Medical Education in the Era of Advancing Technology

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Technology is developing rapidly and affecting the field of medicine in two main areas- medical education and health care. As a rapidly evolving field with the need and ability to constantly incorporate newer technologies, medical education must be able to prepare future doctors as per changing trends in practice patterns, the role of medicine in disease diagnosis and treatment, and innovations, and advances in medical science. In this article, we discuss the various digital learning tools introduced into medical education, as well as their advantages and disadvantages. We also try to understand how the shift to artificial intelligence may affect medical education and practice and how we can make technology efficient without losing the human dimension in doctor-patient relationships.

Niels Bohr once said, "Prediction is very difficult, especially about the future"; however, medicine is a dynamic field with continuous changes in practice patterns, the introduction of discoveries and innovations around the role of medicine in different diseases, and technological advances. Therefore, we must be able to anticipate and predict the problems that await us in the future and prepare our next generation of doctors for the future by educating them appropriately.

Today, technology is advancing rapidly at an overwhelming rate which can presumably affect medicine in two ways-first, through its influence on medical education, and second, via its effects on patient care. In this article, we aim to address the question of how advancing technology can affect and change the system of medical education, and how to optimize this configuration without losing the human dimension in doctor-patient relationships.

Currently, courses in many medical faculties incorporate both traditional and advanced methods of teaching, such as in-person classroom lessons and presentations. In general, these programs are managed by expert lecturers to provide high-quality basic medical education that all students should know. This develops a sense of community within the members of the classroom using the traditional understanding and allows students to make presentations from time to time. Owing to the concurrent expert guidance available in traditional learning, this method seems most appropriate within medical education.[1]

A few studies have discussed the future of medical education; notably, all studies concur on adherence to the four main themes of Flexner's work to prevail against the challenges faced today-standardization and individualization, integration, a habit of inquiry, and improvement and identity creation.[2-4] However, these reports have failed to provide concrete directions and goals for the future of medical education. Furthermore, ample evidence from the point of view of medical educators is not available to guide on how to prepare for the future with advanced technology and expanding knowledge, and how the next generation should be educated per their characteristics.[2-5]

As health and education services are being digitalized all over the world, medical education is not left untouched by these developments which have possible due to modern digital recording systems that routinely document health services and allow data sharing, free access to information clouds to everyone, "on the go" learning, search engines, and databases, virtual learning, and artificial intelligence tools. Medical education must keep pace with these developments as modern medical students are digital natives who grew up with these technological developments and are bound to encounter more educated and technologically aware patients as future doctors themselves.

Nowadays, pre-graduate and postgraduate medical education paradigms are changing as they require increasing research and regular upgradation of medical knowledge and education curricula. The growing concern that patients, medical students,

and residents practice on themselves is shifting clinical medicine away from point-of-care training to patient safety and quality, and reorganizing the curriculum. Educators are paying more attention to digital technology for medical education that encourages self-learning and independent research.[6] While the coronavirus disease-19 (COVID-19) pandemic caused widespread disruption of medical education and practical training, it also accelerated the implementation of emerging teaching technologies in the field of medical education.[7,8] Medical schools throughout the world were closed and all meetings for professional development were canceled during the pandemic to ensure social distancing and curb the disease spread. The measures used during the pandemic led to an increased use and adoption of newer technology in the education sector, including medical education.[9]

The most significant change in medical education has been the replacement of basic approaches in providing medical education with known technological approaches, such as online teaching. Medical institutions introduced programs to train their faculty on the use of technology for online courses, and eventually, traditional physical classes for large groups were replaced by online classes using advanced technology, while small group sessions and seminars were replaced by interactive webinars using web conferencing platforms.[10]

However, the major challenge faced by medical educators was regarding hands-on clinical training, which requires clinical visits, interactive patient sessions, and training of clinical skills training. So far, existing technologies, such as videos, podcasts, virtual reality, simulations, and computer games, have been used to facilitate medical education, while platforms, such as websites and blogs, are used to provide basic information. Additionally, real-time mobile video tools, and applications can be used to teach clinical and communication skills training, which allows remotely monitored yet personalized coaching by trainers.[11] Such digital platforms offer an environment wherein educators can provide immediate and real-time feedback.

Graduates in the 21st century want to "hit the ground running" which requires that traditional clinical education be updated with the latest technologies. Thus, educators need to constantly update and develop themselves to become "digital literate".[12] However, technical limitations and hesitancy in adjusting to the latest technologies on the part of educators are some of the major obstacles encountered.

