente 2019). At group level the completion rates were a lot higher (44.0% and 51.4%, respectively), presumably because those who committed to group work were more motivated than those who did not take action to join a group.

Inspection of the assignments shows truly creative and innovative thinking and co-creation of knowledge. However, the envisioned kind of learning was not realized in all groups, and the absence of a tutor may have been an important factor in this. Tutors are an important part of PBL (De Rijdt *et al.* 2012). Observation of group interactions of successful teams revealed that these online, virtual teams can collaborate on learning tasks without extensive guidance, but this requires additional communication, and technological skills and support (Verstegen *et al*. 2018). Explicit discussion about group organization and task work, a positive atmosphere, and acceptance of unequal contributions seem to be positive factors. Additional support is required to prepare participants for virtual teamwork, develop digital literacy, and stimulate more elaborate brainstorming and discussion.

5.2 Conclusions

The three examples described above show that successful student-centered education is possible and feasible online. They show a variety of student-centered formats that share many characteristics with PBL, although they might not be fully classified as such in a strict definition: learning is centered around authentic problems and the course design stimulates contextual, constructive, collaborative, and self-directed learning (Dolmans 2019). They also illustrate how the course designers have adapted to the context, target group, and resources. When synchronous contact is possible, online discussions can be as effective as face-to-face discussion (Verstegen *et al.* 2016). When students are working professionals, this can still work, but it might be better to allow the student groups to make their own appointments (as in Example 1). When these working professionals also live in different time zones, it might be necessary to give up on the idea and reshape the learning activities. That is why we moved to a format that allows students to work far more individually in the second example. We reduced the amount of interaction required from students and thought carefully about the roles of students and teachers throughout the course—for example, moving most of the teacher efforts to giving elaborate feedback midway instead of at the end, because there are no (synchronous) meetings. In the third example, the context of the MOOC forced us to move to a design with very little teacher involvement and support. In this example, we moved all the responsibility for shaping the learning process to the participants, and gave them full freedom in deciding what to do and how to interact. We accepted the massive dropout, which is common in MOOCs, and accepted that the groups decided for themselves what to focus on and how much time they wanted to spend on the course. Therefore, there was no exam, just a certificate of participation.

The most important lesson we learned is that successful online education requires careful preparation. Simply moving face-to-face education to online delivery leads to suboptimal solutions. This might be necessary in a crisis, such as the Covid pandemic, but it will not suffice to cater for different target groups, such as post-academic students. The design of good online education starts with a careful analysis of the target group: their entrance level, but also their living conditions, study habits, and study skills.

In post-academic education, the target group is often varied. This asks for flexibility and adaptability. Allowing groups to choose their own means of communication and their own approach makes it possible to divide roles and tasks according to each team member's strengths and availability (Filius *et al.* 2018). Providing a clear structure to support the group process (e.g., in the form of a collaboration script in Example 1 and the PBL steps in Example 3) can help groups to finish tasks in time. Stimulating groups to explicitly and repeatedly discuss their progress and their collaboration also helps. Another solution can be to allow students to work more individually and at their own pace, as in Example 2.

What an online course can look like depends on the available resources. It is clear that students and staff need adequate technological resources and support. They may need a combination of additional skills for online (international) collaboration online, including competences related to ICT, intercultural and cultural, communication and language, self-management and organization, collaboration, and domain-specific competencies (Verstegen *et al.* 2018; Kolm *et al.* submitted). Results of this review showed that little is known about how such competencies can be integrated into online learning environments, and how they can be assessed. Furthermore, online teaching can be very demanding for staff (Whittet 2021). Staff time will often be used differently, and the roles of students and staff might shift, especially when students are also working professionals and thus adult learners. Our experience is that the visibility of teachers is important. Garrison and colleagues (1999) further elaborate this into different domains of teacher presence to explain that in the online environment teachers have different roles, not only in teaching the course content, but also in organizing the students' activities and interactions, and the social processes involved in online collaboration. Intermediate, formative feedback helps students to keep on track

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Online education is different from face-to-face education in many ways. Building trust requires explicit time and attention. Expectation management and providing a clear course structure with explicit moments for (synchronous or asynchronous) contact stimulate interaction. However, it is also important to keep the course design simple and allow students to take the lead.

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6 Health and life sciences digital learning for various target audiences within innovative university ecosystems: case studies

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Abstract

The health and life science ecosystem is subject to rapid cycles of technical and procedural innovation, making lifelong learning essential for all sector stakeholders. However, there are major obstacles to the organization of, and access to, continuing education. This chapter illustrates six case studies launched at the sector's request. They reveal how the use of digital learning and a hybrid approach (combining classroom-based and remote learning) boosts learnability, creates more dynamic learning environments by providing a more effective response to expectations, and removes obstacles by streamlining access to training for as many learners as possible.

6.1 Introduction

The health and life science sector is a complex socioeconomic ecosystem as it encompasses a wide range of roles and stakeholders who work as part of a daily effort to improve human health. The research and education taking place within universities contributes to the sector's dynamism. While innovation stems from the results of research, lifelong learning is a powerful tool for transferring knowledge and skills and maintaining the high level of skills required in this sector of activities.

This evolving ecosystem, characterized by rapid cycles of innovation, has a constant need for new skills, and demands that a varied pool of talent profiles is at hand to support it as it grows. To illustrate this

need, a campus that is home to health, biomedical, biopharma, and life sciences departments will also be home to around 300 different professional roles (IFIC 2016; BioWin 2020). These roles are occupied by employees from a varied range of complementary professional backgrounds, with very different educational backgrounds spanning the ISCED levels.

It is not realistic to expect that, today, a lifetime's worth of skills can fit into a single initial qualification, whatever the level of education. The knowledge and skills acquired should be seen as perishable goods that always need to be refreshed. Learnability is a key concept that should be encouraged, and lifelong learning is an effective way to do so.

However, a series of obstacles face continuing education. First, European surveys (Eurostat 2016) describe the barriers encountered when trying to access adult education and training. These include a lack of availability and a lack of time, costs, health problems, the lack of employer support, course content that does not match field realities, geographical distances, entry criteria and, last but not least, a negative opinion associated with initial training that was not stimulating enough.

Second, particular aspects of the health ecosystem complicate the delivery of training programs. Examples of these include the speed with which knowledge and skills become obsolete, the rapid growth of particular activities, the lack of equipment available for training, along with its cost, the diverse range of profiles that require training, and the mobility and geographical locations of attendees.

If learning strategies that remove the obstacles listed above can be developed, continuing education is an essential tool for lifelong career development (Toffler 1974). We present six case studies to illustrate hybrid or 100% online training models that are agile and flexible enough to meet health and life science field expectations and overcome the constraints highlighted above.

6.1.1 Case studies

We ran each case study in response to the field requirements. The course's pedagogical and didactic approaches were developed according to the context of their target audience. For each case study, we will clarify the context, the target audience, the methods used, and the results obtained.

6.2 Training needs that require equipment or environments that are not readily available

6.2.1 Context and target audience

Access to specialist equipment—often expensive and quickly obsolete—is a real obstacle to training. Due to budgetary or technical reasons, initial and continuing education providers do not always have access to this equipment. The development of digital training modules could remove this obstacle by enabling experimentation in an e-laboratory environment, among other things for procedural manipulation (Blumstein *et al.* 2020). Here we present two examples of this, each with its own target audience, namely flow cytometry and cell culture using a laminar flow hood.

6.2.2 Training model and methodology

A flipped classroom to teach flow cytometry

This case study used a flipped classroom model for vocational course teaching staff (undergraduate level) and their students, for training in the theory and practice of flow cytometry. There were two learning phases: independent study for the theory phase, and a laboratory-based practical phase. More specifically, the theory was taught through an online module that presented how the device worked, along with the underlying theory, accompanied by concrete examples to put the theory into context. To consolidate and cement this independent learning, students could complete quizzes to test their understanding of the module as part of a self-assessment process. Once students had completed the theory course, the next phase was live experimentation in a professional environment with supervision from a technical expert.

Teaching cell culture with a virtual reality serious game

This teaching method consisted of using a virtual reality module (VR) to teach cell culture using a laminar air-flow hood. It was developed to train lab technicians and remedy employer anxiety concerning the availability of staff trained to work in aseptic environments. The VR module was then offered to master's students who need to learn this technique during their initial education. The VR activity is presented as a video game. It includes, as an introduction, a reminder of the essential rules to follow when working with a laminar flow hood and in cellular biology procedures. The learning sequence is broken up into six sequential stages, with each building on the last and increasing in difficulty. This means that students can stop playing at any time and later pick up where they left off.

6.2.3 Solutions to the initial need delivered by the e-laboratory

Via the flipped classroom to teach flow cytometry

It is neither realistic nor desirable for most educational establishments and training centers to own flow cytometer instruments (as many other large or costly instruments) to be used solely for training. This kind of expensive device needs to be used every day by staff with advanced technical skills. Thus, for the practical teaching phase, the school signed a partnership with a lab that used flow cytometry as a matter of routine.

In terms of pedagogy and didactics, the flipped class was initially offered to teaching staff so that they could receive training in or refresh their skills in what has become an essential technique in clinical biology. This enabled knowledge to be passed on, with a multiplier effect, to students studying toward their initial education.

Furthermore, through this integrated and immersive independent learning method, students were immersed in a professional, relevant, and stimulating learning environment.

Via virtual reality to teach cell culture in an aseptic environment

First and foremost, this VR method increases the time each learner can practice by increasing the number of virtual workstations available, while drastically reducing the time needed to complete an experiment by removing the need to wait for extended periods for cell culture incubation.

In terms of pedagogy and didactics, this immersive method enhanced learning quality through genuine experience-based learning in which mistakes are permitted (and sometimes encouraged in case of doubt). The method enabled each student to repeatedly perform the correct actions as many times as they needed, developing the actions and behaviors used when working in aseptic environments until they became second nature. Here, the only consequence of a virtual mistake is to gradually improve the lesson learned, as students came to understand the actions and procedures to avoid. The scenario was divided into episodes, each accompanied by immediate feedback. Lastly, the hardware used (VR headset) and the script, inspired by techniques used in video games, made learning fun.

In addition to this, virtual reality considerably reduces the environmental impact of an experiment (which represents a saving of no less than 12 kg of disposable plastics per student per course, as well as saving the energy consumed to maintain incubation temperature).

6.3 The pressing need for qualified personnel

6.3.1 Context and target audience

When it comes to human resources, the life sciences sector operates on a just-in-time basis. It is becoming increasingly difficult to recruit qualified personnel, as graduates in this sector are quickly snapped up (BioWin 2020). This is why intensive training courses for jobseekers can create a pool of talent to support the sector's growth and keep it competitive. These courses, run as classroom-based courses in our labs, are a real success, with most participants finding a job at the end of a course (the employment rate on completion of these courses varies between 85% and 100%).

However, given the strong appetite of the sector, we have seen a rapid and steady shift in candidate profiles. While applicants hailed from relatively uniform backgrounds the first times the courses were organized (graduates with bachelor's and master's degrees in life sciences), there has been a steady shift to more varied and less qualified backgrounds. Their initial training, if they had any, increasingly lacked a focus on the desired subjects, meaning that many applicants failed the pre-selection test for access to training (>40% failure rate). An analysis of test results revealed that the failures were linked to a lack of prerequisites in laboratory calculations and life sciences. In addition, these failures led to anxiety and stress with regard to the pre-selection test itself, with some candidates no longer daring to sign up for training courses. To remedy this situation, online courses were developed to increase the pool of candidates who could access them.

6.3.2 Training model and methodology

The digital tools that were gradually put into place initially consisted of a battery of online calculation exercises similar to those included in the pre-selection test, and two asynchronous learning modules. The first asynchronous module covered the methods used for laboratory calculations (e.g., concentration and dilution formulae), accompanied by a battery of online tests at which participants could have unlimited attempts and receive detailed corrections. The second asynchronous module used videos and animations to enable participants who were retraining to quickly acquire or refresh the basics of molecular and cellular biology.

6.3.3 Solutions provided by this model to the initial need of qualified personnel

Figure 1 shows how once the online calculation exercises were in place, the ratio between the overall failure rate (in dark blue) and the failure rate for the calculation section of the pre-selection test (in light blue) was inverted, resulting in a lower total failure rate and higher participation in training courses.

The online asynchronous learning module on laboratory calculation subsequently implemented was well received by students (n=38): 76% found it useful, 89% learned something new, 74% felt better prepared, and 63% were more confident in passing the admissions test.

More recently, an online course in molecular and cellular biology was offered in addition to the calculation module. Today, it helps prospective candidates with no life science background (>50% of students every training session) to pass the pre-selection test. As an example, an applicant with a master's in speech therapy, and with 10 years' experience as a speech therapist, was able to successfully retrain thanks to the online support available to her. After passing the admission tests and passing the course with flying colors, she found work as a biotechnologist.

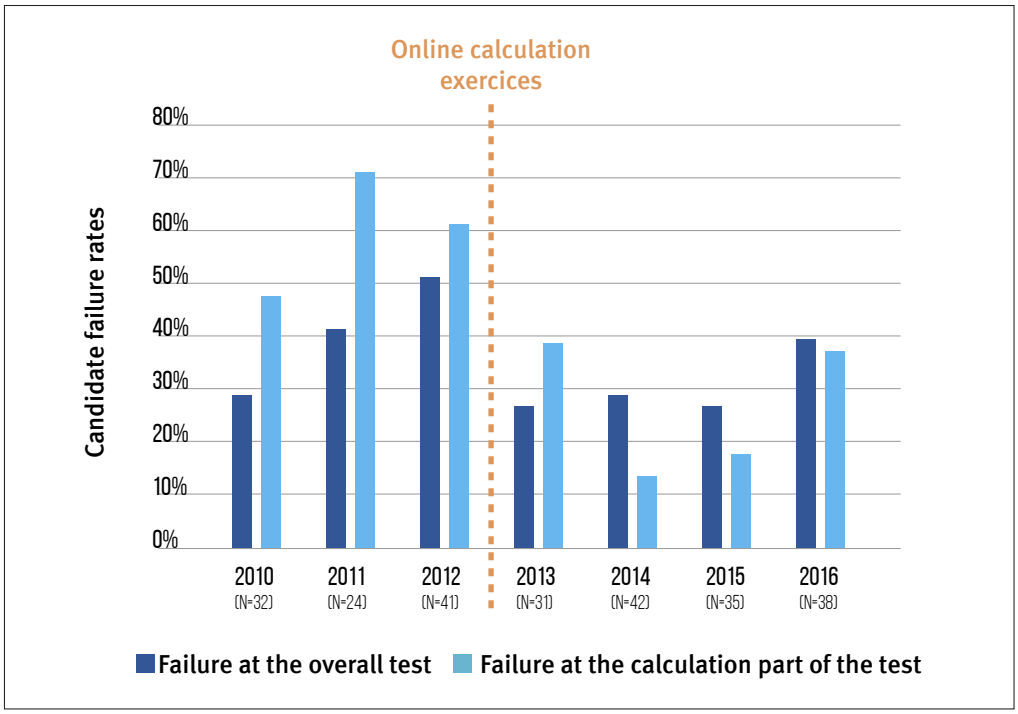

Figure 1. Changes to the failure rates in pre-selection test for specialist training courses for jobseekers between 2010 and 2016. The test contained two main parts: one part on calculation exercises (data shown) and a second section testing knowledge of life sciences (data not shown). N = number of people who passed the test. The information provided to participants in 2013 was inadequate and unsuitable, resulting in limited uptake of the online calculation exercises the first time they were available. Communication was improved in subsequent years, mainly regarding the purpose of the initiative, to enable as many students as possible to prepare for and pass the calculation section of the test.

6.4 The need for career-long continuing professional development

6.4.1 Context and target audience

Some healthcare professionals have a legal obligation to take continuing professional development (CPD) (Moniteur belge 2015). These CPD courses enable them to maintain and develop the specialized skills required in their professions. However, very often these courses are extremely time-consuming, demanding not only an investment in terms of attending the course itself, but also to earn or refresh the prerequisites for the course, or sit an admission test where one is required.

This is the case, for example, with a postgraduate certificate in improved teamwork for healthcare staff working in oncology. It takes the form of a long CPD course (15 ECTS credits), catering to the current trend of outsourcing treatments away from the hospital, arising in part from the increasing oral administration of cancer treatments. This course demands a long list of prerequisites in which attendees must be competent before they can access it.

6.4.2 Training model and methodology

An online module to prepare for the certifying course, taking the varied applicant backgrounds into account (doctors, nurses, pharmacists, physiotherapists, psychologists, etc.) has been created. Learners can choose to study the module at their own pace and according to their own working hours, so that they can refresh their knowledge of the basic concepts. In an effort to take the varied prerequisites into account, students can join the course at different points, for a tailored learning experience (see Figure 2). Students can begin the target course itself only once they have successfully passed the admission test to the certifying course at the end of the online module.

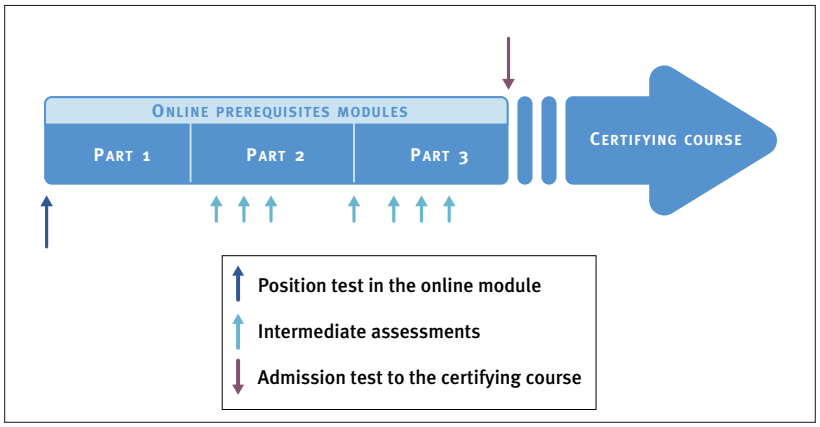

Figure 2. The horizontal arrow is split into two main sections: the online prerequisites module and the certifying course accessible following completion of the online module. Students can join the online module at part 1 or at the beginning of part 2 following a position test (dark blue arrow) that evaluates the student's current knowledge. During parts 2 and 3, students can take assessments at the start of each chapter (light blue arrows), the results of which can help them decide whether they need to study this module, or whether they already know its content and can proceed to the next chapter. Students can access the certifying course following an assessment at the end of the online module (red arrow).

6.4.3 Solutions provided by this system to the initial need for career-long CPD

A total of 80% of participants in the first session (n=17) found the online module in preparation for the admission test to be useful, relevant, and a practical way to revise the essential prerequisites, as well as to refresh theoretical concepts that they had not encountered since their initial training. They also noted the importance of structuring knowledge acquired through informal learning on the job. In addition to this, 86% of them thought that this kind of approach would save them time.

6.5 The need for remote learning in an international context

6.5.1 Context and target audience

A biotech start-up was selling high-tech products and services based on polymorphic genetic markers for certain forms of cancer. To accelerate its entry onto the international market, it was vital that the company could quickly, and remotely, train its customers in using its innovative technology and procedures. Opportunities for classroom-based training were limited due to the geographical area involved, and the time window was limited by international competition. The company had to establish itself everywhere and at once as soon as it had trained its customers in a disruptive technology.

6.5.2 Training model and methodology

The method we developed was a small private online course (SPOC) to train new customers in the basics of genetic oncology while also covering ethical and technological aspects. The online module included videos from experts and short sequences of online training in relevant concepts, accompanied by tests with automatic corrections (multiple-choice and multiple-answer questions). The structure was modular and progressive, and each stage of the course had to be passed before moving on to the next. Customers had to pass a final test to earn the certification required to purchase the product from the company.

6.5.3 Solutions provided by this system to the initial need for remote learning

Thanks to the SPOC format, learners could sit the course at a time and place of their choosing. After just six weeks, 106 attendees had taken the course, from 37 countries on every continent; 26% of attendees studied the course to completion and passed all of the tests. However, it was necessary to modify the 100% asynchronous online course with (i) synchronous assessments to prevent cheating in the final assessment, and (ii) synchronous meetings to cement trust between the company and its potential customers, and to create an interactive student community.

6.6 The need for training for patients

6.6.1 Context and target audience

Patients with chronic illnesses are faced with professional and personal challenges (finances, family, mental health, etc.) in addition to their medical problems. In parallel, a growing number of them want to play an active role in their care pathway (i.e., patient empowerment).

Yet patients and caregivers are often overlooked when it comes to training. At the time of writing, there are few Belgian training centers that deliver structured courses for this target audience. There is, however, a positive correlation between how much a patient knows about their illness and greater adhesion to their treatment (Foulon *et al.* 2011; Fondation ARC 2016), thereby leading to longer life expectancy and a better quality of life. In this context, it becomes critical to offer patients tailored learning tools so that they can not only learn about their illness, but also learn *how to live with it*. This becomes all the more pressing given the increase in intermediate care (e.g., home care with oral cancer treatments) that requires the patient's active participation.