A previous study reported that although both faculty and students agree on the benefits of online education during the current pandemic, the majority of faculty believe that online learning is less effective than face-to-face learning and teaching.[13] The key concerns described by faculty members that affect the development and implementation of online learning in medical education were time constraints, poor technical skills, inadequate infrastructure, lack of institutional strategies and support, and negative attitudes of many faculty members.[14] To address this, the authors suggested some solutions as well, which include enhanced educator skills development activities, incentives and rewards to create time for the development and delivery of online content, and improved

organizational strategies and support for all those involved in the development and delivery of online content, encourage a change in norms and attitudes, and create a positive culture.[14]

In this regard, internet-based learning is reportedly more beneficial than traditional course-based education; in particular, when applied to small student groups, their enthusiasm for learning increased tenfold owing to easier access to knowledge.[15] Many learning tools introduced by digital technology are now also used in medical education-databases and search engines, educational videos, podcasts, simulations, virtual learning environments, social networking sites, blogs, massive online open courses, and artificial intelligence tools.

Educational videos: Recently, especially after the COVID-19 pandemic, healthcare professionals have turned to videos for teaching clinical skills as well as theoretical knowledge. Videos are considered an effective learning tool as they can be used to effectively demonstrate skillful techniques and specialized physical examination methods.[16] YouTube is a freely available website and has been described as the most suitable tool for this.[17] The videos uploaded by the trainers can be watched by thousands of students trying to understand the concepts that are otherwise taught in face-to-face lessons. Additionally, considering that some students are visual learners, such videos allow the option of recall for better learning opportunities and can also be used to refresh the memory before performing the procedures in question.[17]

Podcasts: These are audiovisual files created by individual users. Podcasts have gained popularity in recent years owing to their utility in medical education and the ease of accessibility and affordability have made them a good e-learning tool.[18]

Medical students are considered "adult learners," i.e., they often have limited time due to responsibilities outside of their didactic education, are self-directed in what they need to learn, and are intrinsically motivated to learn by the desire to learn better.[19] Thus, a digital content delivery format, such as a medical education podcast, offers unique content suitable for the needs of an adult learner. Podcasts can be accessed asynchronously anytime anywhere as per the learner's time and needs. This accessibility enables "on the go" learning where students can listen to podcasts as convenient, such as while going to school or exercising. Additionally, the student may coordinate their didactic education with the podcasts to suit their learning process or cover missing aspects.[20] Podcasts are uniquely student-focused, both in terms of ease of access and content that the student wants-one can easily search for and listen to a podcast about the illness and condition of a patient they are interested in.

Database and search engines: Database search engines are software designed to find high-quality research evidence easily and quickly. Cyberspace contains vast information produced in different environments; these search engines are designed to explore this information from different websites and organize them under one roof.[21] Databases and search engines facilitate students to access necessary information, improve their understanding of the lessons, and participate in discussions.[17]

Simulation: As a form of learning, simulation-based education involves experiential learning from an artificial representation of a real-world process.[22] Medical simulations provide clinical skills with methodological applications; they involve humanistic applications that can be used as an alternative to real patients and allow the user to practice as much as possible without the fear of making mistakes. Professional attitudes, ethical practices, and communication skills can also be gained through medical simulations.[22]

Virtual learning environments (VLEs): These are online platforms that provide students with interactive course environments and assessment tools in addition to the standard resources and activities. VLEs allow students to become aware of real-time working conditions and basic difficulties.[23] As a form of integrated learning, they can facilitate communication between teacher and student and be used as content hubs for formative and summative testing.

Virtual reality (VR) is one such educational method; unlike the normal interfaces used in medical education, VR combines educational training with the 3D world. In a virtual environment, multiple factors, such as the type of activity, its severity, and feedback time, can be adjusted as per the type of treatment and individual response.[24] For instance, when dealing with motor activities, students can see the motor results and repeat the action with improvisations.