6.6.2 Training model and methodology

A project for cancer patients and their caregivers has been initiated. The initiative was based on the results of a Fondation contre le Cancer survey of cancer patients (pers. comm., data not published) that inventoried their training and empowerment needs. This initial stage identified a few key themes to be developed as a priority. In the next stage, research has been conducted to determine patients' preferred format for receiving this information. A needs analysis through patient associations and, in parallel, focus groups with current and former cancer patients and their caregivers were carried out. In the focus groups, participants debated the ideal format that the project should take in terms of both structure and design. The conclusion was that patients want (i) straightforward, flexible access to key information in terms of the times and locations it is available, (ii) information presented in a tailored, centralized, and educational format, (iii) to feel they play an active role in their treatment and are free to make decisions, (iv) classroom-based sessions where they can talk with other patients and professionals, and (v) an intuitive, social learning environment.

This bottom-up methodology was used to design a structured learning experience, tailored to the needs of cancer patients and their caregivers. It was decided that the project should be developed in French and Dutch (Belgium's official languages), and should ideally be accompanied by an information website with interactive Q&A sessions (in partnership with hospitals), with special training available for patients eager to learn more (e.g., to become patient partners). Indeed, the Université libre de Bruxelles is developing a patient partnership model that recognizes the "expertise of living with the illness" and that will enable trained patients to become an integral part of the care team. It should be noted that in order to ensure this model is optimally supported, a certifying training course for healthcare professionals and teaching staff is also available.

6.7 Discussion and conclusion

6.7.1 Digital learning makes it easier to access training

The challenges involved in lifelong learning in the health sector present a dual nature: on the one hand, intrinsic aspects of the ecosystem must be taken into account, while on the other, obstacles that make it difficult for learners to access training must be removed. Table 1 contains a summary of the teaching tools we suggest for different target audiences to overcome this dual challenge.

Some intrinsic aspects of the healthcare environment make it more difficult to organize training: (i) the technical nature of the equipment or the environment, which makes training expensive, dangerous, or difficult; (ii) the astounding boom in particular fields, which rapidly exhausts the natural talent pool (i.e., fresh graduates entering the jobs market); (iii) short innovation cycles, which mean that knowledge and skills quickly become obsolete; (iv) the huge diversity in stakeholders and job descriptions; (v) the sector's competitiveness, accentuated by international competition.

Some obstacles encountered by learners must also be removed: (i) training schedules that are incompatible with family and working life; (ii) boring teaching methods and a lack of employer support; (iii) a negative learning experience from initial training, seen as too rigid; (iv) a lack of confidence in the prerequisites.

To overcome these obstacles, training developers have at their disposal an arsenal of digital and hybrid solutions, such as those described in our case studies (e-laboratories, virtual reality serious games, online content and exercises, asynchronous online courses, and blended learning). Learning outcomes should be used to structure these teaching methods, in order to maximize independent learning and its enjoyment. Flexibility, in particular, encourages an individual training path, which seems vital if learners are to commit to their CPD, thereby promoting attendance and completion.

Suggested method (click here for more details)	**Target audience**	**Challenges presented by health ecosystem**	**Main obstacle removed for learners**
1. Flipped classroom	(i) Teaching staff and (ii) their students	Equipment not (often) available	Disengagement caused by learning stripped of context
2. Virtual reality	(i) Professional technicians and (ii) master's students	Equipment not (often) available	Negative experience of initial training (joyless training or inability to make mistakes)
3. Asynchronous online exercises	Jobseekers	Talent pool too small to support growth and stay competitive	Disengagement caused by a loss of confidence in prerequisites (i.e., feeling of being poorly prepared)
4. Asynchronous online courses	Health professionals	Variety of target audiences and job descriptions Continuing education for active health professionals	Course schedule incompatible with work and home lives
5. SPOC	Clients of red biotech companies	International competitiveness	Difficulty accessing training due to geographical distance
6. Hybrid approach (online + classroom training)	Patients	Position patients at heart of the healthcare ecosystem	Health problems and course schedule incompatible with work, health treatment, and home lives

Table 1. Teaching tools suggested for different target audiences.

Legend: The **flipped classroom model (1)** was offered to CPD teaching staff and their students, to enable them to learn to use expensive equipment (flow cytometry) that is not often available for training purposes. Learner engagement is facilitated through training tailored to real industry needs, and which can therefore quickly be applied to real-world situations. **Virtual reality (2)** was offered to lab technicians in the biopharmaceutical industry, and then to master's students, to learn how to work in an aseptic environment (working with a laminar flow hood) that is not often available in training. The gamified training facilitated learner engagement and the structure permitted procedures to be learned through making mistakes. **Online exercises and refresher content for basic concepts (3)** encourage vulnerable target audiences with low self-confidence to take part in admissions tests for courses in cutting-edge fields, even if they are lacking the correct initial training. **Asynchronous online courses (4)** for active health professionals help them to optimize their training schedule through flexible learning for better time management. **Small private online courses (SPOCs) (5)** make it possible to standardize training on an international level to ensure proper use of products and services with very high added value, and to further an organization's international reach. **A hybrid approach (6)** that takes patient particularities into account facilitates access to training for patients.

6.7.2 Versatile methodology accommodating learner diversity

Continuing education represents one way for the university to better deliver on its commitment to maintaining and developing innovative ecosystems, characterized by the rapid evolution of knowledge and practices. This means it is important to provide versatile training tools for the full range of stakeholders working in this environment, even those who are not part of the traditional university audience (e.g., jobseekers, trainers, and patients). The unique criteria and challenges of different learner profiles should be taken into account when designing and organizing training programs.

Collaboration with regional employment agencies (Forem, Bruxelles Formation) can increase jobseeker employability by giving them an opportunity to retrain in professional biomedical roles, which are flourishing and creating many jobs. In light of the fact that some health and biotechnology sectors are facing major difficulties in recruiting qualified talent, the industry can no longer rely on its natural recruitment pool: there simply aren't enough young graduates. Foundation and prerequisite modules can then help potential candidates from more generalist backgrounds, or with less training, to access training programs that lead the vast majority of them (85% to 100% in the examples cited here) to find stable employment in these sectors. These asynchronous online modules contain micro-sequences of taught classes, and an extensive selection of practice exercises (with unlimited attempts). They tend to be open to all, and the user experience is streamlined and collegial, to help learners train at their own pace, building the confidence they need to register for the course pre-selection test.

Hybrid methods, like flipped classrooms, facilitate the updating of skills for teaching staff at professional schools. The digital component makes it easier for teaching staff to access the course, and the practical component (which takes place in a lab) provides an opportunity for contact with technicians and researchers who are immersed in real-world applications.

When the training session targets a mixed audience simultaneously (multidisciplinary or transversal courses, for example), the challenge is to ensure that all learners reach the same standard, and it is vital to check that applicants meet the prerequisites. In this context, a number of educational tools are available to us to tailor the training experience (e.g., access via different entry points to the course, separate prerequisite modules, remediation, an active learner community within a SPOC, blended learning containing online theory modules (synchronous or asynchronous) accompanied by classroom-based sessions and workshops).

6.7.3 Lifelong learning plays a structural role within innovative university ecosystems

University education is no longer limited to young people coming straight from mandatory secondary education. Lifelong learning is becoming a firmly rooted custom. This kind of training builds on knowledge and competences acquired during initial training or professional experience. It is complementary training that supports learners in the personal and professional challenges they encounter throughout their lifetime. Universities play a pivotal role in the innovative ecosystems that drive research and education. With their hospital, industrial, and institutional partners, they are particularly well placed to identify skills gaps and propose training courses tailored to maintaining the dynamism of the innovative, primarily research-based, ecosystems they are part of.

The training methods described here demonstrate these close partnerships between different stakeholders in the health sector. Some of the courses, which were initially designed for working professionals, have formed a feedback loop into university education (e.g., the virtual reality aseptic environment course initially designed for biomedical companies is now available to master's students, in an effort to improve an aspect of their education that will be essential in their future career). By encouraging the joint creation of open partnerships and programs, we create an educational continuum that makes the sector more competitive, and boosts the employability of students and those working in the sector. Furthermore, in doing so, the lack of employer support—a major obstacle—is immediately remedied, as employers play an active role in the design and content of lifelong learning courses, and adapting, if necessary, initial training programs.

6.7.4 Digital learning encourages learnability and makes learning fun

Learnability (i.e., the desire and ability to grow and adapt to new circumstances and challenges over the long term through learning (Manpower 2020)) is a major challenge in keeping up with an evolving, sometimes disruptive environment. To develop this skill, however, access to lifelong learning needs to be streamlined. Making people want to learn, offering a quality learning experience, boosting learner and employer engagement, and delivering quality content are all major challenges in creating a society that likes to learn.

Once created, digital pedagogy tools can easily be reused many times. However, a considerable investment of time and resources is needed to develop digital pedagogy tools (which involve input from wide range of professions, such as scientific illustrators, UX/UI designers, writers, IT managers, coordinators, content experts, to name but a few). It is therefore important to carefully weigh the benefit–cost ratio of this kind of strategy. In addition to the budget, other criteria to take into account include updating courses to remove obsolete knowledge and techniques, the robustness of the script, modification following assessment of both learners and content, the technological maturity of learners, more open access for all, and the considerable, often underestimated, environmental cost of implementing digital tools. These important criteria are beyond the scope of this chapter but are worthy of further study.

Based on the pedagogical experiments proposed in this chapter, the authors believe that courses that include digital learning help to streamline access to lifelong learning for the different target audiences that make up the health and life sciences ecosystem. While this observation is true by necessity during the Covid-19 lockdowns (as part of the "coronasolidarity" program initiated by ULB Engagée, i.e., a series of actions to support partners and the living areas where the university is located during the Covid pandemic, HeLSci's digital catalog was given for all, free of charge), it was true in the days before Covid and it will remain true when Covid is in the past.

While the sector targeted here is the health sector, we firmly believe that this training model will be just as relevant to other innovative sectors.

6.7.5 Discover the case studies

The case studies described in this chapter can be viewed on our YouTube channel (text in French): https://youtube.com/playlist?list=PLxUZwhc1Qa6Usa8h2zrrYxhrd4pIkOwnF

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7 AI in medical education

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7.1 Introduction

In the past decade medical education has been implemented thanks to the innovations provided by the technological advancement to reflect patient care delivery readjustments.

In the near future, the greatest impact on medical training will likely derive from artificial intelligence (AI) technology developments, causing a paradigm shift in teaching. Indeed, in the age of Big Data, AI provides new teaching and learning solutions for both medical education and training, as for any other field of learning and teaching. Today, with the advancement of AI systems, the old medical education models that relied on experimental results and informed textbook teaching no longer hold. The abilities that physicians require to meet patients' healthcare needs are all affected by AI-enabled systems. Medical students and physicians in training should be prepared through teaching and educated guesswork to deal with and exploit such technologies rather than simply being forced to react to them (Rampton *et al.* 2020). As medicine moves toward precision medicine, the term "precision medical education" has been introduced to illustrate the use of tools and diagnostics to personalize medical education to individual learners (Duong *et al.* 2019). This has become even more pressing with the advent of the Covid-19 pandemic, which has forced e-learning to become a daily reality for training and education on a broad spectrum.

7.1.1 Knowledge Space Theory

The foundation of AI in education relies on the Knowledge Space Theory (KST), a psychological development applied in the field of e-learning introduced by Doignon and Falmagne in 1999 (Doignon and Falmagne 1999; Falmagne and Doignon 2011). KST is a competence-based theoretical framework that aims to functionalize and categorize the "knowledge structures" into domains and states in order to personalize learning. The "knowledge domain" can be interpreted as a set of problems or "items" to be learned and the "the knowledge states," which is the subset of items an individual is capable of solving.

KST theorizes that dependencies and relations between these items represent a "prerequisite" to learn a more complex item. These prerequisite inferred relations aim to reduce the number of all possible learning patterns to achieve an easily manageable amount of knowledge states. The set of all knowledge states is referred to as knowledge structure. This was the first attempt to develop individual learners' domain-specific competence framework with intelligent adaptation techniques.

7.1.2 AI applicability in medical education and training

The traditional apprenticeship mode depends on multiple variables (e.g., time, trainees' relationship, amount and diversity of learning material provided), which will likely be addressed and altered by AI to meet ever increasing workload demands and reduce the individual variability that is thought to contribute substantially to learning styles (Hart 2016). Education in every field consists of three basic components (Williamson *et al.* 2004):

1. The curriculum, which represents what the teacher intends students to learn;
2. Instruction, which is how the teacher intends to teach;
3. Assessment, which is how the teacher determines what the student has learned.

AI can be applied to any of these three basic components to provide personalized learning and individualized teaching.

AI can also be applied to any of these basic components of training: (i) to automate "learning profiles" according to both the skills/competences of the student and to predefined training curricula (e.g., the European Training Curriculum for Radiology); (ii) to provide comprehensive digital teaching file databases; and (iii) to decrease the time needed to evaluate multiple curriculums, solve multidimensional problems, provide greater classification accuracy, and establish a relationship between different variables.

7.2 AI and radiology education

Compared to other medical specialties, radiology practice will be most affected and altered by the coming of AI, in terms of the process of learning in radiology. Radiologists should be aware of three levels of knowledge for AI applicability, similar to those needed in the early 1990s with the development of magnetic resonance imaging (Figure 1).

The first level will be taken up by AI tools creators, who possess the most in-depth knowledge of the software that should be applied to clinical problems (MR physicists); the second will be occupied by radiologists as AI tool deployers, who understand the core concepts of AI, in order to create "appropriate protocols" for specific assisted and/or automated interpretation. The last step will be covered by AI-using radiologists, who neither create nor design new tools, but rather use them.

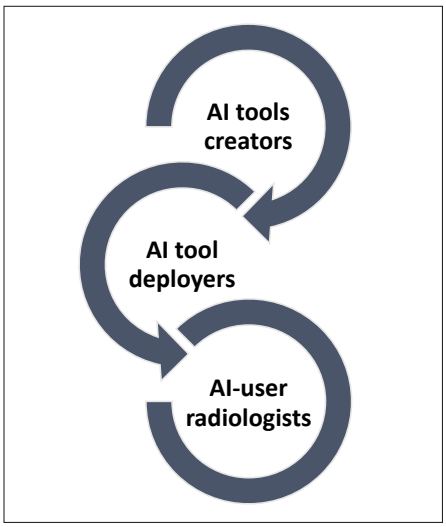

Figure 1. Three levels of knowledge for AI applicability.

Today, much attention has been given to teaching radiology trainees about AI and, although the idea of using AI to improve education is not new, its application to medical and radiological education remains limited. It has become a necessity, however, due to the amount of data that continue to increase in imaging, both extractable by the human eye and extractable only by software. Data have empowered radiologists but also challenged them computationally because of their abundance and complexity.

The main topic of education in the years to come will be the role of AI in radiology practice, establishing training programs to teach trainees how to carry out "supervisory duty." Alongside this, AI will likely become a major instrument in radiology education: software assistants could offer new opportunities to bring learning into the ongoing practice of attending radiologists.

Trainees need to understand how AI can be applied in radiology, possibly how to assess the reliability of AI algorithms, and how to consider where and when to implement new AI algorithms, in order to avoid false positive/negative results that would affect patient management. Students should also be able to judge critically whether the tool truly adds value to patient care. Today, there is a need for resources to teach radiology residents about AI (e.g., the National Imaging Informatics Curriculum and Course specifically for radiology residents, www.siim.org/page/niic 2021).

7.2.1 AI in education in the short term

The AI tools currently available offer a vision of augmented intelligence, and radiologists are taking on new responsibility, on top of image acquisition and interpretation, as "active supervision of AI tools"; trainees will need to learn how to step into this role (Figure 2 depicts an example of a diagnostic flowchart that sees the radiologist as supervisor).

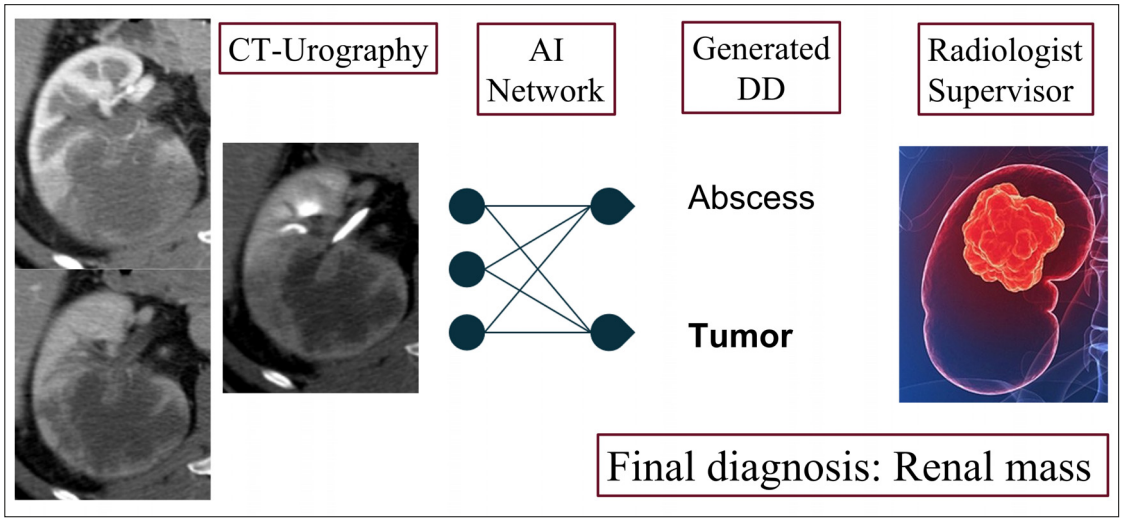

Figure 2. Diagnostic flowchart of a patient with suspected kidney tumor using an AI-based tool generating a differential diagnosis with the radiologist as supervisor confirming the current diagnosis. Notes: CT = computerized tomography; DD - differential diagnosis.

Two significant AI applicability domains are already diffusely employed in the radiologist's daily work:

1. Computer vision AI systems facilitate the performance of the following main tasks within medical imaging: classification with abnormality detection, anatomic segmentation (Figure 3), image quality assessment, improvement of protocols and worklists, and extraction of new biomarkers from raw imaging data.

2. Natural language processing (NPL) has the ability to understand human language and might be applied to several tasks with regards to exam reports (Figure 4).

Specifically, AI and NLP can aid as time-saving tools for decision support, to build a searchable database, to monitor trainees' performance, and to build student portfolios (Tajmir and Alkasab 2018).

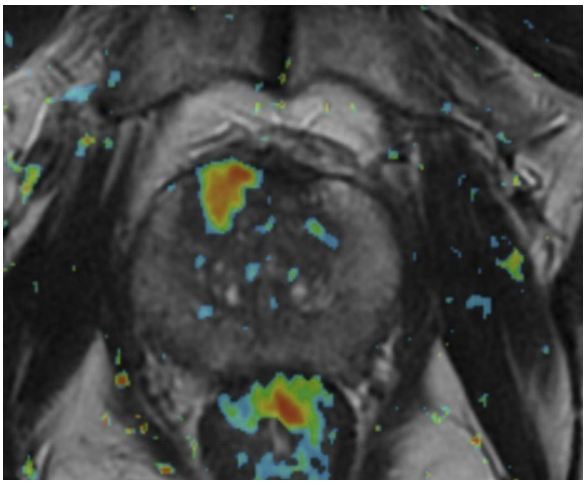

Figure 3. Case example of prostate MRI with a computerized automated system for segmentation and classification of a suspicious area on T2WI. Notes: MRI = magnetic resonance imaging; T2WI = T2-weighted imaging.

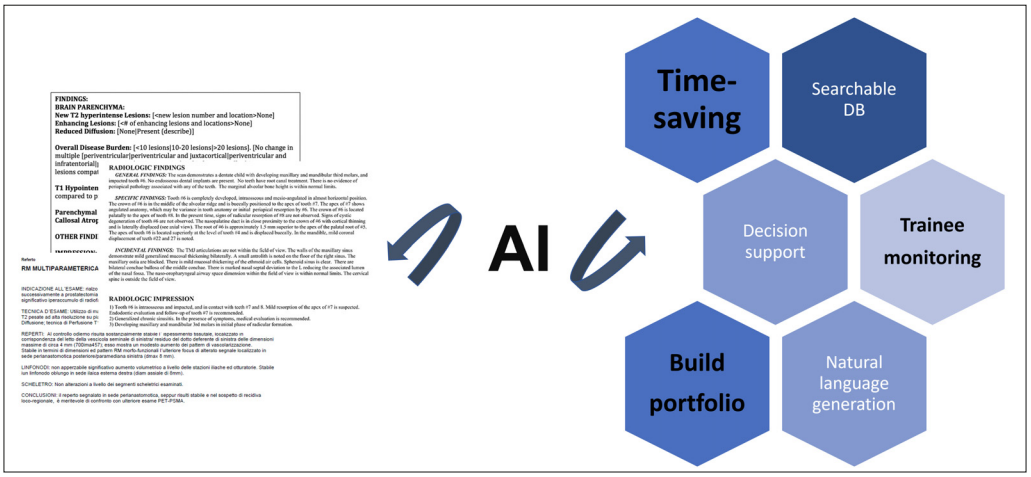

Figure 4. AI and NLP advantages provided to radiologists in their daily practice. Note: DB = database

7.2.2 AI in education in the long term

Potential advances in training will come from the increasing ability to process natural language, both written and spoken, to continuously monitor the work of trainees and attending radiologists, to shape teaching cases, to identify examinations that could become teaching cases, to help automatically annotate, export, and create educational modules, to associate relevant diagnoses, to compile a portfolio and compare the case experience to that expected for the trainee's experience level, and to help trainees create better reports and avoid common pitfalls (use of ambiguous or unhelpful phrases such as "clinical correlation" "cannot be ruled out").