Many studies have drawn attention to VR applications as an adjunct to training in surgical subjects, such as for improving understanding of fracture anatomy, and knowledge and skills in clinical branches.[25,26] In cases where standard clinical training cannot be fully performed due to patient safety concerns, ethical considerations, and financial constraints, a simulation-oriented curriculum coupled with the use of nonhuman inanimate models has been reported to be very effective in transferring skills to practice.[27,28]

Massive online open courses (MOOCs): This is another popular educational method used in medicine and healthcare. MOOCs are generally context-focused courses that provide an open dialog between educator and learner. They can provide easy access to accurate information regardless of place and time when delivered by trusted institutions and universities.[17]

Artificial intelligence (AI): It is a critical technology transforming social life. Doctors can now collaborate with AI-powered applications that can easily collect huge data, process it to make diagnoses, and recommend treatments. However, in medical education, students often feel terrified by the information overload that is now available due to the ease of use of AI. Therefore, medical education institutions must include management skills in their curricula for the effective use of AI, in addition to communication and empathy skills necessary for dispensing the vast knowledge attained with the help of AI because AI will deeply affect the existing health system.[29]

AI is believed to play an important role in healthcare in the near future as AI-powered devices may outperform humans cognitively;

hence, future physicians should understand the importance of interacting efficiently with these machines while working in a technologically advanced environment.[30] AI may affect every aspect of medicine, but its role in radiology is of particular interest.[31] AI-powered haptic gloves have been used by dental students to feel virtual objects while suturing or performing nerve blocks; this allows students to practice a variety of skills with immediate skill-related feedback so they can improve their technique significantly over time. Although the initial costs for such systems may seem high, the hardware is cost effective in the long run.[32]

Using these modern learning tools, technology is impacting medical education in four major areas-it provides a tool to interact with students, broadens networks and enables collaboration, provides an individualized medical education experience, and facilitates access to information.[33] Merton, Reader, and Kendall mentioned two primary aims of medical education in their book on student-physician sociology-learning and applying the knowledge needed for diseases and their treatment, and gaining a place in the health community.[34] At the center of these goals are two key relationships-between the learner and their educational content (such as knowledge acquisition), and between the learner and the teacher (community development).

Medical education is a form of social activity in a common community-one of its primary aims is to facilitate the entry of its members into a community with common goals of disease treatment and patient care, feeling safe, and welcome, sharing a common social fabric, and developing a sense of belonging.[35] Educational relations are particularly effective in the construction of this feeling of community, and students try to create this community with their role models or consultants through the vertical relationships experienced throughout their education life. Therefore, effective mentoring can not only help students increase their knowledge but also gain a foothold in the medical community. However, these traditional relationships, while effective, generally required physical, and geographical proximity. In the digital age, these barriers have disappeared, and social media platforms have allowed individuals from all over the world to connect with colleagues, seniors, and juniors to share educational content.[36]

The open nature of digital platforms allows for a two-way flow of information and ideas between teacher and learner; therefore, the communities created through these platforms are more horizontal and can potentially include a wider spectrum of people and ideas.[37] On the other hand, finding meaningful one-on-one mentoring can be difficult in this wider community on social media. Consequently, the most productive education ecosystem would be a hybrid model that incorporated horizontal digital communities with vertical self-guidance.[36]

While advanced technology makes medical education more individualized, student-centered, and accessible, it also raises some concerns, the most important being the spread of misinformation.[38] Content presented by faculty in traditional education is generally reliable and drawn from reputable sources; however, the nature of business and operation in digital media platforms obscures

diligent quality assurance of information. Therefore, students must be extremely cautious on online platforms and look for verified references about the content being consumed.

Advanced technologies affect medical education in terms of the management of knowledge; however, they cannot substitute or complement medicine as an "art of patient care." The humanistic side of the medical profession-especially the art of care-is more difficult to replace with technology. The art of care has been central to the profession for more than 2,000 years; patients rely on the doctor's bedside attitude rather than their assessment results.[39] Therefore, effective communication with the patient and a compassionate approach are vital in clinical practice. Although essential components of the art of care, such as communication, empathy, shared decision-making, leadership, and team building, are often less frequently featured in the medical school curriculum, content memorization, and analysis play an important part. With the incorporation of advanced technologies like AI into medical practice, tasks such as memorization, and analysis may become less important, so medical education should focus more time to be devoted to the art of care.

Yet again, effective leadership, and creativity, which are increasing needs in an ever more complex healthcare system, are distant aspirations for AI. Likewise, AI is unlikely to be able to solve system problems with team-based approaches. Nevertheless,

future doctors should be prepared to take responsibility for health systems while leading changes to provide the best possible care for the patient. As machines evolve in accessing, storing, and analyzing information, the human aspects of medicine in providing healthcare gain more importance. Listening, intonation, touching and counsel are and always have been critical components of medical practice.[39] Studies suggest that higher quality care delivery and effective patient communication significantly increase a physician's job satisfaction. Therefore, it can be reasonably assumed AI can effectively reduce the professional burden on doctors and rebalance it by adding meaning to their professional lives.[40]

In the new educational environments, technological advancements, and the digital domain have become the main drivers of access to information and interpersonal communication. Accordingly, modern medical education should adopt these new technologies in medical education in addition to the traditional models and evaluate their advantages and disadvantages very well. A hybrid model built on the components of both traditional and digital paradigms, with strengths, and prudence, will presumably be the best for a modern student (Figure 1). The challenge for medical education today, however, is to create hybrid models that effectively integrate both approaches, where future doctors can acquire and manage knowledge effectively, practice in a humanistic way, develop the art of care, and build community.
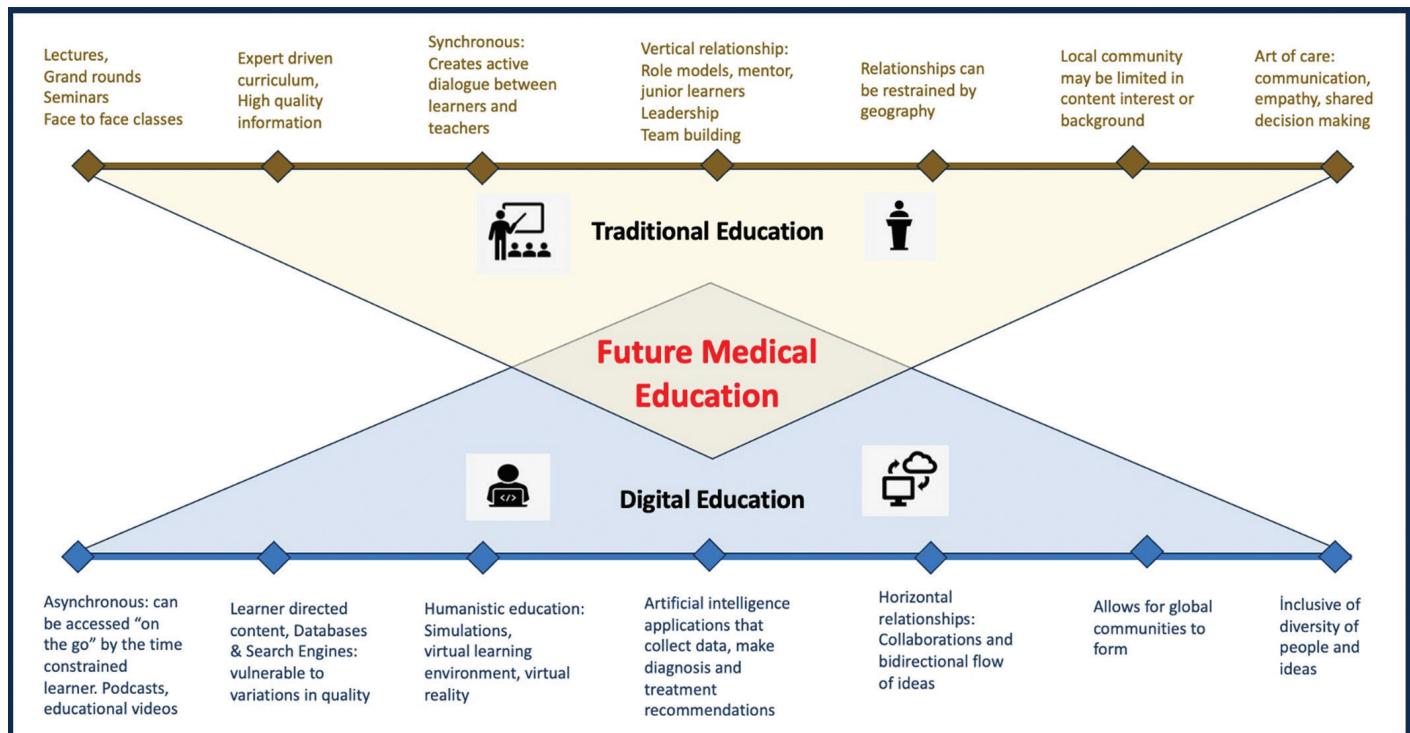

FIG. 1. The future of hybrid medical education
Adapted from Das et al. Medical Education in the Digital ERA, JACC: Advances, 2022; 1 (2)

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