The knowledge gap between trainee and attending radiologist continues to widen, but AI could build knowledge efficiently, and highlight and correct individual cognitive biases. The challenges addressed with AI are the lack of integrated access points to knowledge (currently being mainly books and lectures), lack of an effective tool to deliver the appropriate diagnostic thinking, of uniform diagnostic accuracy of trainees and medical students, and lack of control over time spent between trainees and teachers.

AI offers solutions to several different challenges (Duong *et al.* 2019; Forney and McBride 2020):

- Often, young trainees are in the frontline of busy emergency departments and overnight shifts, where appropriate triaging of urgent cases and accurate interpretation of critical diagnoses is vital. AI might offer ordering support, automated protocoling, and acute case triage to trainees; on the other side, through the application of AI, educators might offer automated case logging, report discrepancy detection, and annotated residence performance data.
- Lesion measurement and volumetric segmentation are often time-consuming operations that could be automatized with AI to provide proper case interpretation and improve diagnostic accuracy.
- During radiologic training, case flow assignment is often random and unbalanced. AI, with individualized rotation of "must see" cases, might improve study interpretation, providing more educational cases with efficient distribution of resources (Figure 5).

Figure 5. AI could set individualized case-flow assignments to "must see" to improve study interpretation and provide more educational cases with efficient distribution of resources. The figure shows examples of less frequently encountered cases that radiology residents should be able to report.

- AI might provide an "intelligent" tutor/mentor to create virtual curricula for rotating trainees, to track learning performance, and to strengthen performance with challenging topics.
- Trainees should be guided into the cognitive processes related to the diagnostic decision-making process. Diagnostic decisions can be "fast" or "slow" according to the clinical setting. AI can improve slow decisions with systematic AI-based decisions, improving the quality of the diagnostic outcome and reducing time to diagnosis, thus increasing the number of reported studies; fast thinking can be optimized as individuals become familiar with cases.
- To address the issue of high- and low-level supervision, AI might enrich the learning experience by creating trainee competency profiles, synthesizing and refining information, addressing errors in reasoning and discussing considerations from clinical best practice to management decisions (Figure 6).

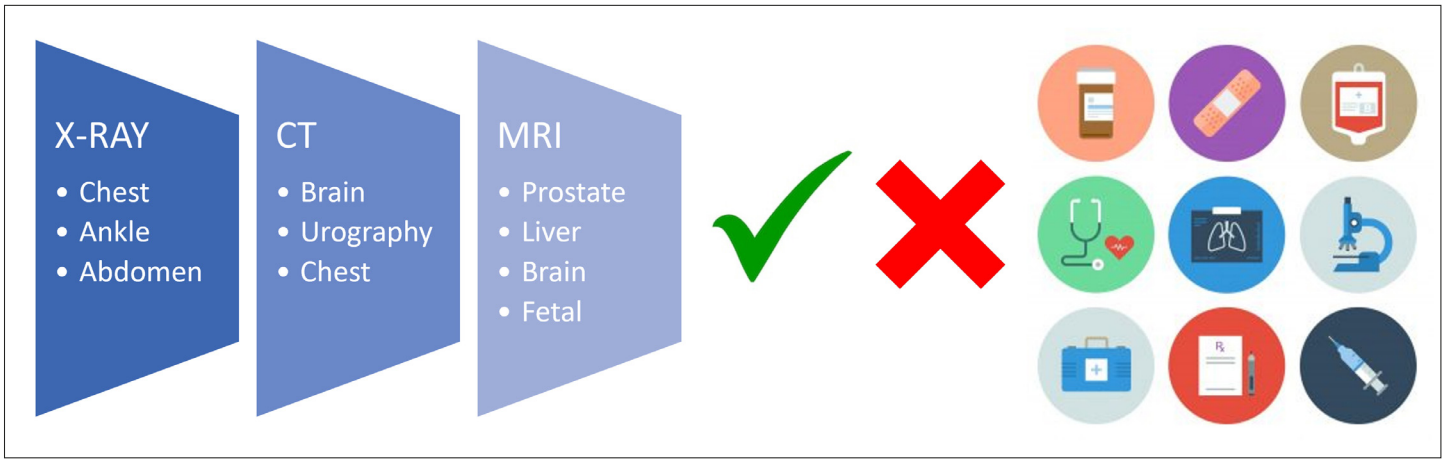

Figure 6. AI might enrich the learning experience by creating trainee competency profiles, synthesizing and refining information, addressing errors in reasoning, and discussing considerations from clinical best practice to management decisions.

- AI might promote interactive flipped learning (Bye 2018) for personalized education in order to optimize supervisor–trainee interactions with deeper discussions of clinico-radiologic sessions, as opposed to the traditional learning methods.
- High-fidelity, stimulating training might provide real-time feedback and situational learning tailored to students' learning, simulating mini-call conditions, extracting information from patient charts, and increasing autonomy under faculty supervision.

Duong and colleagues (Duong *et al.* 2019) proposed a novel AI model based on the creation of a trainee experience profile. Table 1 summarizes challenges in medical training, the solutions that might be offered by AI-based tools, and the derived improvements.

Challenge	AI solutions	Derived improvement
Lesion measurement & case flow assignment	Automated segmentation and measurements	Better study interpretation, more educational cases, efficient distribution of resources and education
	Rotation of «must see» cases	Proper case interpretation and improve diagnostic accuracy
Case-based learning	Complement existing bottom-up platforms used to teach radiology	An intelligent tutor might similarly create modules or virtual curricula for rotating trainees, track learning style and performance and reinforce challenging topics
Guided decisions	Teach cognitive processes related to diagnostic decisions	Allow for trainees to derive diagnostically meaningful information that might otherwise be hidden
	AI can optimize the relative contributions of "thinking slow" and "thinking fast"	Slow decisions can be augmented by systematic AI-based decisions which may improve the quality of trainee reasoning. "Fast" thinking requires quick heuristics developed as individuals familiarize themselves with cases
	Reduce time-to-diagnosis and increase quantity of cases studied to improve quick decision-making.	Guided decisions may assist individual trainees on multiple levels of decision-making and improve the quantity of training cases and quality of personal time spent learning from them
High- and low-level supervision	Support human-machine interactions and extend human interactions to enrich learning experiences	Intelligent triangulation and the creation of trainee competency profiles, synthesizing and refining information, to address errors in reasoning and discuss more abstract considerations from clinical best practices to management decisions
Flipped learning	Promote interactive flipped learning for personalized education	Supervisors and trainees may spend less time reviewing basic ideas and more time on deeper discussions of radiologic and clinical principles and hold review/Q&A sessions
High-fidelity simulating training	Real-time feedback and situational learning tailored to unique events, match students' learning styles and provide feedback	Better simulate mini-call conditions, expeditiously extract information from patient charts and increase autonomy under faculty supervision

Table 1. Summary table of the challenges in medical training, with solutions that might be provided by artificial intelligence (AI) based tools, and the derived improvements.

7.3 Reliability and ethical issues

AI techniques require significant rate-limiting research, development, and real-world validation with head-to-head comparisons. Trainee performance must be assessed through reliable and valid measures. Quality measures are integral to the improvement of radiology education (Sarwar *et al.* 2015). The learning theories may serve as metrics of the successes and failures of AI in implementation and practice (Walker *et al.* 2017).

A core idea in intelligent tutoring systems is that a student interacts with adaptive interfaces that personalize learning experiences based on the student and her current level of learning. However, AI can have both a positive and negative impact on learning. Although it may provide exciting new opportunities for adapting learning content based on the student's individual characteristics and learning style, computer programs scale up very well, and AI can thus easily scale up bad pedagogical ideas (Tuomi *et al.* 2018).

7.4 Conclusions

The goal of AI is to understand some aspect of an individual's health by considering a multitude of variables. As such, it is closely tied to the concept of "precision medicine," which is a healthcare framework focused on prevention and treatment strategies that take individual variability into account. As AI allows us to move toward precision medicine, it favors the application of precision education by:

- Introducing learning materials to the student, compiling a portfolio and comparing the case experience to that expected according to the trainee's experience level;
- Providing educational platforms that can be adapted to the student's needs at any time;
- Identifying what a student does and doesn't know through diagnostic testing;
- Developing personalized curricula based on the student's specific needs, to tailor the learning experience for each individual student;
- Introducing the virtual mentor and the virtual resident as novel professional/educational models.

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8 The Pediatric Simulation Games: an educational platform for European pediatric emergency medicine

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Abstract

In recent years, high-fidelity simulation has emerged as a powerful teaching method in the field of pediatric emergency medicine and critical care, facilitating long-lasting and rapidly achievable learning. To date, however, there has been no shared European educational method of simulation. Achieving this aim is of utmost importance in order to establish a common diagnostic and therapeutic approach to the care of critically ill children.

In this context, the Pediatric Simulation Games, an educational event organized by Sapienza University of Rome based on team competition and an innovative approach—"learning to play" and "playing to learn"—represents a valid project to improve the training of pediatric acute care providers, and standardize knowledge and skill acquisition through the involvement of different European universities belonging to the CIVIS.

8.1 Simulation-based teaching

Currently, simulation-based teaching represents one of the most appealing educational resources. The success and spread of this phenomenon is due both to the progress of technology and the need to find a more effective instructional methodology than classical lessons to stimulate the learning of new medical students (Bertazzoni *et al.* 2016).

Recent literature demonstrates increased retention of knowledge and skills after simulation-based training (Weinberg *et al.* 2009; Ojha *et al.* 2015). In pediatric emergency medicine in particular, simulation with

high-fidelity mannequins facilitates the learning of technical skills as well as the management of clinical scenarios, fostering competences that will prepare the future pediatricians to face real clinical cases in emergency departments (Cheng and Lockey 2015).

Teaching with simulation comprises three stages: (i) the introduction of the clinical scenario (one minute); (ii) the simulation itself (14 minutes); and (iii) the debriefing (15 minutes). A skilled instructor can therefore guide a scenario and evaluate the performance of the team in approximately 30 minutes.

This educational technique has several advantages compared to traditional teaching, with the student having an active rather than passive role:

- Traditional teaching allows students to retain only 50% of what they see and hear, whereas a practical scenario of 15 minutes allows them to retain 80% of what they experience, activating all the senses.
- The debriefing, with its three phases (gathering, analysis and summary), stimulates the student to make a cognitive effort and thus learn the correct management of clinical cases in the long term.
- Simulation also allows the student to learn team-working skills, which would otherwise be impossible to obtain with traditional teaching. Indeed, during the simulation the student must practice leadership and optimize group dynamics to achieve the best possible diagnostic therapeutic management, hence also practicing multitasking.
- Finally, simulation enables learner engagement in a psychologically safe environment, allowing them to make errors without patient harm and without fear of judgment.

Although simulation is a model that has gained more and more consensus in recent years, new strategies are required to improve the quality of simulation, develop validated assessment tools, engage the student, and enhance learning. In this context, “gamification” is used as an adjunct to traditional teaching strategies in medical education to achieve these aims (Rutledge *et al.* 2018).

8.2 The Pediatric Simulation Games

The Pediatric Simulation Games are an example of this process.

The Games are now a fixed appointment in the educational program of Sapienza University of Rome. Their objective is to improve the diagnostic and therapeutic skills of pediatricians in emergency medicine through simulation with high-fidelity mannequins, without neglecting the theoretical background that every student should obtain before participating in the Games. Indeed, adding an element of competition between teams to the Games made students more willing to study and prepare harder before taking part, because of the natural instinct of teams to wish to excel.

Currently, all Italian pediatric residency programs participate in the Games, sending reanimation teams composed of six or seven residents, which start their preparation and training six months before the Games. During the Games, five international professors, renowned for their scientific contribution to pediatric emergency medicine, work as judges, ideating the clinical scenarios and evaluating the teams at the end of the simulation. To allow every team to participate more, the Games are composed of four rounds, with play continuing for four days in a row. At the end, a final takes place between the winners of each round.

The mood of the games is "learning to play" and "playing to learn":

- *Learning to play*. In a friendly but highly technical competition, there is an international jury composed of major figures from global pediatric emergency care and simulation, from countries not directly involved in the competition, who handle the education debriefings at the end of each session.
- *Playing to learn*. The residents have to study for a long time before the event and will continue studying even after the Games, preparing for next edition in order to improve and compete successfully.

The PSG is a stimulating and growing event, with previous student participants showing enthusiasm for the experience. Furthermore, over the past three years, a progressive increase in technical knowledge has been seen, for two additional reasons. First, in several teams, students who participated in previous editions of the Games have passed on their knowledge to members taking part in subsequent editions. Second, the clinical scenarios have been made progressively more complicated to stimulate the learning of new objectives. The main positive feedback from previous editions of the Games, however, is with regards to the spread of an improved standard of care among all Italian pediatric residents in terms of management of children with critical conditions. This has been made possible, first, due to the involvement of an international jury comprising major figures from global pediatric emergency care and simulation, and, second, due to the solid training outcomes achieved by students before the Games, with the aim of winning.

The Games are truly changing teaching methods with a new educational model, which has immediately led to unexpected effects on the training of pediatricians, ensuring uniformity in the management of child critical illness among future specialists. Thus the involvement of teams from other European countries could be very important to encouraging comparison between very different pediatric residency programs and stimulating standardization of care. In fact, one novelty of the last edition of the Games was the participation of teams from other European countries. It has been interesting to see how, even with a background of different training and languages, residents have created and participated in efficient multicultural resuscitation teams. In this regard, we think that promoting the Pediatric Simulation Games and other similar events within international programs such as CIVIS, which includes eight different European universities, could be an important step forward in the development of a common academic approach in the area of pediatric emergency medicine.

The primary aim of this project is to create a strong educational network between CIVIS universities in order to achieve a common diagnostic and therapeutic approach for critically ill children and to guarantee the same high standards of care internationally. A secondary aim is to promote the exchange of

knowledge and to disseminate common updates on specific and relevant topics in pediatric emergency medicine. Our aim is that this shall be achieved by appointing a committee of pediatrics/pediatric emergency care teachers in those universities participating in the CIVIS agreement, which develops common objectives and skills in those working toward the role of pediatric emergency physician, and which uses a common teaching method based on simulations and consisting of three stages: *planning of the scenario*, *teamwork* and *evaluation*. It should also develop a common pediatric emergency medicine textbook that is constantly updated and consultable in e-book format.

In this scenario, the Pediatric Simulation Games could represent an innovative and fun testing platform to verify the application of a new European educational method in the field of pediatric emergency medicine, examining each university team's ability to solve different clinical scenarios, and the ability of teams composed of members from different countries to work together.

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9 Humanities in 21st-century medicine: a way to restore balance post-Covid

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9.1 Introduction

In the last year and a half, the world we know has been turned upside down. The Covid-19 pandemic has changed the way we see and think of the world, probably for good. Nonetheless, perhaps this is the ideal moment to reflect and see how we can learn from this experience, imagine it as an open and not a closed window. An opportunity. Life is never concerned with certainties but always with coping, learning, and benefitting from uncertainties.

In this short essay I will discuss how in medical education the humanities should never be seen as soft skills added to the serious hard sciences but are integral and complementary. Around 100 years ago, William Osler, addressing the Classical Association at Oxford, called for a union between the Old Humanities and the New Science. In part alluding to Shakespeare, he remarked, "Twin berries on one stem, grievous damage has been done to both in regarding the Humanities and Science in any other light than complemental" (Osler 1919). He was right. And now, during this pandemic, this is clearer. So I will briefly discuss what the medical humanities are and why they are so needed, and give an example of how they can be implemented into medical education and practice.

Figure 1. © maradon 333/Shutterstock

9.2 What are the medical humanities?

This is too short an essay to go into great depth about what the medical humanities are, however I will paint a few brushstrokes in attempting to do so. The term medical humanities was first coined in the 1940s by the science historian George Sarton (Hurwitz and Dakin 2009) and since then they have been developing at an interesting pace. They have gone through different transformations, beginning with the medical humanities and mutating through the health humanities to critical medical humanities. Dare I say that perhaps the next mutation will be into ecological medical humanities? Two general definitions seem to me relevant in this short essay. The first defines the medical humanities "as an inter- and multidisciplinary field that explores contexts, experiences, and critical and conceptual issues in medicine and healthcare, while supporting professional identity" (Cole *et al.* 2015). The second sees medical humanities "as an interdisciplinary field concerned with understanding the human condition of health and illness in order to create knowledgeable and sensitive health care providers, patients, and family caregivers" (Klugman 2017). Both are interesting; from the first I wish to emphasize "supporting professional identity" and from the latter its inclusion of patients and caregivers. Above all, the medical humanities should be inclusive since it seems that our main errors are born in exclusion.

Another example of a humanistic approach to medicine can be seen in the work, presentations, and essays of Iona Heath, the former president of the Royal College of Practitioners in London. In one essay, entitled "How medicine has exploited rationality at the expense of humanity," she identifies the dualism at the core of medical practice. This dualism goes back to the "Twin berries" of Osler: the scientific and the humanistic. Heath writes: "a rift runs through every consultation. On the one side, evidence has a huge part to play, assuming it is free of bias; on the other side is the substantive role for humanity. Clinicians must constantly bridge the rift because, as [Arthur] Kleinman writes, 'physicians are poised at the interface between scientific and lay cultures'" (cited in Heath 2016). This dualism makes the profession both a challenge and a privilege, for who else (apart from perhaps the priest or the grandmother) can have an insight into the hopes, worries, and dreams of the ordinary person? This is of course why medicine has always been an important source for art, textual or visual. The dualism exists since, as in the words of Siddhartha Mukherjee, "medicine is an uncertain science" (Mukherjee 2015), concerned not with cases but with people (Liao 2017).

9.3 Why the medical humanities now?

The entire world is living the pandemic together and although it is exacerbating the already existing inequality, we are still all affected to greater or lesser degrees. Perhaps for this reason, and this alone, the humanities, whose objectives are to try to make sense of the world we live in "by the recording and interpretation of human experience" (Arnott *et al.* 2001) are paramount now. Or, as Hetan Shah mentions in his revelatory article, "Covid-19 recovery: science isn't enough to save us," "science gave us vaccines, but SHAPE (social sciences, humanities and the arts for people and economics) disciplines help us get to social realities such as vaccine hesitancy. Humanities insight is more robust when STEM and SHAPE come together" (Shah 2021). Among other things, the humanities can help develop critical thinking, give insights into the diversity of the human

condition, promote interdisciplinary research into the human side of medicine, emphasize the importance of empathy and emotions, as well as physician well-being and resilience, and help cope with the uncertainty which, as we have seen, is inherent in 21st-century life. The medical humanities attempt to restore the balance, to help rehumanize medicine, but it is not only patients who suffer from this dehumanization, aggravated during the pandemic with the need to use PPE, and increase barriers and distances between carers and sufferers, but also the healthcare professionals. Healthcare professionals seen by some as heroes but by others as dispensers of unpopular policies have been alienated both from the ideals that drew them to medicine but also by the absence of united and coherent political policies, which have made their work doubly arduous. And this seems to be on a global scale since the lack of a concerted, unified, and international policy to combat the pandemic has been pathetically and tragically obvious. Numbers of healthcare professionals have died, numbers have committed suicide, but countless more have been affected by burnout, depression, and post-traumatic stress. So, if the need to reinstall or restore the humanities into medical education and practice was required before the pandemic, it is now an urgent and critical necessity. The rehumanization of medicine involves an enhancement, restoration, and adherence to the humanity of both students, healthcare professionals, and patients. Williams and Turner put it succinctly when they say "the most fundamental of argument in favor of medical humanities is that they may allow or validate the greater understanding of the human condition as part of medicine" (Williams and Turner 2018).

9.4 How can we implement the humanities into medical education?

Anton Chekhov allegedly remarked that "knowledge is of no value unless you put it into practice," so how can we implement the humanities into medical education? In this section I will briefly remark on a project that has this aim. The Doctor as a Humanist was started in 2017 as a response to the aforementioned dehumanization of medicine and an attempt to rehumanize it. It is an international organization of students, scholars, educators, and practitioners dedicated to the study, preservation, and promotion of humanism in medicine around the world. It has the underlying mottos of "bringing back the heart and soul to medicine" and of "looking for the person in the patient." It aims for inclusiveness, internationality, interdisciplinarity, and intergenerationality.

The Doctor as a Humanist has organized two face-to-face symposiums, one in Mallorca in 2017 and the other in Moscow in 2019, as well as three international online courses and two virtual symposiums; the first was transformed from a face-to-face symposium planned to be held in Mexico City in 2020, and the second, New Realities in Times of Covid-19, was organized jointly with McGraw Hill Education. I will concentrate here on the first virtual symposium, since it was a direct, heartfelt, raw response to the pandemic. New Realities in Times of Covid-19 deserves an article on its own.

The Doctor as a Humanist Virtual Symposium was inaugurated in April 2020, with the following words from John Donne, "No man is an island entire of itself; every man is a piece of the continent, a part of the main" (Donne 1624/1959). Donne wrote these words nearly 400 years ago after recovering from an infectious disease, probably typhus. They seem to reiterate the feeling that all humankind has been living one shared experience. This symposium, a direct response to the Covid-19 pandemic, offered a way to

try to make sense of the moment being lived through, as well as aiming to support and give some hope to healthcare professionals, medical students, and the general public. The symposium went on for two months, with a session being held every two weeks. In total there were nine sessions. The topics were: Caring for health professionals; I swear to take care of myself; Health narratives in times of Covid-19; Covid-19: an international experience; Humanitarian medicine: a vocation; Poetry can save us; The power of music; Complementary ways of doing medicine; and Medicine and philosophy. The response to this series of symposia was encouraging, with 240 students, professors, residents, and healthcare professionals from 24 countries and 47 participating universities attending the sessions. There was a deep sense of international collaboration and of trying to do something together for the benefit of all. In these trying and testing times, humanities is a way to express our nature and essence; in other words, a way of expressing what it means to be human. And this is essential.

9.5 Conclusion

Returning to John Donne's same poem from 1624, he continues, "any man's death diminishes me because I am involved in all mankind."

We need our fellow humans now more than ever. The words of one of the members of The Doctor as a Humanist also ring true: "I have no doubt that medical humanism and the arts are already helping; and they will help us to learn to take better care of our patients, our loved ones, and ourselves" (Soriano 2020). So too do those of Albert Schweitzer: [1] "I have given up the ambition to be a great scholar. I want to be more—simply a human" (Schweitzer and Bresslau 2003; Globokar 2015). To be more human, and more humane is indeed a worthy aim, but we need to balance this with our relationship with the world around us. As the French author Sylvain Tesson says, "The world was a jewel box. The jewels were increasingly rare, since humankind had helped itself to much of the treasure" (Tesson 2021).

Humans need to learn to take care of the remaining treasure; the forests, the seas, the animals, and all that we have failed in such a short time, not just to cherish but to conserve. Coope places this in the context of the Covid pandemic, writing that figures from the UN and WHO "have drawn attention to relationships between human impacts on the natural world and human disease pandemics, suggesting that Coronavirus is a warning to us to mend our broken relationship with nature" (Coope 2021).

The key is balance, and this leads me to look back to the image of the tightrope walker (Figure 1) at the beginning of this short text, and to remember two famous 20th-century painters: Georges Braque and his fellow Cubist revolutionary Pablo Picasso. Both are relevant since Braque, speaking of his relationship with Picasso, mentioned that they "were like mountain-climbers roped together" (https://news.masterworksfineart.com/2017/07/11/georges-braque-and-pablo-picasso). This parallels Osler's "Twin berries" reflection of the importance of the symbiotic relationship between the sciences and the humanities in

[1] Medical missionary and theologian. He was awarded the Nobel Peace Prize in 1952 after a lifetime's work in western Africa.

medicine. Symbiotic but fragile and vulnerable, and illustrated by the tightrope image, where balance is critical. So, let us imagine that this image reflects the importance of embracing uncertainty and restoring the integral balance between the sciences and the humanities. Our lives depend on it.

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10 Using moral dilemmas in medical ethics educations

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10.1 Introduction

More and more, our personal and professional lives are intertwined with (or shaped by) new technologies. Living in an interconnected world where physical boundaries can no longer hinder us from teaching and training professionals located hundreds of miles away creates a pressing urgency to carefully assess the impact and potential of such technologies for education. Several technologies are specifically being developed in order to better train health professionals. Virtual reality (VR) offers the opportunity to immerse health professionals in different scenarios, and to learn from virtual experiences and consequences without taking any risks (Jeon *et al.* 2020). VR was also used to develop a training tool for audiology (Bakhos *et al*. 2020) and ultrasonography (Hu *et al.* 2020), and even for showing how to conduct basic medical procedures like CPR (Jaskiewicz *et al.* 2020).

The focus of our chapter is to review the use of moral dilemmas in medical ethics education, taking into account the new technological opportunities. A first aim will be to distinguish between two main approaches in accounting for the role of dilemmas in teaching medical ethics (which we label "principle-centered" and "experience-centered" for convenience). While at first glance they might seem incompatible, we will suggest that each could play a significant part in medical ethics education, provided their respective scopes are clearly defined. As our second objective, in the final section we will show how digital technologies can be deployed in order to enrich both approaches.

10.2 Medical ethics education and moral dilemmas

In both medical ethics handbooks (Kushner *et al.* 2001; Bedzow 2018; Hope and Dunn 2019) and educational articles (Giubilini *et al.* 2016; AlMahmoud *et al.* 2017; Bedzow 2020) there is a clear assumption

that ethical education has an essential role in the training of future health professionals. Even authors who tend to be rather skeptical with regard to the effectiveness of ethics courses for medical students seem to agree that such courses might play a legitimate role in medical education, at least as a signal that medical professions have not lost their moral compass (Sokol 2016). But the experience of countries like the UK, where we can trace a 40-year time span of institutional development in medical ethics training, leaves quite a number of questions unanswered (Stirrat 2015). We are still far from a consensus in terms of how medical ethics should be taught or how medical students should be evaluated (Savulescu *et al.* 1999), and there is a lot of work still to be done in establishing adequate measures for the impact of medical ethics courses.

Tough moral dilemma-like choices are common for medical professionals, and sooner or later they will probably find themselves in a position where they will be required to recognize and deal with them. Dilemmas are so troublesome because they are situations in which we seem to lack a unique morally ideal option: no matter what we choose to do, something really undesirable will eventually happen. What should a doctor do when a patient's autonomous decision is to refuse the only course of treatment that, according to the doctor's medical opinion, can save her life? How are we to distribute scarce therapeutic resources (Farrell *et al.* 2020)? When are the medical research risks acceptable, and on what grounds? There are many other morally charged issues as well, which have radically divided society over the past decades, like abortion, euthanasia, embryonic gene editing, and transgender medical surgery. One could even argue that medical professions are under an unfair moral pressure sometimes fueled by the unrealistic expectation that doctors should have an answer to each moral dilemma as a matter of professional opinion.

While such an expectation might indeed be rather over-demanding, sadly dilemmas are rather a feature than a bug in the professional life of a medical doctor. Although the situations that health professionals usually face in practice do not always exhibit the same kind of clear dramatic conflict that we encounter in hypothetical cases from textbook moral philosophy, it is still worth asking whether the latter can be part of a suitable method to prepare health professionals for coping with medical moral dilemmas.

10.3 Principle-centered approaches to dilemmas

We are going to use principlism as the main illustration for the principle-centered approaches (PCAs), but many of its core tenets when it comes to moral dilemmas are also to be found in classic moral theories, like deontologism or utilitarianism. Hypothetical dilemmas are commonly used in PCAs, mainly for testing certain normative claims. For example, does deontology admit exceptions to moral rules? If lying is morally wrong does it mean that it is wrong to lie in all possible situations? What if, like in the famous example, the life of a friend depends on your willingness to lie? Say that one of your best friends hides in your home because someone wants to kill him. Shortly after that, someone knocks on your door. When you open the door an angry man stands in front of you, axe in his hands, and asks you a direct question: is your friend here? You can choose between telling the truth and risking your friend's life or lying. For a philosopher like Kant (1949), who is quite reluctant to admit exceptions, this dilemma is challenging. If

he admits exceptions (i.e., lying is sometimes morally justified, although we have a duty not to lie), then it is hard to define under what conditions lying becomes permissible. If we are not careful and we rush into admitting that we are allowed to lie in order to avoid bad consequences, then we are open to the objection that we have in fact abandoned deontologism. Moral philosophers use dilemmas to challenge theories or to test moral claims, and typically debate or discuss them from a third-person point of view.

Beauchamp and Childress (2013) have assembled "principlism" by combining the central points of the "grand" classical moral theories as applied to the specific domain of biomedical sciences. They clustered the moral duties, values and obligations specific to biomedicine under four main principles: autonomy, beneficence, non-maleficence, and justice.

The principlist view was just as intensely criticized and defended over the years, but it probably remains one of the most influential approaches in biomedical ethics today. The "Georgetown mantra" (as it is sometimes referred to) was accused of being "imperialist, inapplicable, inconsistent and inadequate" (Huxtable 2013, p. 40) because it promotes the moral values of a particular culture. Other authors object that it fails to articulate a unified theory (Clouser and Gert 1990) or that it fails to account for the additional moral responsibilities doctors have like expressing regrets, apologizing and making amends (Fiester 2007). We will not try to defend principlism as a moral decision-making procedure, nor take any particular stance in this debate here.

Principlism can be interpreted both as an action-guiding theory or a justificatory method for decision-making (Hine 2011). While Beauchamp and Childress do indeed describe a multiple-stages procedure for reaching a moral decision (with the most important steps, arguably, being the "specification" of principles and the "balancing" of reasons), principlism can be viewed minimally as a normative justification process where reasons and justification are somehow more important than the decision itself. When it comes to difficult dilemmas, it offers us a tool for mapping the moral problem at hand.

Principlism, like other PCAs to dilemmas, offers a theoretical framework for analysis, useful for assessing what precisely is the source of the moral conflict in a decision situation. A PCA offers health professionals a method to grasp the moral conflict in dilemmas by uncovering the principles (or values) that stand in tension. For example, when doctors encounter patients who do not consent to the best treatment option, asking instead for a less efficient but pain-free solution, the difficulty can be described as resulting from a tension between the principle of autonomy and the principle of beneficence. Moreover, doctors can easily recognize their own personal dilemmas as tokens of a more general type, and look for a resolution to the general issue that takes out from the equation more personal considerations. This can also provide an institutional advantage, as an important tool to shift the burden of responsibility from health professionals to a predefined protocol generated using a principlist method to assist decisions.[1] Such a shift might prove extremely valuable in certain situations, as it may help reduce emotional distress among medical doctors faced with impossible decisions. For example, in the current Covid crisis, the

[1] This point, as well as the short discussion and example that follows in the paragraph, was suggested by our colleague Elena Druica.

limited number of beds available in intensive care led to doctors having to choose between patients. An external protocol, embedding moral rules derived from accepted principles, may act as a mitigator for the stress experienced by the doctors faced with such decisions.

As a teaching strategy, principlism offers a particular method of analyzing the dilemmas by specifying moral principles, and by trying to balance the ethical requirements that they generate. Specifying the principle of autonomy, for example, includes the desideratum that the patient needs to be well informed and consent voluntarily to the therapeutic option. The rules of informed consent are thus justified as specified requirements of the principle of autonomy.

Although Beauchamp and Childress are confident that moral dilemmas can be clarified by specifying and balancing moral principles, they do not claim that principlism can lead to a solution for each imaginable biomedical dilemma. Especially when it comes to hard moral dilemmas they argue that it is important to acknowledge them as they are: dilemmas with no clear-cut moral answers. If we take this more reserved and humble attitude that they recommend, then the unwarranted moral expectation that all moral dilemmas have a unique solution might be deflated (2013, pp. 12–13).

By starting from theoretical moral concepts and principles, the PCAs enable health practitioners to understand the conceptual features of moral dilemmas. Their debates and discussions over dilemmas will be theoretically sound and better articulated analytically. The normative background confines the participants or students to approach the dilemmas from a more detached and objective standpoint, making it easier for health practitioners to offer solid moral reasons in support of their decisions. All these particular features of PCAs are even more useful when the purpose is to create or assess a policy or a procedure, since specifying principles might lead to more straightforward results in such cases.

Another advantage of a PCA is that it can be used in an exploratory or anticipatory fashion. Five years ago (we are writing this chapter in early 2021) a discussion in a medical ethics course about the ethical challenges of a generalized global pandemic would have seemed far-fetched or purely hypothetical. However, contemplating the dramatic reality of the Covid-19 crisis, saying that health professionals would have been better prepared to cope with it if such hypothetical scenarios were more often discussed in medical ethics courses and training over the previous decades, seems like a fairly reasonable point to make. The normative and conceptual structure of a dilemma (as a conflict of principles), in a PCA, is not sensitive to context or “reality”: it remains the same irrespective of whether the case happened, will happen, or will never happen.

Using PCAs in medical ethics education will lead, according to its proponents, to students or participants getting a firmer grasp of moral concepts (values, principles, duties, or rules) and a more systematic understanding of the sources of moral conflict. It will also help them understand the moral justification for the various regulations of the conduct of health professionals and of their interactions with patients and society at large.

However, a PCA is not a one-size-fits-all solution for medical ethics pedagogy, and we should be aware of its potential weaknesses. Analyzing dilemmas from an abstract principled point of view is epistemically demanding: participants need to understand the principles, use a specific normative vocabulary, and know how specification and balancing work as theoretical steps in the analysis. The last requirement in particular is far from trivial even for people with solid training in moral philosophy, so the objection goes that it is too much to impose it on students without such a background.

Using a specialized normative vocabulary helps organize the debate, but discussions could easily slide into a quarrel over the content and the nature of the principles, values or rules. For example, the principle of autonomy signals a lot of content: it is easy to imagine a lot of things but it is hard to define and clarify it with surgical precision. While such exposures can be important and enriching, their intrinsic conceptual complexity and time-consuming nature might lead to the course or training being "hijacked" and turned into a purely philosophical lecture.

There is also a risk that participants might get the feeling of being taught what to do or being judged for their past decisions. In particular when there is a gap between the theoretical framework and the moral intuitions, expectations or experiences of the participants, exclusive reliance on PCAs might not generate the kind of moral motivations and action-guiding capacity that are often expected as outcomes of an ethics course (although the question regarding the measurement of the outcomes remains).

10.4 Experience-centered approaches

As opposed to the theory-laden outlook that is specific to PCAs, experience-centered approaches (ECAs) deploy dilemmas as an educational means to reflect personal experiences, arouse the interest of participants and initiate a dialog or a debate between them, or between them and the trainers. ECAs do not discount knowledge of moral theories nor do they argue directly against the normative relevance of a theoretical framework; they merely place the lived experiences of attendees in the foreground, claiming that moral dilemmas are dialogical issues solvable through discussion and participation. Most likely, it is the particularist theories of morality (Dewey 1996; McGee 2003) that offer a source of conceptual and methodological inspiration, rather than the "grand" moral outlooks captured by deontology or utilitarianism.

The moral case deliberation (MCD) method is in our opinion a very clear illustration for ECAs. It enables medical practitioners to discuss their experiences, understand and try to figure out what could be done in different moral cases (Abma *et al.* 2009; Molewijk *et al.* 2008; Stolper *et al.* 2016; Tan *et al.* 2018). MCD engages the medical staff in a dialog without risking to start a moral debate in a dogmatic fashion, meaning that they do not assume before the debate or discussion what is morally wrong or good (A.C. Molewijk *et al.* 2008, p. 123). MCD relies on the dialogical method, which allows trainers to initiate the discussion with the aim of clarifying misunderstandings through open communication and interaction.

It remains however rather underdetermined how the dialogical method clarifies normative conflicts while not relying on any particular normative framework. As part of the "dilemma method" advocated by the

proponents of MCD (A.C. Molewijk *et al.* 2008, p. 124), participants are informed that there is no guarantee of a consensus or solution after an ethical medical dilemma is raised. A general moral question is formulated, and then several personal opinions are expressed, highlighting different points of view and their justifications. This way, it is hoped, attendees will recognize salient moral features, and transform their possible feeling of powerlessness into a positive and constructive attitude.

Moving personal experiences to the forefront enables medical personnel to share their own thoughts and work-related dilemmas. Compared to the PCAs in teaching medical ethics, the dilemma method in MCD is more interactive as long as participants feel comfortable enough, and trust the trainers and other attendees, who are often their own colleagues. Also, when everyone needs to express their own opinion and insists on the fact that moral truth does not exist, it offers the health practitioners the comfort to readily be engaged in a discussion and start a dialog with someone who doesn't share their point of view. The idea of epistemic authority is disavowed, while paternalistic authority and moral exhortation are kept to a minimum.

One of the charges that proponents of MCD bring against "top down" theoretical approaches that rely heavily on abstract principles is that they are inherently paternalistic. Irrespective of the merits of this objection, the alternative of a purely subjective or relativistic moral universe might be just as unappealing. If all moral rules of medicine are to be dissolved in personal experiences and only dilemmas that are "felt" do count, then it is reasonable that the expectation of predictability in the moral behavior of health professionals should be dropped. Furthermore, it seems difficult to reconcile denying the idea of moral authority with accepting the relevance of epistemic authority (for example, of doctors about medical issues).

Although health professionals in MCD can take into account the interests of patients, it is still unclear how they are represented, since patients do not typically take part in MCD training. This is further complicated by the assumption that all personal experiences are at least prima facie equally relevant. Of course, getting access to the personal experiences of patients is not always possible, as in the case of neurologically impaired patients, babies, etc. But it is unclear how ECA deals with these sorts of dilemmas since it relies primarily on the personal experiences of health professionals.

From a pedagogical point of view, if experiences are the crucial ingredient, then obviously participants need some clinical experience. Therefore medical students in their first years would not benefit from proper ethical training, potentially being unprepared to cope with work-related moral dilemmas.

One of the fundamental differences between PCAs and ECAs stems, in our opinion, from the different manners in which they answer the question "What comes into a dilemma?" A general point made by Solcan (1998, p. 22) can be helpful in rendering the difference intuitive. He distinguished between the "structure" of a dilemma or hypothetical case (which encapsulates the main conflict or tension in the scenario) and the more theatrical details that give narrative color to the story. For Solcan, a dilemma can

be sufficiently described, from a theoretical point of view, in terms of its structure. To take the example of the most famous dilemma in contemporary moral philosophy[2], it is irrelevant from this perspective whether we are talking about a trolley or any other possible danger, or about people being tied up to the rails or being, say, locked up in different rooms, etc. The only thing that matters at the end of the day is the choice between actively saving a larger number of people at the cost of sacrificing one, or letting the larger number of individuals die. For Solcan, as for PCAs, dilemmas are content-thin.

In ECAs, on the other hand, dilemmas are the actual lived experiences of the agents, and no detail is just a simple narrative accessory. Your feelings or the weather that day, the fact that the patient was wearing a blue blouse, everything comes together in the dilemma-as-experienced. Such details might look unimportant if seen through the lenses of the moral theorist, but we know from a broad empirical literature how (arguably) normatively insignificant features do actually heavily influence moral judgments and decision-making (Petrinovich and O'Neill 1996; Haidt 2012; De Freitas and Johnson 2018). So, while probably less central from a purely normative standpoint, the content-rich descriptions of dilemmas could prove to be more accurate in depicting the decision-making problems faced by real agents in real situations.

While the epistemic assumptions of PCA and ECA are very different, and they might look rather incompatible, we think they both can claim a legitimate place in medical ethics education, as long as we can define some "division of labor" between them. A first and quite obvious suggestion is that PCAs are more appropriate for introducing medical ethics to students lacking the relevant clinical experience, since ECA-inspired tools like Molewijk's dilemma method would not be available in their case. On the other hand, ethical training for experienced health professionals, equipped with relevant experience and some moral reasoning tools, might benefit more from an ECA approach confronting difficult moral decision-making situations encountered by participants.

Another avenue for delineating the respective domains of PCA and ECA in medical ethics education might consider the nature of the issue that is to be tackled through ethical training. Imagine that the participants will be the new members of an ethics committee tasked with drafting the ethical regulations or codes that will govern a clinical or research setting. In such a situation, it is reasonable to assume that approaching dilemmas from a principled standpoint and making clear the general structure that is common for a potentially large number of cases would be of significant practical benefit for the trainees. On the other hand, if the objective of the ethical training is to solve a very local issue, tied to a very specific medical organization (e.g., an ethically toxic climate in the workplace), then an ECA looks like the way to go.
While this chapter focuses on exploring the different outlooks embedded in the two approaches to moral dilemmas, it might be worth highlighting one crucial point of agreement. When it comes to the ethical education of medical students and professionals, both PCA and ECA recognize the importance of moral dilemmas as a pedagogical tool. An ethics course constructed as a mere collection of norms and interdictions can be of informative value, but if one of our objectives is to train students' ability for ethical reasoning and analysis, then confronting and discussing dilemmas will be instrumental.

[2] We are referring to the trolley dilemma formulated for the first time by Philippa Foot (1967).

Moreover, as we will argue in the next section, the new digital technologies offer very promising opportunities for both pedagogical approaches, potentially expanding their application and improving learning outcomes.

10.5 Digital technology, moral dilemmas, and medical education

As hinted in the introduction to this chapter, emerging technologies have already been used for a while in medical education, either to teach participants how to conduct certain medical procedures or how to operate particular medical devices. But, recently, digital technologies were also proposed as tools for the ethical training of medical students and professionals.

Filmed clinical scenarios were used in order to immerse students in VR-generated moral situations (Torda 2020). The CLASSIE modules described in Torda's paper might prove very useful to fill one of the gaps in deploying an ECA, since they would enable the students who were not personally confronted with ethically difficult clinical situations to get some first-person experience of the dilemma, to discuss it with the instructors, and to ask specific questions based on their own digitally generated experiences. This technology is promising for both students (inasmuch as they will be offered a more engaging learning setting) and for the instructors who can now focus on discussing and clarifying certain misunderstandings rather than trying to engage the students in a theoretical endeavor over different moral scenarios.

Digitally enhanced scenarios offer attendees a risk-free environment where they can tackle multiple moral dilemmas. The participants can experience different outcomes, link their decisions with probable consequences, inspect the underpinnings of their own decision-making process, think about how they can act differently in the future, and last but not least learn how to cope with their own decisions.

As a pedagogical tool for medical ethics, virtual reality (VR) enacts content-rich moral dilemmas that can in turn be used to study moral decision-making (Niforatos *et al.* 2020) or even to understand the behavior of health professionals when faced with a moral dilemma (Francis *et al.* 2016).

Although VR is a powerful technological enhancer, with exciting educational applications, its effects on selfhood and the way in which the digital experience might influence our choices as moral agents in real-world settings remain unclear and a matter for debate (Zahiu 2019).

Gamification is another very promising educational technology (Hamari *et al.* 2014), and has turned out to be quite effective in other disciplines, for example in teaching computer-programming languages (Elshiekh and Butgerit 2017). The basic concept of gamification is to engage participants in a setting organized as a game, challenging them with specific tasks, allowing them to advance in the game only after they fulfill the tasks and get in turn rewards (points or even certificates).

Dilemmas can be used as game scripts by developers to engage the users in first-person and third-person scenarios highlighting different outcomes and particular features. For PCAs, a third-person "gaming" perspective comes at hand, while for ECAs first-person perspectives would probably be more valuable, immersing the participant in rich content (sound, images, interaction between avatars, and so on).

Gamification offers real support for a PCA since one is able to create a controlled environment and design dilemmas based on theoretical concepts. For example, we can easily imagine several dilemmas embedding a conflict between the principle of justice and the principle of beneficence without being constrained by reality. This feature enhances the exploratory use of PCAs, since medical professionals will train to be prepared even for hypothetical but possible scenarios. This feature is especially valuable for medical professionals working in the field of emergency and disaster management.

In this chapter we have surveyed the two main approaches to the use of moral dilemmas in teaching medical ethics. We have concluded that both a principle-centered and an experience-centered approach would benefit from the current advancements in digital technology, which has the potential to bridge certain gaps. While supportive of the pedagogical use of instruments like VR and gamification, we admit that there are still open questions regarding the appropriate measurement of the impact of ethics courses in terms of their actual influence on the future behavior of the trainees (Campbell *et al.* 2007). However, if a central aim of ethical education in medicine is to produce ethical doctors, then their ability to recognize dilemmas, analyze them, interpret and come to terms with their own personal and professional experiences, must somehow be part of the desired outcome.

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We are deeply indebted to our colleague Elena Druica for her comments, kind criticism, and suggestions offered in various stages of this project. This chapter is very much inspired by (and also a by-product of) our work together over the past years. While Elena's feedback was invaluable for improving the chapter, we retain the responsibility for any of its shortcomings.

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11 Toward an open medical school: liquid education of surgery practices through Operemos

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Abstract

This chapter presents a preliminary approach toward an open medical school in hospitals through a new Spanish educational technology: Operemos. It describes this innovation in medical education, which works as an online teaching opportunities manager to flexibly promote practices and rotations in surgery. The new system supports teaching, learning, assessment, and management processes from medical students', clinical teachers', and educational managers' sides. It produces a new dynamic of fluid higher education practices in clinical settings, which interconnects a set of factors to offer an educational experience customized by the student, who can select diverse online and face-to-face learning opportunities designing their own educational itinerary to achieve their teaching objectives. It requires students' engagement, commitment, and integration in the generation of resources and providing feedback for assessments, which is the co-responsibility of teachers and students in medical education. Similarly, teachers offer many opportunities to a limited number of students, including digital materials, delivery, and assessment within the platform. All elements and actions are tracked and registered for different educational purposes, and prospection can ensure quality processes. Thus, it can enhance student motivation and self-directed learning, while promoting a change in planning, delivering, and assessing liquid training in hospitals, with fewer barriers and updated information to ensure the connection between educational agents, the quality of the education provided, strategic use of all types of resources, and continuous evaluation. An overview of this new concept of an open medical school through Operemos, followed by a technical view of its structure and functionality, will show how this new platform can offer a current pandemic solution and future medical education.

11.1 Introduction

"Operemos" a Spanish term that can be translated as "let's operate" is an online platform that is changing medical education practices and rotations in surgery within teaching hospitals from the 'Universidad Autónoma de Madrid' (UAM), such as the University Hospital Fundación Jiménez Díaz (UH FJD), among others.

It was created in 2019 by Dr. Héctor Guadalajara and implemented by Veni Vidi Surg, S.L., after a proof concept pre-tested through a pilot study within the General Surgery and Digestive Unit at UAM and UH FJD in 2020 (Guadalajara *et al.* 2021), the year of the beginning of coronavirus disease (Covid-19). It provided a solution to enable the continuation of surgery practice in hospital. This chapter describes how Operemos is transforming medical education toward an open school, and aims to first theoretically, and subsequently practically, show the basis of Operemos and how it works from the perspective of medical students, clinical teachers, and managers.

We will describe how Operemos was conceived, how it works, and its extension and possible use in other settings and contexts. For this reason, we will start by introducing the theoretical constructs in which Operemos has been based, and describe later its current structure and functionality, ending with a reflection regarding its current use and rapid evolution.

11.1.1 From opening up education to open schooling

Open education (OE) is a movement that has grown alongside the evolution of the internet and educational technologies (EdTech) toward the universal opening up of content and knowledge. According to Iiyoshi and Kumar (2010), the implications of opening up education can be summarized in a set of recommendations, which include key questions to consider when envisioning the opportunities and challenges it brings to our systems and societies:

- *How can OE tools, resources, and knowledge improve education quality? How can OE improve what already exists?* Through "social pedagogy" in blended and boundary-less education, toward blended learning environments involving good combinations of face-to-face and online educational settings, integrating pedagogical methods with new network-based learning tools to deliver quality educational opportunities through connecting experts and learners in settings that, before, had been almost inaccessible (e.g., an operating room (OR)).

- *How can we rethink resources, relationships, and rewards?* Progress is made through changing practices and policies. As in disciplinary research, OE advocates teaching needs to be open and built on others' good practices (i.e., active learning).

- *How to recontextualize roles and values?* Through accreditation and certification. Educators are starting to slightly change their roles. Technology has a role in facilitating this transition.

- H*ow is governance managed in OE?* The distributed nature of the collective effort can be critical for value, viability, and sustainability.

- *How to facilitate the know-how of OE initiatives?* It must be easy for all users. It is crucial to transform "tacit knowledge" into "commonly usable knowledge."
- *How have mechanisms to harvest, accumulate, and distribute the new educational assets been designed?* Through replication, as in research. For instance, OE should be growing and constantly improved by its agents and others interested in joining.

However, education is a human process that implies good communication between the actors involved in it, who are usually teachers and students in direct contact (online or face to face), and indirectly engaged with through other intermediate key roles (e.g., managers). Furthermore, in OE and EdTech, other actors influence the learning process who support how technologies shape and support teaching and learning processes.

This contemporary educational transformation has also connected with a new concept, Open Schooling (OS), which is defined as "the physical separation of the school-level learner from the teacher, and the use of alternative teaching methodologies, and where feasible, information and communications technologies (ICT) to bridge the separation and deliver the education and training" (Phillips 2007, p. 12). According to Abrioux and Ferreira (2009), OS has the aspiration of making education available to all further open and distance learning (i.e., e-learning). The principal behind OS is that each institution can select what type of education can flexibly be provided through these new forms of teaching, learning, and assessment through ICT.

In medicine, OE and OS have classically been applied through higher-education initiatives such as massive open online courses (MOOC) on health sciences (Liyanagunawardena and Williams 2014). These short OE courses are usually based on the Coursera platform, in the English language, and are usually offered by prestigious universities. Thus, current traditional higher-education models of continuous education have been moved to online environments to offer more massive rather than personalized education, and are theory or introductory driven rather than practical or in specialized areas, which are current gaps that need to be covered in OE and OS, especially in health sciences and medicine. For instance, specialties such as surgery require the personalization of educational strategies during continuous face-to-face practice.

11.1.2 From liquid modernity to continuous evaluation in fluid education

Another key influence in the creation of Operemos has been the sociological construct of "liquid modernity" coined at the beginning of this century by Zygmunt Bauman (2000). He states that "fluidity" and "liquidity" are metaphors to extend to the dynamic nature of present societies, and can be considered a visionary concept that has acquired recognition during pandemic times.

In higher education, this adjustment seems to be creating a new, urgent, and indeed unprecedented setting for educational processes, and challenges for educators and students during Covid-19 times. In a liquid-modern setting, teaching and learning alike are "de-institutionalized" (Bauman 2005), highlighting

the value of flexibility and provisionality in terms of generation of knowledge without rigid patterns or physical and technological constraint.

In fluid education, course evaluation through a continuous assessment strategy facilitates measurement of learners' competences at any time. This approach promotes learner self-regulation through continuous evaluation (Coll *et al.* 2007), looking for new ways to facilitate teachers to follow students' learning process, gathering multiple outcomes while supporting them in acquiring and using autonomous regulation competencies. Similarly, students have continuous information about their learning process and results, with possible opportunities, resources, and ways of improving them. Here is where EdTech has a role in driving learning assessment if learning activities are, simultaneously, assessments.

Nevertheless, the pandemic has highlighted the need to start planning, using, and testing more flexibly liquid continuous evaluation to ensure education can rapidly adapt itself to unexpected circumstances, maintaining optimal outcomes for all educational agents. Indeed, the aim is to educate with non-rigid instructional designs, while keeping agents on track to ensure educational quality independently of co-occurrences or turning points.

11.1.3 Humanistic medicine in higher education

Operemos has tried to respond to these ongoing movements, including the last one, which influences EdTech: the humanistic approach (i.e., person-centered approach). In medicine, this approach centers practice in the patient–physician relationship to protect human communication from technical or biomedical advances (among other things, such as bureaucratic influence on electronic health records; Gorlin and Zucker 1983).

Similarly, humanistic training is recognized in medical education as applying scientific knowledge and technical skills for the emotional, social, and cultural needs of individual patients and their families (Swendiman *et al.* 2019). Universities are increasing its presence in medical education curriculums with core humanistic values: professionalism, interpersonal and communication skills, cultural competency, and empathy (Hartzband and Groopman 2009).

At present, medical competencies such as listening, respect, caring, compassion, and support in the clinical encounter pose more risks than was the case in the previous century (Schattner 2020). In the case of academic surgeons, key humanistic attitudes seem to be humility, responsibility, high performance, and respect, adding a "standard of behavior" (i.e., respect and empathy; Swendiman *et al.* 2019). The influence from past role models sustains practice and a sense of mission (e.g., to transfer their humanism on to their students and residents). Thus the promotion of humanistic attitudes in teaching surgery can be undertaken through medical education practices, rotations, and residency periods: modeling, highlighting these characteristics in practice, applying them in communication with peers and patients, and maximizing the opportunities to learn them by doing medicine (e.g., through Operemos).

11.2 Overview

11.2.1 What is Operemos?

Operemos is an OE initiative toward an open medical school that targets communication, technologically and easily, between clinical teachers and medical students in a social networking style. From a humanistic medical education perspective, these students, who will base their learning in medical practice on connections with teachers and peers while being responsible for the activities, will probably go on to apply these learning attitudes with other colleagues and future patients (i.e., transfer their learning).

Operemos operates through a humanistic medical practical approach in a liquid learning environment that addresses educational processes from all actors flexibly, and continuously promotes assessment outcomes bidirectionally (students rank teachers' activities, while teachers assess student outcomes after each activity). These actions facilitate the users (the students and the clinical trainers) to be connected among them through the activities to undertake and assess. Simultaneously, the platform facilitates the users to be on-track on surgical practices announced as activities in Operemos through the clinical trainers' publications, who are surgeons in the different teaching hospitals. The activities can be either face-to-face or online, although the latter group has less representation, as the main objective of Operemos is to protect face-to-face activities, even in pandemic times.. The platform, therefore, acts as a manager of teaching opportunities. Students are the protagonists of autonomously self-directed learning itineraries according to the teaching objectives to be marked in each unit, subject or course. Similarly, teachers propose opportunities with a cap on numbers (especially in relation to an OR activity). They can include materials to check before the activity, such as the health and safety procedures required in relation to Covid-19. The managers can check the scorecard and the effectiveness of all activities and actors, enabling them to propose adjustments while ensuring optimal advancements on all sides.

11.2.2 How does Operemos work?

- Operemos aims to promote practical training in real life, especially in present times in the context of the pandemic.
- Due to its flexible nature, it can easily include Covid-19 secure circuits (e.g., videos about how to access the OR at UH FJD, adding health and safety personal protective equipment to new UAM students entering for the first time).
- It can guarantee a bidirectional continuous assessment strategy to ensure continuous evaluation, providing feedback to all educational agents (i.e., students, teachers, and managers) about the medical education undertaken in the hospital at any moment.
- It looks to obtain optimum performance in medical education within hospitals with minimum inversion (as it requires few technical staff to develop and maintain the platform, to manage students' and teachers' records, and a main manager, who can be the university's representative responsible for managing the scorecard).

- It is designed to be mobile-friendly (Figure 1), including mobile project features such as when the activity takes place (calendar), where it is going to be held (to avoid agglomerations), who is the clinical teacher (to facilitate teacher–student common knowledge), and team building (to promote connectedness, medical identity, and a common humanistic approach).

Figure 1. Mobile project features of Operemos: when, where, who, and team building.

For example, as depicted in Figure 2, an activity can be organized by faculty surgeon Dr. Dominguez on March 14, in OR number 1, accepting a student to be taught a specific surgical intervention, and once the activity has been completed, each participant (teacher and student) assesses the other, recording everything in Operemos.

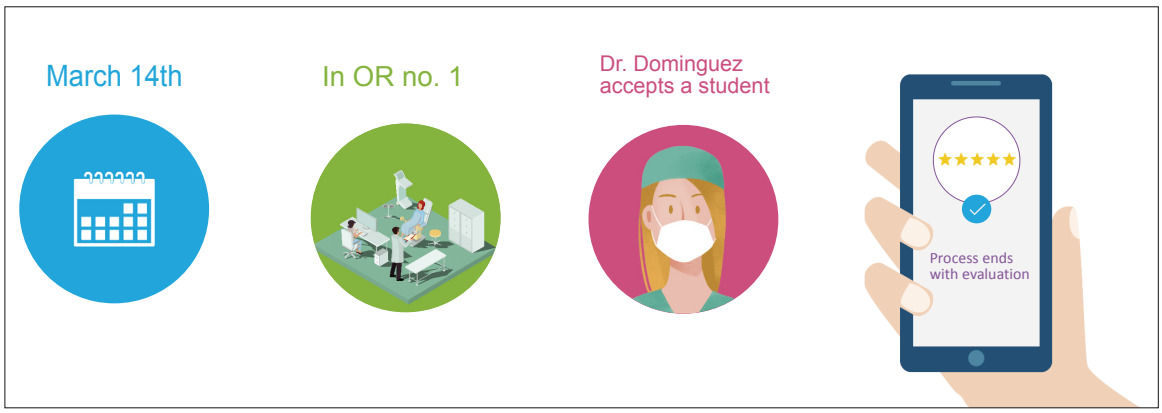


Figure 2. An example of how the mobile project features of Operemos work.

In essence, this means that medical students can now build their careers through self-management of medical practice itineraries. Clinical teachers can easily use technology to bring people together, transmit a humanistic approach, and collect evidence with regards to certifying their teaching. Managers at the universities can organize and keep track of their students, activities, and resources through a scorecard.

11.3 Operemos platform

Operemos (www.operemos.es) is an online teaching opportunities manager, used in the flexible promotion of surgery practices and rotations. It is a web-based tool to manage different users' profiles and thus covers all educational platforms' needs. It can adapt its functionalities to different user profiles so that student, teacher ("trainers" onwards), and educational manager can use it intuitively.

11.3.1 Student

Students are one of the main users of this platform, so there are multiple functionalities to give them all the tools they need to improve their educational process. They have access to all the online and face-to-face activities that have been assigned to the cohort to which they belong (e.g., students in fourth academic course studying Introduction to Surgical Practices), thus not only offering them the possibility to attend face-to-face activities (main means of learning), but also a large library of online content so that they can continue their training wherever they are and not limited to face-to-face teaching hours.

Activities

One of the main objectives of this platform is for students to be able to self-manage their training. With this in mind, on their main page they can see all the activities that are on offer for them to attend, with information about type of activity, date and time, place, trainer, and trainer's score. In addition, to facilitate choosing an activity, the student has different filters available to find the activity that best suits their needs, depending on type of activity, keywords, date, specialty, or location (Figure 3). This is an essential aspect of the platform, whose main objective is to be user-friendly.

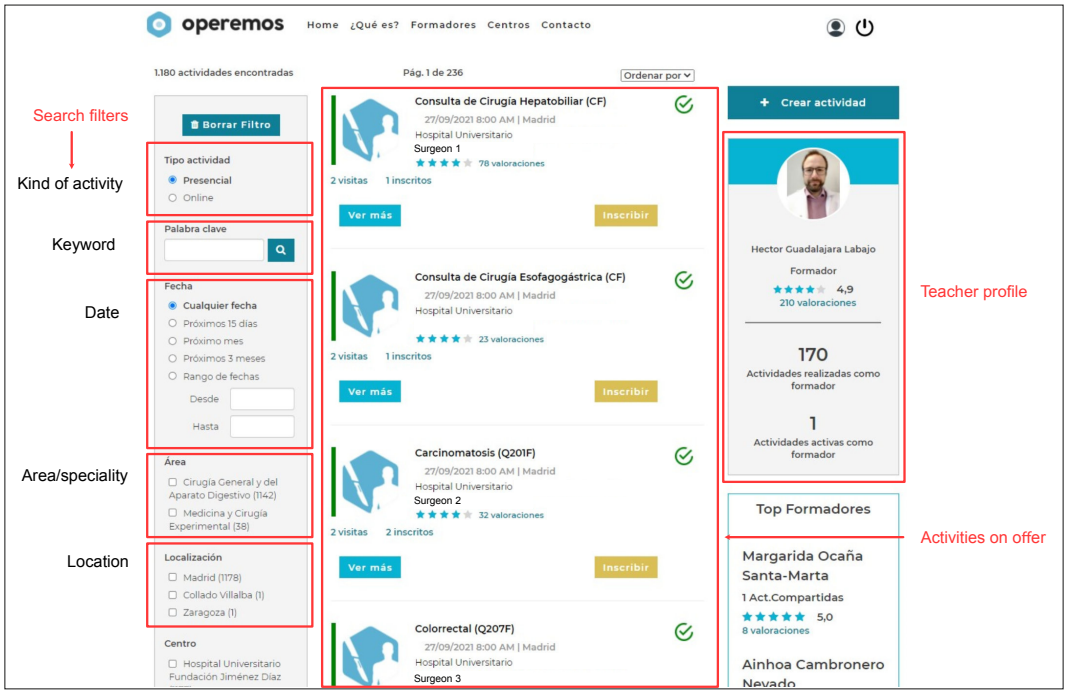


Figure 3. Student main page.

Enrollment process

To find out more about an activity, once a student clicks on the relevant link they can see more detailed information that the tutor thinks is important for the student (Figure 4), for instance how to get to the location where the activity will be held (for live activities), a more detailed explanation of the procedure, or videos or papers the tutor considers interesting and has added for the student to review before the day of the activity.

Once the student has read all the information about the activity and decided that they wish to attend, as long as there are available places (to enable the best attention for the student and in line with Covid-19 safety measures), they can register for the activity and then wait for the trainer to confirm they have been accepted for attendance.

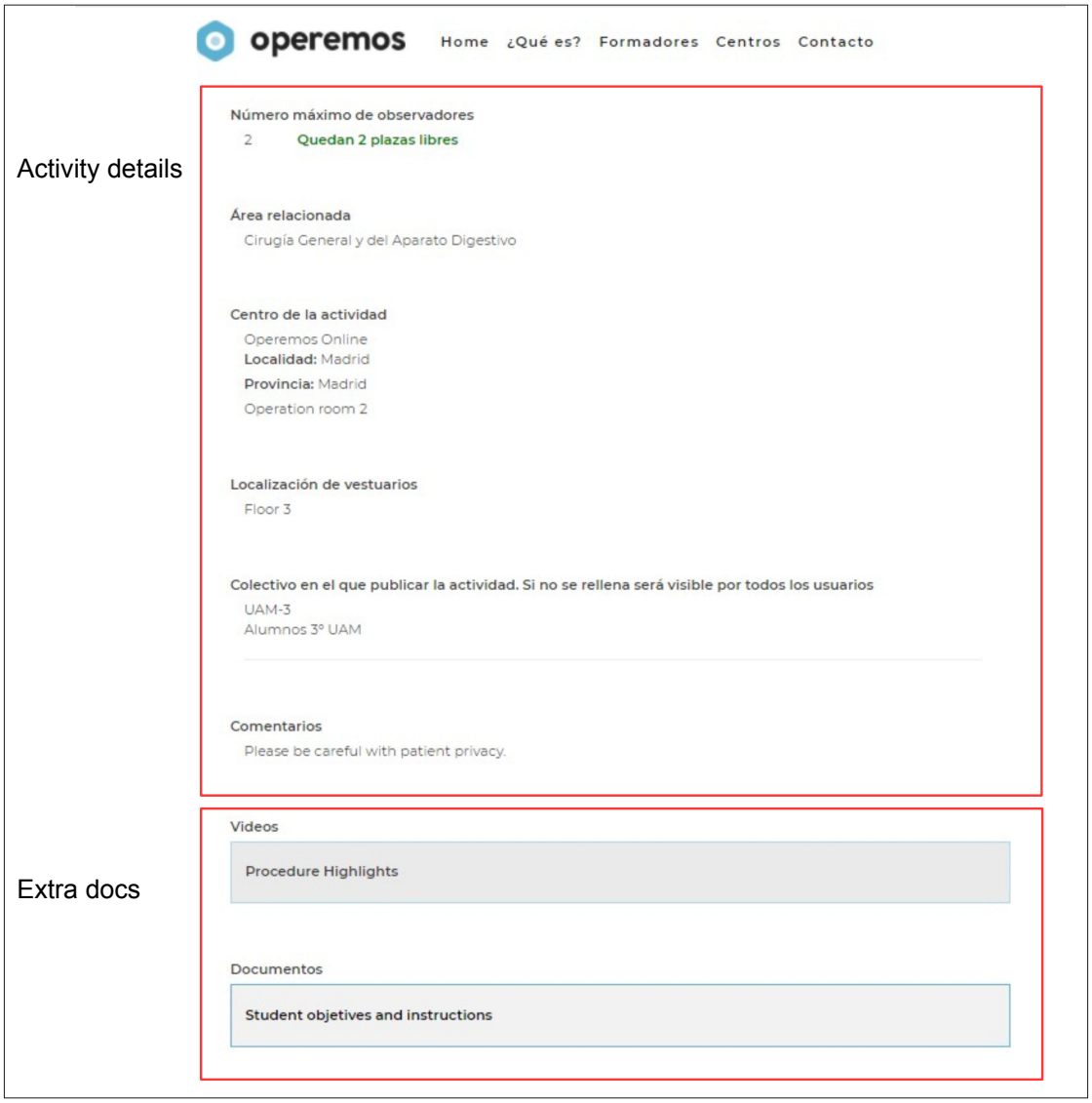


Figure 4. Enrollment process.

Once the trainer has accepted the student's request to attend, the student through Operemos is provided with a contact method to communicate with the trainer and clarify any questions that may have arisen about the activity. This is important as it enhances trainer–student communication and relations.

Bidirectional evaluation

Operemos is an innovative platform that breaks with the classical unidirectional grading system in which the tutor evaluates the student. In this case, each time a student performs an activity managed through Operemos they are required to evaluate the trainer responsible for the activity (Figure 5).

This is essential in ensuring the student feels that their words are also important in the training process, helping to create a ranking of trainers and sowing the seed of the humanistic approach in the relevance of communication in a dyad. Similarly, the trainer will evaluate the student's performance during the activity, promoting a concept of continuous evaluation and control over the student's progress.

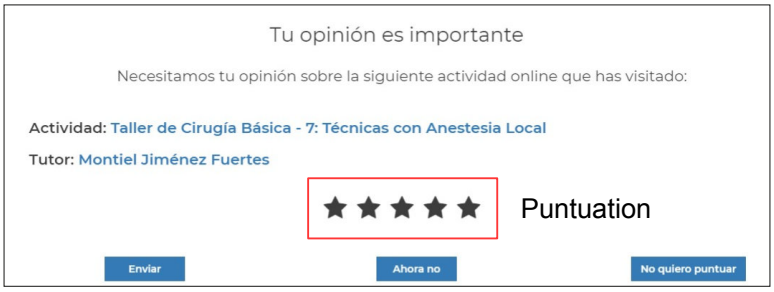


Figure 5. Evaluation procedure.

Once the evaluation process has been completed by both parties (trainer and student), the activity will be registered in the student's profile so that both student and manager can consult the activities attended by each person (Figure 6).

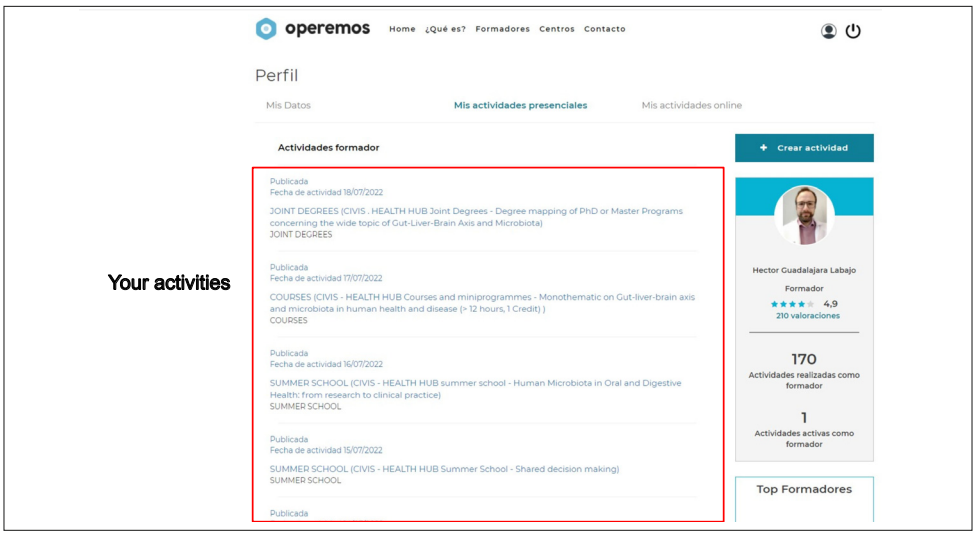


Figure 6. Register of student activities.

11.3.2 Trainer

One of the main objectives of this platform is to provide support to all users of the educational system, so the second user of this platform is the trainer (Figure 7).

Good performance on the part of trainers has a fundamental role to play in student learning, which is why all possible steps must be taken to facilitate their work and thus be able to offer higher-quality training. The trainer's opinion was considered during development of the design of Operemos, in order to create a platform that is easy for them to use, thus speeding up their work and giving them all the facilities they need.

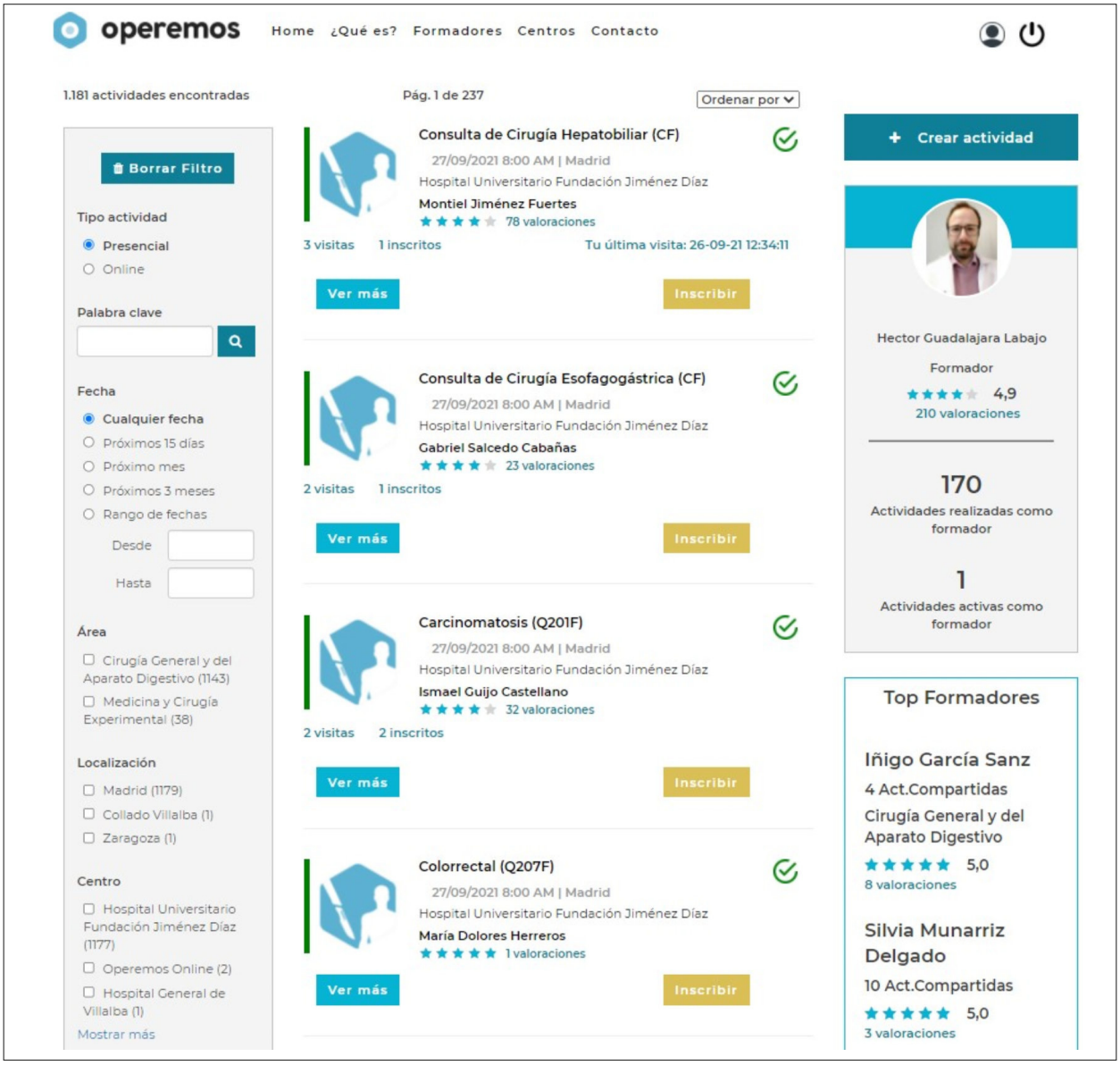


Figure 7. Main page for trainers.

Activity creation

The trainer's profile looks similar to the student's, however it also offers the ability to create activities, both online and live (Figure 8).

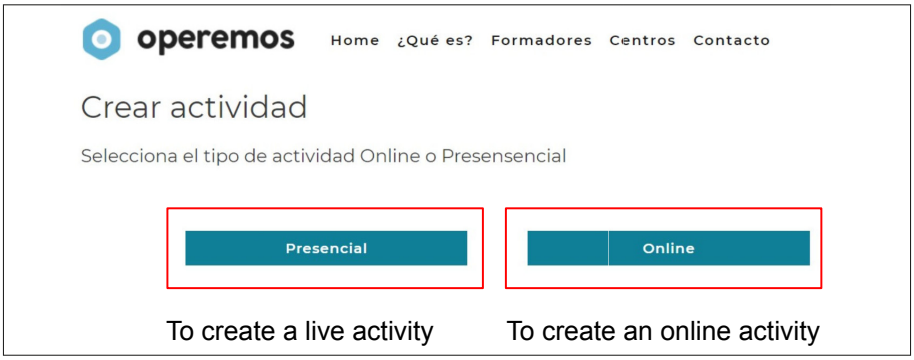


Figure 8. The functionality to create an activity.

The activity creation process is straightforward. It consists of filling in a form in which all the information about the activity is provided so that students can consult it before signing up, to ensure that an activity suits their interests (Figure 9).

The trainer can specify that, when signing up to their activity, the student should read or watch a video related to the procedure to be carried out, to ensure they have the necessary knowledge to attend. The trainer may also indicate a specific number of students who can attend the procedure, avoiding crowds, and thus preserving a safe learning environment (e.g., Covid-19 friendly), maintaining the capacity of the location, respecting safe distance, and ensuring that more personalized education can be provided to students.

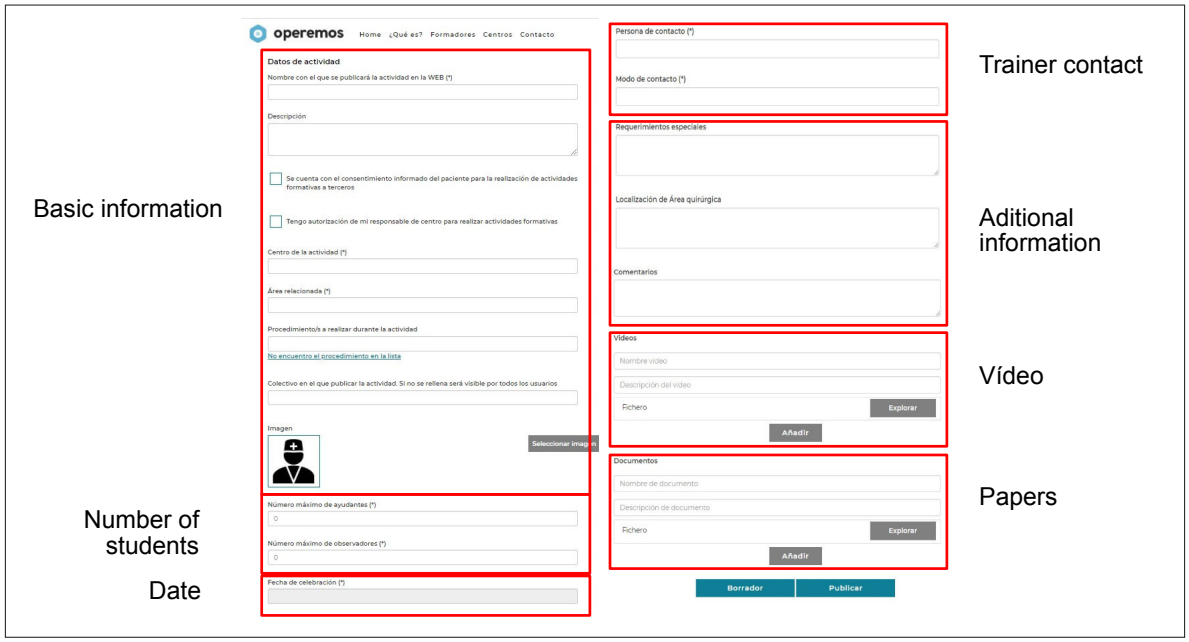


Figure 9. Activity-creation form.

Operemos also permits the creation of training itineraries. A trainer can put together a list of tasks necessary to achieve teaching objectives before a student's attendance is permitted (Figure 10).

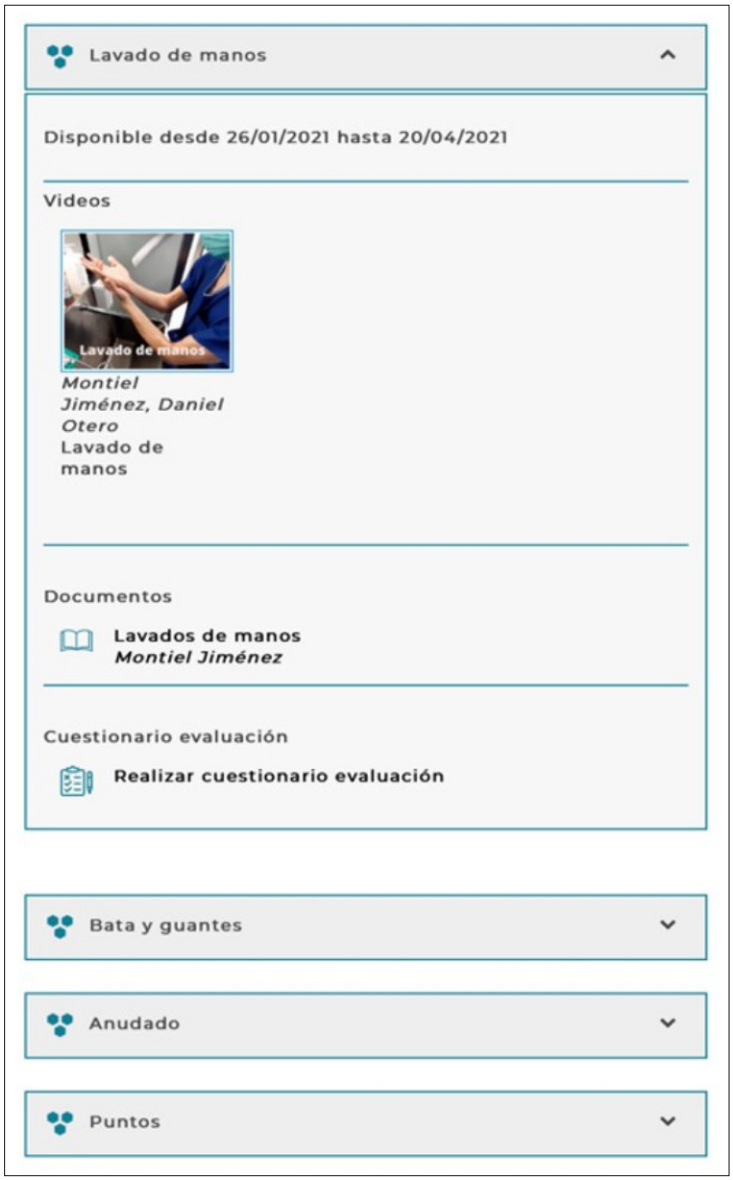


Figure 10. Training itinerary.

Acceptance/rejection of students

One of the objectives to improve teaching is to offer closer, personalized, and high-quality training. To achieve this, trainers need to know which students will attend their activity, so they can prepare appropriately in terms of teaching method tailored to the students who will attend, which helps trainers and students get to know each, facilitating the creation of a team.

For this purpose, Operemos includes a system for accepting or rejecting requests for student participation in activities (Figure 11). In this way, every time a student expresses interest in attending an activity, the trainer will be notified, and it is they who confirm or reject the student's attendance as they deem appropriate.

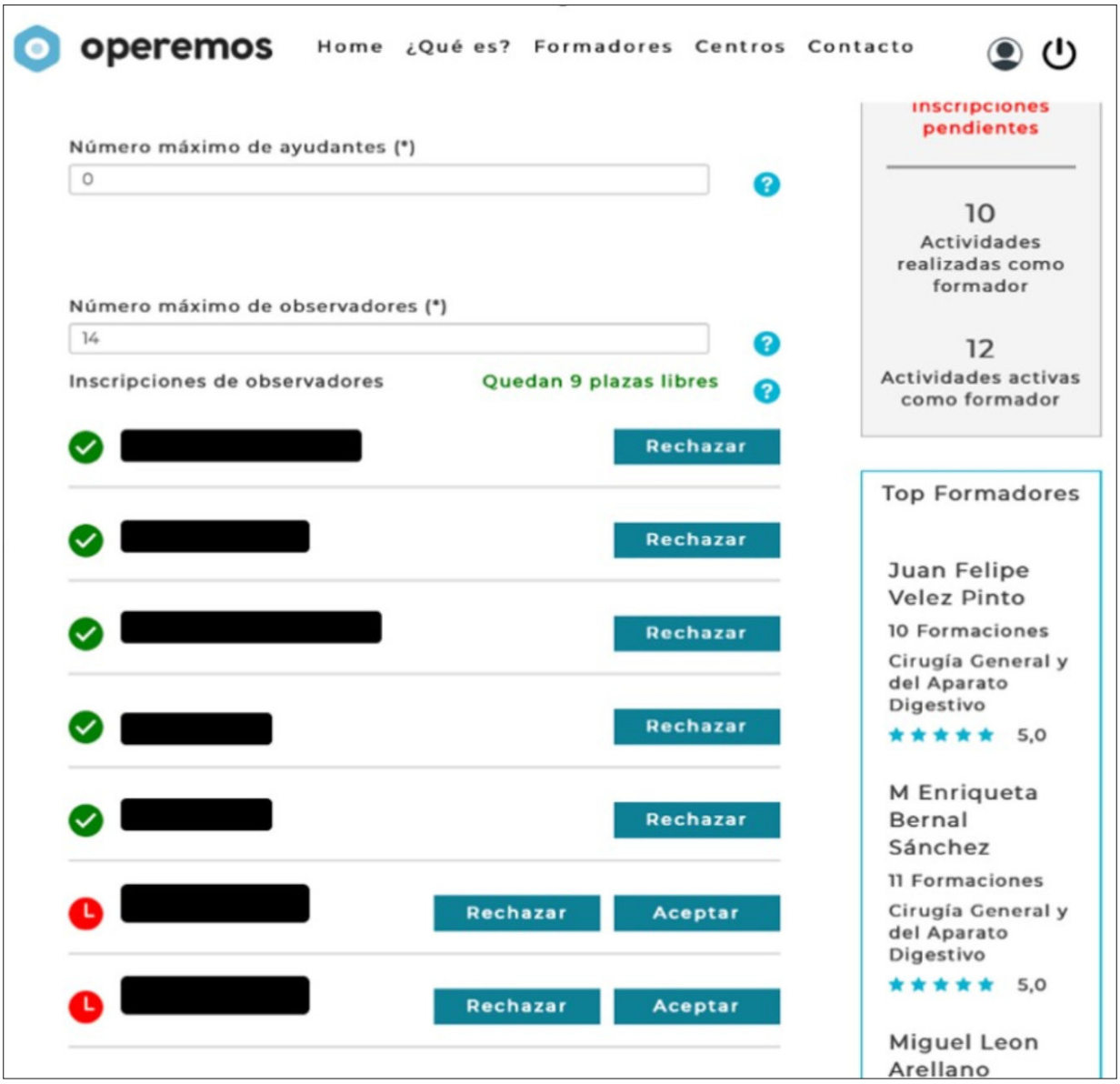


Figure 11. Acceptation/rejection process.

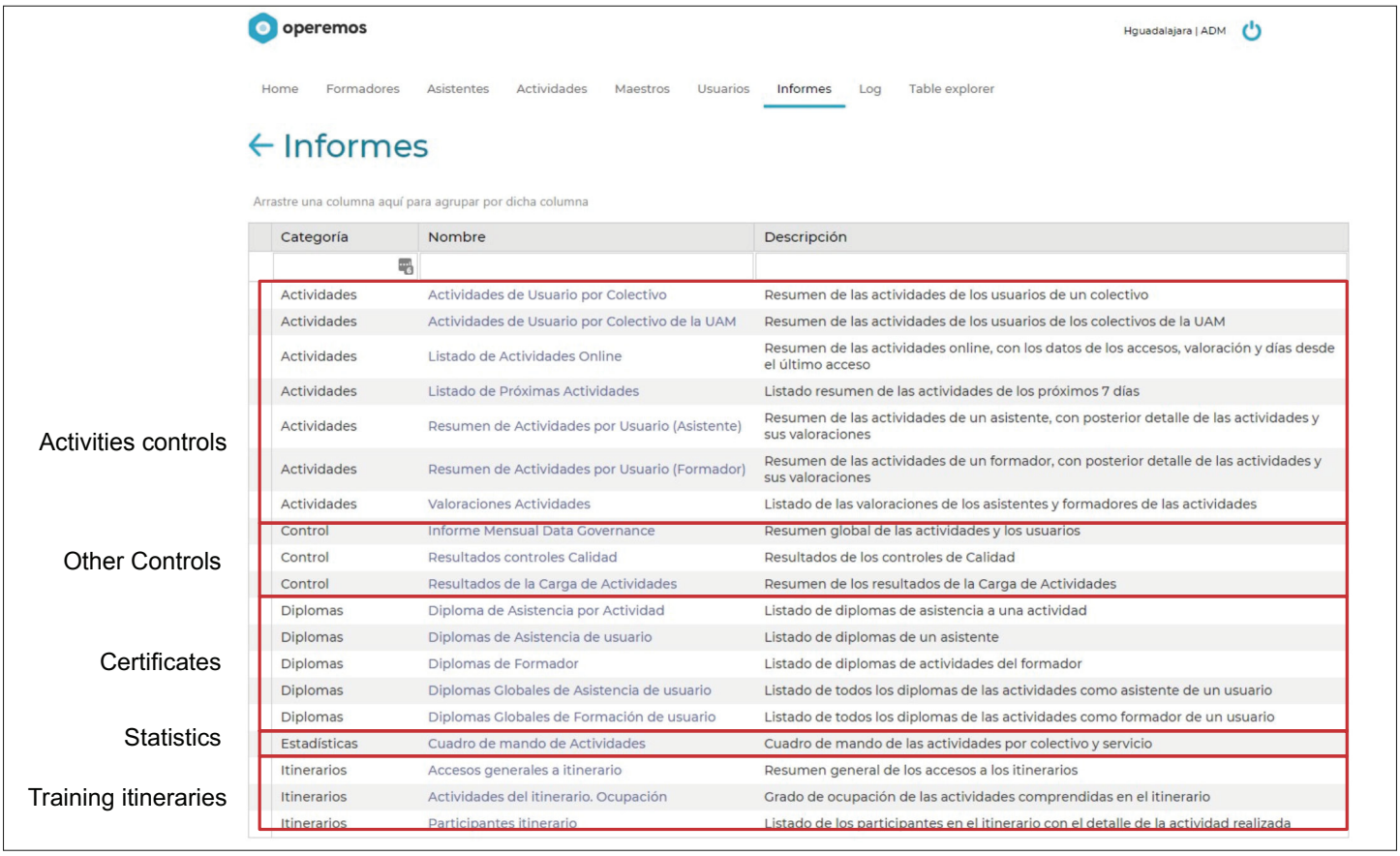
Assessment and recognition

After each activity, and to conclude it, a bidirectional evaluation process is carried out. Once this evaluation process has been completed by both agents, the activity will be recorded in the trainer's profile,

together with the assessment the student has given them. This is essential because it allows trainers to accredit their training activity and be included in the ranking of best trainers, with the prestige that this involves (Figure 12)—after all, it is a public ranking, accessible by everyone (Figure 13).

This process increases trainer motivation since their ranking position will depend on these evaluations and their students. Knowing that they are being evaluated increases their interest in the activity, thus improving their learning.

Figure 12. Trainer certificate



Categoría	Nombre	Descripción
Actividades	Actividades de Usuario por Colectivo	Resumen de las actividades de los usuarios de un colectivo
Actividades	Actividades de Usuario por Colectivo de la UAM	Resumen de las actividades de los usuarios de los colectivos de la UAM
Actividades	Listado de Actividades Online	Resumen de las actividades online, con los datos de los accesos, valoración y días desde el último acceso
Actividades	Listado de Próximas Actividades	Listado resumen de las actividades de los próximos 7 días
Actividades	Resumen de Actividades por Usuario (Asistente)	Resumen de las actividades de un asistente, con posterior detalle de las actividades y sus valoraciones
Actividades	Resumen de Actividades por Usuario (Formador)	Resumen de las actividades de un formador, con posterior detalle de las actividades y sus valoraciones
Actividades	Valoraciones Actividades	Listado de las valoraciones de los asistentes y formadores de las actividades
Control	Informe Mensual Data Governance	Resumen global de las actividades y los usuarios
Control	Resultados controles Calidad	Resultados de los controles de Calidad
Control	Resultados de la Carga de Actividades	Resumen de los resultados de la Carga de Actividades
Diplomas	Diploma de Asistencia por Actividad	Listado de diplomas de asistencia a una actividad
Diplomas	Diplomas de Asistencia de usuario	Listado de diplomas de un asistente
Diplomas	Diplomas de Formador	Listado de diplomas de actividades del formador
Diplomas	Diplomas Globales de Asistencia de usuario	Listado de todos los diplomas de las actividades como asistente de un usuario
Diplomas	Diplomas Globales de Formación de usuario	Listado de todos los diplomas de las actividades como formador de un usuario
Estadísticas	Cuadro de mando de Actividades	Cuadro de mando de las actividades por colectivo y servicio
Itinerarios	Accesos generales a itinerario	Resumen general de los accesos a los itinerarios
Itinerarios	Actividades del itinerario. Ocupación	Grado de ocupación de las actividades comprendidas en el itinerario
Itinerarios	Participantes itinerario	Listado de los participantes en el itinerario con el detalle de la actividad realizada

Figure 13. Certifications panel.

11.3.3 Platform manager (educational manager)

The final user of the system is the educational manager, in charge of supervising the correct functioning of the platform's processes, managing the administration of users, grouping them according to the organization and courses to which they belong, and administering attendance lists and certificates.

Managers are essential in ensuring platform quality, in charge as they are of verifying each user's data to make sure they are genuine. In addition to controlling all the attendance statistics, the manager also dispenses certificates as appropriate (Figure 14).

operemos

Actividades por Colectivo

Prácticas UAM - 6º Curso - (01/08/2021 - 31/09/2021)

	Total Act.	Otros	Acc Video	Val. Media
Ainhoa	2	2	3	4
Álvaro	5	5		5
Ana	1	1		2
Andres	2	2	1	4,5
Dina	15	15		5
Fernando	10	10		5,0
Giulia	7	7		4
Judit	9	9	15	5,0
María	7	7	2	5
Marta	7	7		5,0
Marta	2	2		3
Stacye	0	0	2	
Total:	28	28		

Figure 14. Attendance control.

11.4 Conclusion

This chapter has introduced Operemos, an online platform operating on social networking principals that acts as a teaching opportunities manager for surgical education in hospitals during a time of pandemic. This EdTech, based on an OE initiative, is based on educational, technological, sociological, and medical theoretical cornerstones and is a step toward an open medical school in hospitals that offers "training à la carte" to medical students. In less than two years, it has achieved major outcomes even with the

unexpected emergence of Covid-19, being used by three Spanish universities (UAM, 'Universidad Complutense de Madrid', and 'Universidad de Zaragoza') in undergraduate and postgraduate programs in medicine, psychiatry, and psychology (with an average of 1,400 users, 65% of students). Two organizations also use it in private and public domains (Takeda and Asociación Madrileña de Cirujanos) to promote continuous training for medical professionals in pandemic times, which demonstrates its versatility at all educational levels.

In summary, Operemos looks to enhance practical training in real life via a new network-based learning tool that is mobile friendly and delivers quality educational opportunities by connecting teachers and students to organize, deliver, and assess practice in OR settings. It is also a mature tool with a flexible nature that includes Covid-19 secure circuits. It was born at UAM, tested at UH FJD, and has rapidly expanded for use in other programs in higher-education institutions (HEIs). It is being incorporated at CIVIS (https://civis.eu/), a European civic university formed by the alliance of eight leading research HEIs across Europe, in which Operemos has been presented and included in an Erasmus+ proposal with Aix-Marseille Université, National and Kapodistrian University of Athens, Universitatea din București, Sapienza Università di Roma, and UAM.

In conclusion, the platform enables medical students to take charge of their learning itineraries, self-managing autonomously which activities to undertake to accomplish a set of proposed teaching objectives in the university pathway. It also facilitates clinical teachers to propose opportunities, deliver them, and assess student outcomes, also being accredited by their students, who work to achieve the teaching objectives marked by them and the HEI. Using Operemos, university managers control the scorecards, ensuring optimal advancements while keeping abreast of the progress of all agents in real life. Thus Operemos represents a significant advancement toward an open medical school in Europe.

Acknowledgements

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12 Virtual and blended mobilities: some thoughts for health sciences studies

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In the midst of the Covid-19 pandemic lockdown, most universities adopted synchronous online teaching, showing a most remarkable capability to adapt traditional ways of lecturing, of supervising group activities, and of giving seminars or problem-based teaching to a full online scenario. Such a resilient response needed further strengthening and securing of course design to face the academic year 2020–21. Many higher education institutions (HEIs) have remained fully online, whereas others have embraced blended modes of teaching and learning (T&L). Although many teachers have adopted this kind of e-teaching as a potentially interesting hybrid approach, even in post-pandemic normality, some important issues have nevertheless not been resolved in an online environment, among them what to do with practical courses, and with mobility.

Indeed, one of the most obvious areas that suffered from constraint of face-to-face activities were science-related degrees and particularly health sciences study programs. Even if some online (distance) universities, such as the Open University (UK), have developed extremely performant virtual practical courses (for different examples, see its Openstem-labs), training within hospitals or laboratories cannot easily be replaced. In planning for 2020–21 at Universidad Autónoma of Madrid (UAM), a blended model was adopted for biology, medicine, nursing, nutrition and biochemistry courses, leaving lectures and seminars in an online, synchronous format, while all practical teaching (including hospital based) was programmed in face-to-face mode, with all due preventive measures in place.

With the pandemic, yet another unsolvable limitation to students came from severely restrained mobility. In our European context, the Erasmus program has proven to be a powerful tool in allowing students to live in a different European country, to be exposed to different teachers and instructors, to different T&L methods, and to interact with peers of different cultures and backgrounds. Indeed, the European Commission reacted very quickly, encouraging (and allowing) universities to promote virtual mobility and, if possible, combined with physical mobility, in what has been defined as blended mobility (BM).

BM was discussed as early as 2018, during the preparation of new actions for the forthcoming Erasmus+ program for 2021–27, long before the surge of SARS-CoV-2. It was seen as one of the most innovative tools to promote "mobility for all", to increase the total number of students benefitting from this extremely successful European program. Implementing BM would allow immersion and integration from home in a distant, foreign classroom, while having the opportunity to go to the host campus and meet face to face, for a limited amount of time, student peers and teachers with whom the course was already (or was to be) shared. It would be convenient for students in special situations—related to work, family obligations, medical conditions, or other difficulties—unable to leave home for an extended period. Previous Erasmus programs were reluctant to acknowledge virtual mobility (VM) as equivalent to physical mobility (PM), but as noted, in spring 2020 VM was certified. Although students did not receive any funds, the allocation for universities' administrative purposes was preserved. During those early pandemic times, the Commission even heartedly encouraged BM.

Another current circumstance that has seen VM and BM programs attract a great deal of attention has been the rollout of the European Universities Initiative (EUI). This program, funded under the Erasmus+ program, aims to generate competitive university networks across Europe, to enable students to obtain degrees by combining studies across different countries, and for staff and faculty to benefit from sharing and belonging to a transnational campus. It has become clear that such transnational campus will benefit from deploying and making possible programs with innovative pedagogies, embedding VM and BM schemes.

Before going into a simple approach for health sciences BM programs, particularly for those that require or rely on heavy practical, face-to-face learning, I will go into further details of these new approaches that may encourage more inclusive, extensive, and enriching mobility for many more students.

12.1 Blended mobility: an innovative approach to address inclusivity

All three types of mobility—physical, virtual, and blended—can be characterized according to the length of time spent in the host HEI. Traditionally, the Erasmus+ program has defined long-term PM for students joining the host university for at least two, and up to 12, months. It has never considered long-term VM as an eligible activity (neither fundable nor acknowledged as such). Short-term mobility, on the other hand, was possible only for staff.

The new 2021–27 program (Program Guide for Mobility Project) includes a specific action, Blended Intensive Programs (BIPs), aimed at funding groups of HEI to design innovative programs of T&L with a component of online cooperation, and to combine short, physical mobility for learners and teachers. The PM component should be at least five days and up to one month. There is also specific mention of BM in the program, aimed at creating strategic partnerships (Program Guide).

As already mentioned, BM programs may offer a very powerful means to make mobility inclusive: by offering more flexible PM durations, it can be more accessible to participants from all backgrounds, circumstances, and even from specific study fields, in which long-term mobility can make more difficult the

completion of curricula. The variety of situations in which students can benefit from this kind of hybrid format makes BM appear one of the most innovative approaches to make internationalization a reality for all: students with fewer opportunities, with physical or mental health conditions, with children, students who are working, professional athletes, all may profit from these schemes. Other unnoticed beneficiaries of BM courses are local students, who can thus interact with international peers, adding to "internationalization at home" objectives of the participating HEI. (See Figure 1.)

- Provide new and more **flexible mobility formats**, and innovative ways of teaching and learning
- Complement **shorter physical mobility** with a virtual component
- Reach **students from all backgrounds and conditions** in all study fields
- Practice a **transdisciplinary**, challenge-based and **transinternational approach**, and foster more flexible curricula

Figure 1. Objectives of blended mobility.

12.2 Both virtual and physical components of a BM course require careful design

In a BM program, the virtual component must be compulsory and have a duration of at least three ECTS. It should comprise collaborative *online* learning exchange and teamwork. The design should include mixing local students in the classroom with students at distance; indeed these students can be from different universities and countries. By bringing them together following synchronous courses, working collectively and simultaneously on assignments and team projects, the virtual component will assure the enriching learning component of any physical mobility scheme. An important point to take into account is that the course program should integrate and recognize all collective actions as part of the overall learning outcomes and evaluation.

The BM program should also integrate the physical component of a BM program to fulfill some academic objectives. When at the end of the virtual component, it should be the time for enrolled "incoming" students to join the host university campus, also to tie down the bond built over the previous months with team fellows, to get some face-to-face tutorials by the instructor(s), to complete the teamwork or to present the collaborative project done at distance. It should also include some extracurricular, social, and cultural activities (i.e., field or town visits with the whole class and the instructor, social activities to experience local cuisine and habits, touristic tours of nearby surroundings). This may not be comparable to living for months (if not a whole year) in a foreign country, but at least it can be a way of experiencing the host university, its environment, and territory in a more intensive, familiar, and warmer way.

If the short mobility takes place at the beginning of the course, it should include both academic elements and sociocultural activities. In this case, it better serves to increase the sense of belonging to the host university, to generate the team, or to detect and correct any difficulties that can hamper the collaborative work afterwards. It can also facilitate course comprehension to get used to instructor dynamics. The duration of the physical mobility in the Erasmus+ BIPs has been set between a working week and a month. (See Figure 2.)

Blended mobility (BM) combines a virtual mobility (VM) program with **physical mobility** (PM) (5–30 days)

- The **virtual component** must facilitate *a collaborative online learning exchange and teamwork*, and bring learners together online to work collectively and simultaneously on specific assignments that count toward the overall learning outcomes
- **Physical mobility** must last *a minimum of 5 days* and be combined with *a compulsory virtual component*
- A **BM course** for bachelor's or master's studies must award a minimum of three **ECTS** credits

Figure 2. Components of blended mobility.

12.3 A good blended mobility course starts with a good blended learning layout

Whereas PM is, by definition, synchronous, the virtual part of BM, i.e. the VM component can be synchronous and/or asynchronous. One of the criticisms of VM is the belief that the online component is mostly asynchronous. That is why it is of paramount importance to make sure that during the virtual component of a BM program, synchronous activities take place, not only with, and led by, the instructor, but also, and very importantly, with the peer learners. This is one of the most valuable components, which can be very beneficial and is stressed in different forums that have intensively experimented with BM (EADTU Innovative Models for Collaboration and Student Mobility in Europe, May 2019; BLENDED Mobility Erasmus Project 2016–18).

Thus one aspect that can facilitate the design of a BM program is to make use of blended learning tools. Blended learning makes use of traditional in-class learning and asynchronous (or synchronous) online activities. First developed at school level, it very quickly reached higher education. One classical format is flipping teaching, in which the transmission of knowledge is done through asynchronous, recorded lectures taken by the student at will and as many times as needed to assimilate the information, and then face-to-face tutorials, and problem- or case-solving sessions led by the instructor (Figure 3).

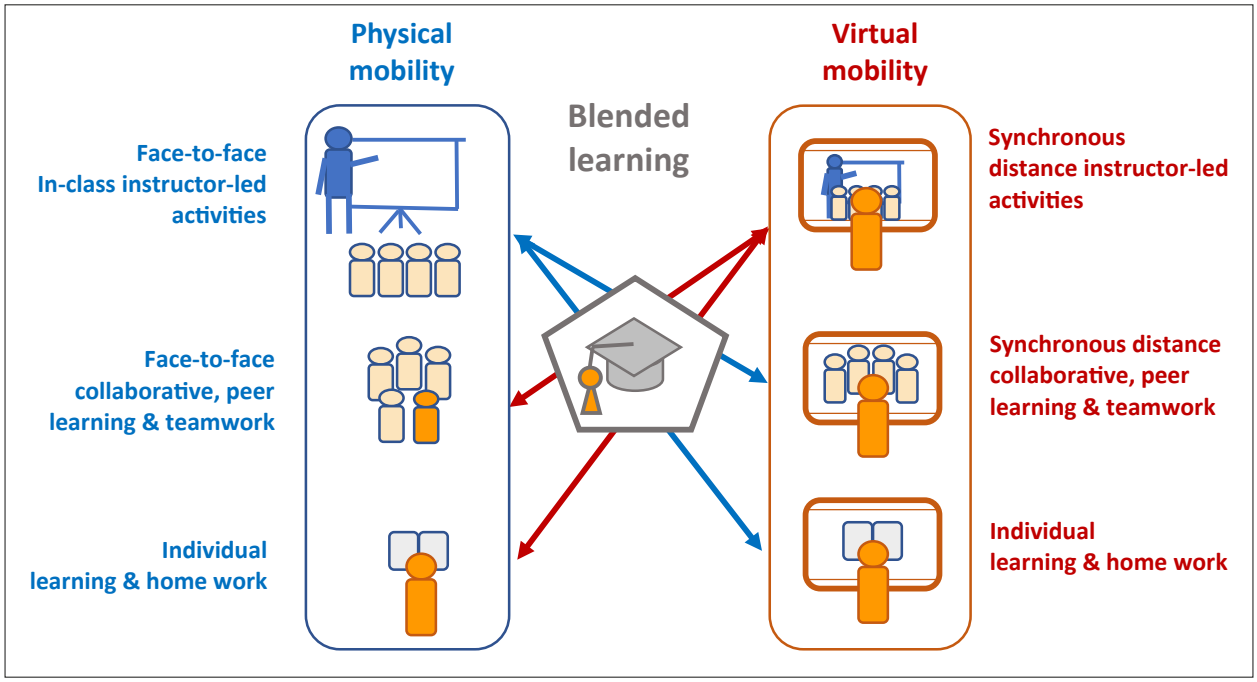

Figure 3. The possible activities in a blended learning course for a mobility student (orange).

Nowadays, the number of activities that can be included in a blended learning program is varied, and aimed at developing skills and learning outcomes, while basic, solid information is acquired. With the level of digitalization reached by HEIs (especially because of the pandemic and the need to carry on education at distance) and the proficiency of students with digital tools, the line between face-to-face, in-class activities and classical (individual, *offline*) e-learning schemes is narrower than ever. For instance, synchronous lectures can be taken in class (face to face) or at distance (through streaming platforms). Collaborative work between students may be performed in situ, in front of the instructor, or at distance by the student teams. Peer learning schemes can be created to promote discussions and debates, synchronously or asynchronously (e.g., through forums or chat) about some designated questions. Such asynchronous activities go beyond classical assignments (individual essays, projects, or problem- or case-solving homework), but can also include self-paced, massive online open courses (MOOCs), bibliographic research, or data mining. All are possible T&L instruments. Importantly, the instructor must design and choose carefully among all these elements the most appropriate for a blended format, independently of whether or not VM students are enrolled.

Once the blended learning course is designed, adjustments to accommodate students in a VM mode may be quite easy to make. In this case, one of the most important arrangements, though, is to form "mixed" teams of local and distant students, to ensure full integration of the latter. The incorporation of the short-mobility component once the long-term virtual component, based in a solid blended learning design, has been set, will then need support from the university office dealing with mobility through Erasmus or similar programs, and an element of planning for social/cultural activities.

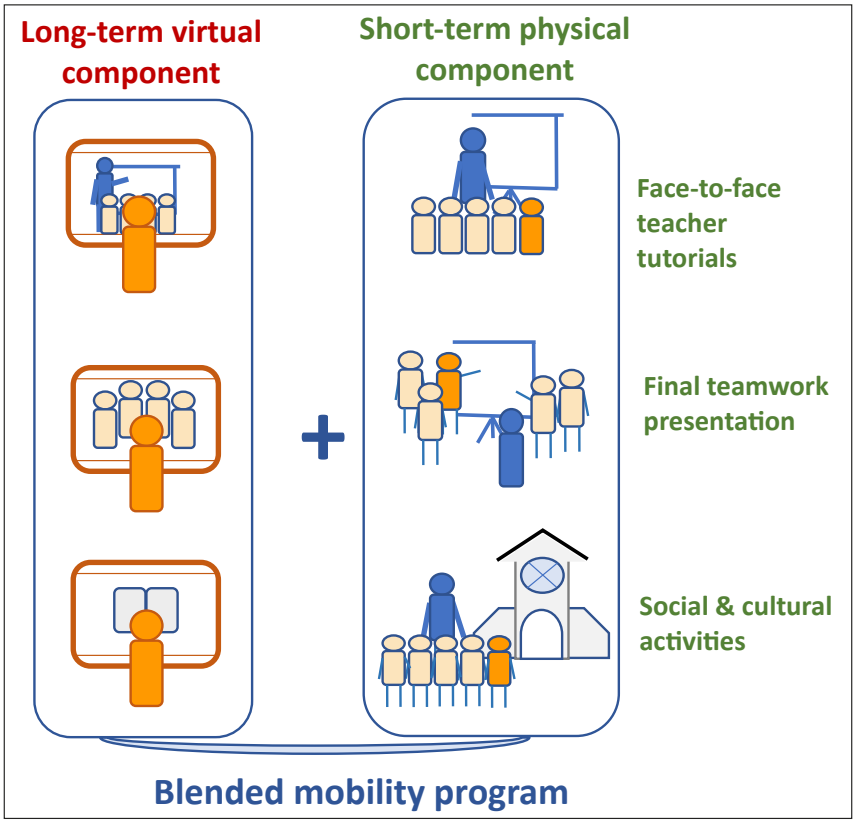

Figure 4. A BM course with both virtual and short-term physical components for a mobility student (orange).

12.4 Practical/hospital training in a BM program: easy if done in collaboration with partner HEIs

Most of the courses that health sciences students must take include some laboratory or hospital training, a specific difficulty possibly encountered when designing a BM course in this area. The easiest way to design health sciences BM programs is in concert with colleagues from one or more partner universities. The practical training could be done during the time of the short PM, or if embedded in the middle of the course, taken at their home university by students enrolled in the BM course. These collaborative courses can also be extremely fruitful for teachers. If more than two universities take part in such programs (as could be likely in the context of EUI alliances), some activities could be led by instructors from different institutions, benefitting from Erasmus+ staff mobility to participate in one or more of universities undergoing the common BM program.

In this respect, it is worth highlighting that the concept underlying the BIP initiative in the new Erasmus+ program is to strengthen capacity building in the participating HEIs for the development and implementation of innovative T&L practices.

- *Travelling to host university*

Step 1: Short physical mobility component, 1–4 weeks

- *Back home*

Step 2: Blended/online course at host university, virtual mobility component, 8–11 weeks

or

- *Home*

Step 1: Blended/online course at host university, virtual mobility component, 8–11 weeks

- *Travelling to host university*

Step 2: Short physical mobility component, 1–4 weeks

Lab/hospital practical activities can be undertaken during the short physical mobility or at home university while attending the virtual component of the blended course at host institution

Figure 5. Basic blended mobility for health sciences courses.

At UAM, we launched a seed funding call for pilot BM courses aimed at faculty members involved in undergraduate/master's courses. Ideally, they should design (or have already designed) a blended learning approach for the coming academic year. The course should preferably be aimed at students from CIVIS (the EUI alliance to which UAM belongs). It should preferably be coordinated with CIVIS colleagues in first/second semester 2021–22 or delivered as an intensive summer course in 2022. We have granted five proposals, one of them intended for health sciences students. It will offer a powerful means to detect the difficulties and achievements of BM in this area. The initiative will also be useful in terms of participants feeling more confident and ready to apply for and be successful in Erasmus+ BIP calls.

In summary, BM programs can be essential in facilitating many students with limitations to leave home for extended periods. If properly planned and embedded in degree syllabi, students could even accumulate several BM courses, with scattered short periods of PM to one or more institutions. To put the prospect into figures, if one student could take one six-ECTS BM course per semester (ideally with only one short physical mobility at the host university at the intersection of both terms), at egression he or she would have taken 36 out of 180 ECTS in one or more host universities. This would account for one to six months of PM in total. The student would have carried out interactive work with multiple fellow students from different backgrounds/origins and been exposed to different teachers from more than one university. When possible, the scheme could easily combine with more long-term PM (still highly recommended by the Commission), not only during regular first or second semesters, but also during intensive periods such as summer terms.

13 A publisher's perspective on future trends in medical education

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McGraw Hill Medical appreciates the opportunity to have presented the information contained in this chapter to an audience of esteemed academics at the renowned Sapienza University of Rome School of Medicine in Italy. When we presented this contribution on February 7, 2020, we did not know how deeply the world of medical education and the world as a whole was about to transform because of Covid-19. The way in which students were educated changed overnight as the pandemic shut down universities worldwide. What we had highlighted as possible future education trends became the new reality for many universities in a matter of weeks.

This chapter is written from a medical publisher's perspective and describes our journey as a content provider in the evolution of medical education. Included are key insights from our own in-person interviews with medical deans, faculty, students, and librarians, as well as important readings from the literature on the topic of medical education. McGraw Hill's primary goal as a global leader in medical education publishing is to partner with medical universities and institutions to create the highest-quality learning resources to fully meet the evolving needs of medical students, faculty, and librarians.

13.1 Electronic books and the internet: McGraw Hill Medical's evolution from print to digital

Project Gutenberg, founded in 1971 by Michael Hart, revolutionized publishing as it was the initial source for electronic books (e-books) (Lebert 2008). These e-books were stored on university computers where students and faculty could access them at no cost. The official birth of the internet in 1983 allowed for

widespread sharing of published information, including Project Gutenberg e-books. Several years later, in the late 1990s, medical journals were among the first formal medical readings available online, which helped pave the way for other forms of digital medical electronic media, including e-book publications. In October 1998, the National Institute of Standards and Technology gained attention when it held its first government-sponsored meeting to discuss e-books, where publishers and technology experts met to address this emerging medium and its wider implications (Young 1998). As knowledge of these digital capabilities spread, customers began to request online content, and in 1999 McGraw Hill Medical published its first e-book, *Harrison's Principles of Internal Medicine*.

In the early days of our digital publication experience, we simply aimed to put as much of our content online as quickly as possible, without fully considering faculty or learner needs. For the next few years, our mission was to move all our content online, which included books and some other ancillary materials that were already available in print. We created our first comprehensive digital site, AccessMedicine, in 2004. Soon after, we expanded our portfolio through the creation of similar sites for other medical specialties.

13.2 A publisher's point of view: the changing needs of our customers

We wanted customer feedback on our digital products, so in 2016 we launched a series of focus groups to further understand the digital media needs and interests of our customers at faculty, librarian, and student level. We spent numerous hours on campuses around the world listening to students and residents, observing classes, attending rounds, and talking with faculty and deans to help us sharpen our understanding of the future of medical education. At that time, courses were taught in a traditional model where students would do some readings on their own prior to class. In class, the faculty member was primarily functioning as the "sage on the stage," standing at a podium in front of a large lecture hall of students, teaching from a deck of slides (King 1993). After class, there was limited interaction with the faculty to ask clarifying questions or to explore a topic in more depth. Students completed homework assignments independently to practice and apply the knowledge gleaned from lectures and readings. This traditional teacher-centered education model has many flaws. First, the teacher, rather than the student, is the focus of this model. Second, it is more passive in nature and does not offer the opportunity for students to develop important critical thinking skills, which are essential for any future diagnostician. Third, students are not active partners in their education, and faculty function as information providers instead of information coaches (Harden and Lilley 2018).

13.3 Rethinking medical education

Pressure to alter long-standing teaching strategies was beginning to surface in the literature, at medical education conferences, and in some medical schools. A 2016 essay, "Educating medical students in the era of ubiquitous information" (Friedman *et al.* 2016), outlined three key competencies to help medical students manage the overwhelming volume of information they needed to know. This paper argued that it was neither reasonable nor helpful to continue to require medical students to commit an overwhelming volume of information to memory. It was more important to teach these learners to "know what you don't know," manage those knowledge gaps by asking appropriate questions, know where to find correct

answers, and critically evaluate those answers once they were identified (Friedman *et al.* 2016). These proposed changes deviated from years of tradition and would require a dramatic culture shift within the medical education community if they were to succeed.

In 2018, Harden and Lilley agreed that medical students should not be taxed with memorizing an abundance of information but should be required to possess specific fundamental medical knowledge and skills (Harden and Lilley 2018) They argued that medical students need to master medical vocabulary, essential medical information, and broad theories, and to possess a general understanding of medical possibilities (Harden and Lilley 2018). That same year, Harden published a paper to expound on these new ideas, which sparked further discussion about the need to alter traditional medical education (Harden 2018). This article outlined long-standing problems with current teaching methods and made bold recommendations about how to efficiently modernize antiquated teaching strategies in medical education (Harden 2018). Harden proposed a move from "just in case" to "just in time" learning, which was meant to address the significant cognitive burden that was traditionally placed on medical students who were forced to memorize thousands of facts (Harden 2018). This shift was meant to stop medical students from memorizing information "just in case" they needed to know it some day. Instead, the end goal of "just in time" learning was proposed, where the student would be taught the necessary skills to identify the correct answer at a time when and if it was needed. This paper prompted a great deal of internal dialog within McGraw Hill Medical about the way our digital transformation was unfolding. It served as a foundation for our observations and conversations with key medical education stakeholders as we visited US and international universities over the next few years.

13.4 Teaching strategies that work: CBL and PBL

Many medical education teaching methods have been stale and in need of an overhaul; however, case-based learning (CBL) and problem-based learning (PBL), which are similar, were not among them. CBL is a type of inquiry-based learning in which the student is provided course objectives, a real-world patient scenario, and a faculty facilitator who is available for consultation as the student works to solve the case (Wood 2003; Srinivasan *et al.* 2007; Thistlethwaite *et al.* 2012; McLean 2016). In CBL, there is some preparation prior to the small group meeting, and the facilitator interacts with students by asking guiding questions (Slavin *et al.* 1995). PBL was first implemented by McMaster University School of Medicine in 1969 and has been widely used in medical education since that time. PBL was originally meant to be taught as follows, although many variations exist (Barrows 1996). A small group of five to nine students are gathered with one tutor who functions as a facilitator of learning. Students are given a problem (i.e., case vignette) to solve and they select reference materials to search for answers to their problem. Expert faculty may be available for consultation to help students better understand certain aspects of the problem. The tutor or facilitator asks probing questions that students should be asking themselves, to help guide them in the right direction toward solving the problem. As students become more familiar with PBL, they begin asking the probing questions of others in their group. This student-centered pedagogy has worked well in medical curricula as it teaches students to take responsibility for their own learning. Both CBL and PBL are used to connect theory and practice in an effort to prepare students for the critical thinking skills they will need when caring for actual patients (Thistlethwaite *et al.* 2012).

13.5 Injecting innovative teaching methods in medical education

While CBL and PBL have proven to be solid, long-standing teaching strategies for medical education, other older methods that were not student-centered needed to be replaced. Innovative teaching methods borrowed from other sectors of education, such as team-based learning (TBL), guided discovery, and flipped classroom (FC) have been introduced in medical schools internationally. TBL educates medical students about the real-world experience of working in a team to solve clinical problems (Haidet 2012; Burgess *et al.* 2017). Prior to class, each individual is responsible for completing the assigned readings. In class, learners are placed into small groups of five to seven medical students (Table 1). At the beginning of class, each student must complete their own individual readiness assurance test (IRAT), which assesses knowledge about the pre-class readings. The same test is repeated with the group through the Group Readiness Assurance Test (GRAT). The group then discusses the answers in a forum where each member voices and defends their response. After this session, the instructor introduces an application activity to the group, which is typically a clinical situation or vignette with multiple-choice questions (Hunt *et al*. 2003; Haidet 2012; Burgess *et al.* 2017). This activity takes foundational knowledge and allows students to apply what they have learned to real-world patient scenarios, which builds clinical reasoning and teamwork skills (Hrynchak and Batty 2012).

Before class	Beginning of class: individual work	During class: group work
Pre-reading	Individual Readiness Assurance Test (IRAT)	Group Readiness Assurance Test (GRAT)
		GRAT review: group discusses answers to test questions
		Application of knowledge activity with the group

Table 1. Team-based learning.

The FC—or, as it was originally named, the inverted classroom—takes traditional activities of learning such as lectures and homework and switches them to make classroom learning more active and engaging (Lage *et al.* 2000). Widespread availability of multimedia played an important role in the creation of this teaching strategy. For example, students with access to the appropriate technology are able to watch a recorded lecture independently prior to class and learn foundational information. In the classroom, they are expected to apply what they learned from the video through participation in a group activity (Lage *et al.* 2000). Guided discovery learning combines lecture-based instruction with student-centered and application-based activities. The four main features of guided discovery are: (i) a foundational learning framework; (ii) independent student research to learn more about a concept; (iii) availability of study guides to direct learning; and (iv) activities where the student must apply knowledge to a clinical problem (Lavine 2005). PBL may be combined with guided discovery in didactic courses for large groups of students. When compared to traditional lectures, guided discovery encourages learners to more deeply understand the subject matter as they synthesize knowledge learned through independent study and engaging activities (Lavine 2005).

13.6 What do medical students want from their education?

As medical education was changing, McGraw Hill wanted to learn more about what was working and what needed further modification. Our primary purpose in connecting with medical students was to ask how they wanted to learn and what could be improved to enhance their medical education experiences. We noted trends and recurring themes from our conversations with students across the globe. Here is what they said:

We want…

- To engage with content;
- Instant feedback from all learning activities;
- High-yield summaries of complex concepts;
- Case-based scenarios and real-world examples;
- To use video in place of lectures and to reinforce learning;
- To learn from test prep questions and answers;
- Visual representations to simplify complicated subjects;
- Audio/podcasts to fit our mobile lifestyle.

13.7 What did we learn from medical faculty and administrators?

During campus visits with students, we also scheduled meetings with faculty and administrators to ask similar questions about recent changes in medical education: what was working and what needed to be altered? Again, there were commonalities between faculty and administrators from across the US and other parts of the world. Here is what they had to say:

- Implementing a new curriculum is not easy and requires meetings with teams of faculty for many hours.
- We need innovative resources because it takes a tremendous amount of time and faculty/librarian resources to prepare high-quality teaching tools.
- How can we teach important skills like clinical reasoning and emotional intelligence?
- Information literacy (media/digital) needs to be integrated into curriculum because there is a lack of consistency in the educational resources students use on their own, and information they find may be “out of date.”
- Students don’t regularly attend class.

- Faculty have variable comfort in facilitating the use of new resources and technologies.
- We are struggling with information overload because there are more medical advances and increased medical knowledge to learn.

13.8 Designing digital products to fit medical education needs

Our teams came together to share what they had learned during visits with key academic stakeholders and began to form a plan to help address common pain points. We learned that changes to medical education were very much global in nature, and we applied the feedback from faculty and students to the creation and enhancement of our digital medical products.

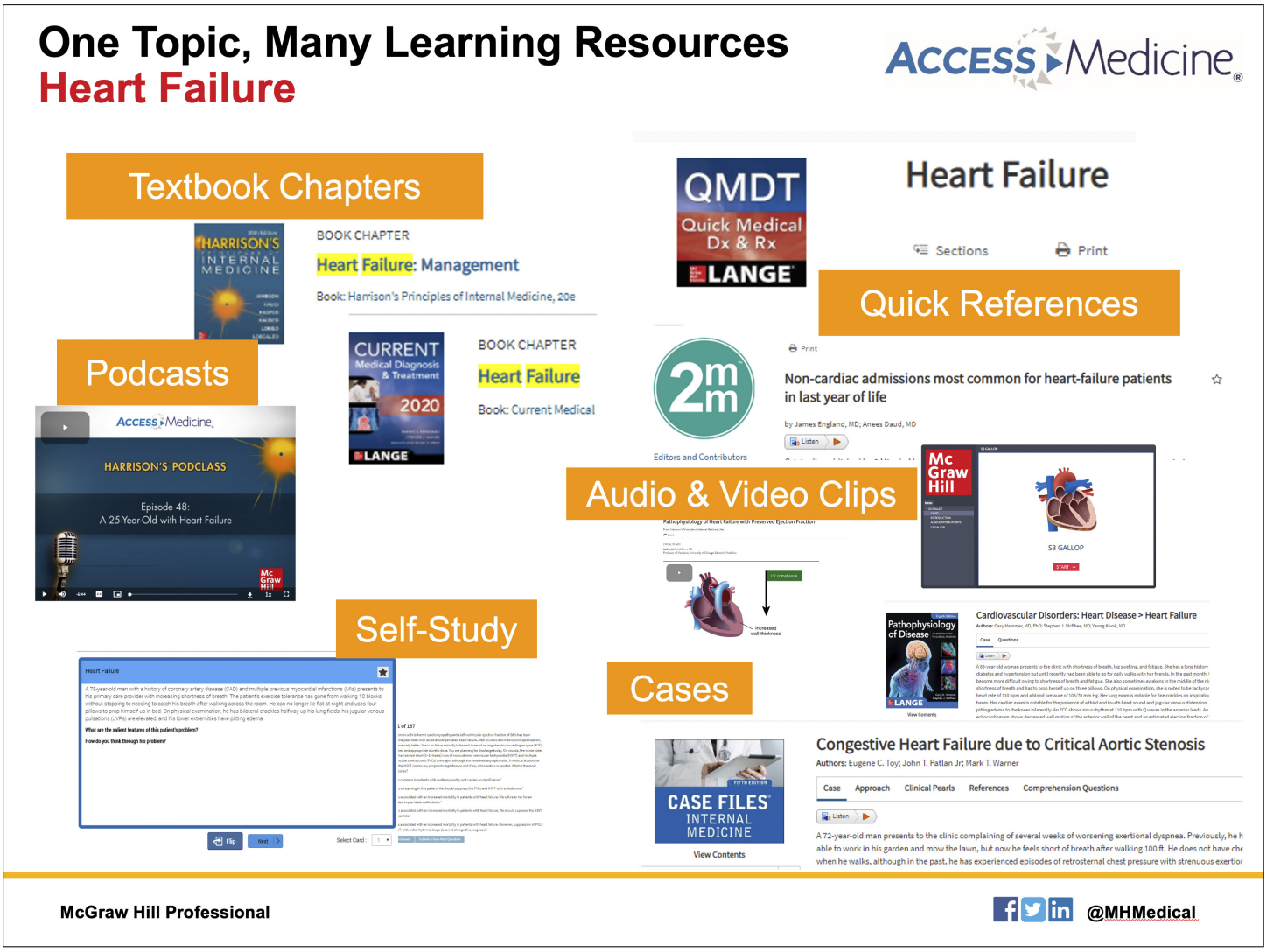

Figure 1. An example of digital multimodal learning from AccessMedicine

Our digital medical products:

- Offer content in a variety of learning styles to meet the different learning needs of medical students
  - Visual learners are supported with high-quality images, animations to convey difficult concepts, and videos of step-by-step procedures, physical examinations, communication, and basic science and clinical medicine lectures
  - Audio learners are supported with engaging podcasts on internal medicine and surgery topics (*AccessMedicine, AccessSurgery*)
  - Reading and writing learners are supported with hundreds of textbooks and the ability to annotate chapters with the *Hypothes.is* tool
  - Students who learn best through answering questions are supported through hundreds of flashcards and thousands of comprehensive questions and answers on basic science and clinical medicine topics, as well as board examination review;
- Support innovative pedagogies, and teaching and learning strategies
  - Our digital sites have an extensive library of peer-reviewed real-world clinical cases to support PBL, CBL, and TBL
  - Passages from our comprehensive digital library of authoritative, trusted textbooks can be assigned for pre-readings in TBL and FC, or to support independent and group research in PBL and CBL;
- Teach students and trainees how to frame clinical questions and assess the results of their search in terms of literature quality (*JAMAevidence*);
- Have helpful technology embedded within our online resources to support faculty and learners
  - Faculty can engage with students through annotated readings using the *Hypothes.is* tool, which is embedded within our textbooks
  - "Email feature" may be used to directly submit answers to question banks to faculty
  - Content from our sites can be shared with students on social media—Twitter, Reddit, Facebook, and LinkedIn
  - Download chapter PDFs for printing or offline reading
  - Listen to content using Readspeaker technology, embedded within our textbooks to support access for every learner.

Our mission statement at McGraw Hill is to unlock the potential for every learner, but without constantly partnering with educators and institutions we cannot get it right and we cannot improve. We truly appreciate your feedback in helping us create the highest-quality content and products that have been educating physicians and healthcare providers around the world for more than 65 years. We are honored to serve you.

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