frontiers | Frontiers in Education

TYPE Mini Review
PUBLISHED 30 September 2024
DOI 10.3389/feduc.2024.1427689

OPEN ACCESS

EDITED BY
Anca Maria Cimpean,
Victor Babes University of Medicine and Pharmacy, Romania

REVIEWED BY
Muhammad Kristiawan,
University of Bengkulu, Indonesia

*CORRESPONDENCE
Lorena Elena Meliţ
✉ lory_chimista89@yahoo.com

RECEIVED 04 May 2024
ACCEPTED 16 September 2024
PUBLISHED 30 September 2024

CITATION
Mărginean CO, Meliţ LE, Văsieşiu AM, Anzanello A, Antão C, Bredelyte A, Tsakalidis C, Lupescu R and Azamfirei L (2024) The impact of pandemics on education—"a nice monster of COVID-19"—Mini review. *Front. Educ.* 9:1427689. doi: 10.3389/feduc.2024.1427689

The impact of pandemics on education—"a nice monster of COVID-19"—Mini review

Cristina Oana Mărginean[1], Lorena Elena Meliţ[1]*, Anca Meda Văsieşiu[2], Andrea Anzanello[3], Celeste Antão[4], Aelita Bredelyte[5], Christos Tsakalidis[6], Radu Lupescu[7] and Leonard Azamfirei[8]

[1]Department of Pediatrics 1, "George Emil Palade" University of Medicine, Pharmacy, Science and Technology of Târgu Mureş, Târgu Mureş, Romania, [2]Department of Infectious Diseases, "George Emil Palade" University of Medicine, Pharmacy, Science and Technology of Târgu Mureş, Târgu Mureş, Romania, [3]Pixel, International Education and Training Institution, Firenze, Italy, [4]Polythechnic Institute of Bragança, Bragança, Portugal, [5]Faculty of Health Sciences, Klaipedos University, Klapeida, Lithuania, [6]Department of Neonatology, Aristotle University of Thessaloniki, Thessaloniki, Greece, [7]Department of Intensive Care Unit, Rhena Hospital, Strasbourg, France, [8]Department of Anesthesia and Intensive Care, "George Emil Palade" University of Medicine, Pharmacy, Science and Technology of Târgu Mureş, Târgu Mureş, Romania

The medical world carries a major burden in terms of specialized human resource and infrastructure. The recent COVID-19 pandemics revealed an urgent need for specialized medical professionals in order to preempt future natural disasters. The aim of this review was to underline the best teaching model for training specialist nurses. Thus, the healthcare systems should work along with national agencies for designing and implementing complex curricula for training specialists in providing healthcare such as specialist nurses or advanced practice nurses involved in the decision-making process. The educational process for these nurses should be based on an international standard involving digital education techniques such as e-learning platform, interactive approaches of the course content, as well as an interactive teaching system based on figures, graphics or videos. Moreover, virtual reality based-medical models should also represent an important aspect of the training program in order to provide the future students with the opportunity to deal with real-life medical situations in advance. These techniques will form the basis of the specialist nurses' up-skilling process resulting in crucial life savior medical competences. The trainers should embrace their new roles in the educational process being aware that the nowadays teaching concept is no longer based on a governance approach, but they should rather mediate, guide and organize the educational process becoming shadow partners of their students in achieving the desired skills. The assessment of the students should also comply to the digitalization process by including novel evaluation techniques such as quizzes, individual and team assignments, objective structured clinical examination in order to objectively mirror the student's progress during the training program. Therefore, this review synthetized current insights in learning and training techniques that should be implemented for addressing the needs of innovation in medical education.

KEYWORDS

education, teaching methods, medical professionals, medical skills, specialist nurses, advanced practice nurses

1 Introduction

The recent pandemics represents a real challenge for the healthcare systems worldwide since the burden of this pandemics was felt even by the countries that were supposed to have the best human and material resources. Nevertheless, the bright side of this pandemics should be embraced by each country that should not resent only the death of the loved ones but should also be aware of the positive post-pandemics hallmarks. The challenges that the medical world had to face during the pandemics brought to light a lot of medical "monsters" that were deeply buried such as an important lack of human and material resources specialized in providing high-quality care along with an inappropriate medical infrastructure. Moreover, the lack of collaboration between healthcare professionals was mirrored in the failure to decrease consistently and fast the COVID-19 morbidity and mortality rates. Looking back to the pandemics years, the medical world should recognize the existing gaps and should focus to create strategies for filling these gaps in order to preempt future human deaths. At this point, COVID-19 pandemics should be looked as a major opportunity to analyze what could and should be changed and to create and implement effective strategies for achieving these "savior" changes.

The educational world was not spared by the effects of COVID-19 pandemics and lots of challenges were faced not only by the teachers, but also by the learners during this period especially due to the online systems. Thus, the educational ecosystems had to tailor its needs to the limitations of the online environment and to provide the best quality in teaching and learning according to the boundaries of the virtual world. It was definitely not the best option, and it was not nearly easy, but it was the only chance to continue the educational process during the pandemics years when the physical contact was not easy. When it comes to the medical field, the teaching process was even harder for medical trainers, as well as the learning one for the medical students since they had no access to real patients and were forbidden to enter the medical institutions. Nevertheless, the medical education had to continue and although it was not a guaranteed success in all situations, all "the unknown monsters" that seemed initially major threats in achieving the goals on medical education remained history now. The problem is that this history should not represent only the past, but also the future since it is crucial to bring to life these "monsters" and to use their positive impact in improving the medical education techniques and to prepare the medical and educational systems to sustain a high-quality training in any hostile environment or situation.

Educational institutions should team-up with the medical ones in order to design tailored programs for creating up-skilled healthcare professionals. It is undoubtable that "together we can make world better," and the bridge between education and health should be maintained by the urgent need to shape specialized healthcare professionals that could face in the future similar changes. Thus, educational institutions across the world should learn to think outside the box and to create tailored-curricula, but at the same time to unify these curricula for matching the international standards. In terms of nurse education, these curricula are meant to up-skill the future specialist nurses in order to become autonomous in their healthcare teams by adding knowledge-based quality to their decision-making process for the patient's best care and outcomes (Furlong and Smith, 2005).

An important step in the medical world would be to increase the number of medical human resources and of those who have the required skills to make knowledge-based decision for the patient's best outcome. Therefore, the training of advanced nurse practitioners or specialist nurses in different medical represents a major asset for the development of a complex effective healthcare system. The giant responsibility of educational institutions consists in providing up-skilling programs for educating specialist nurses with a major positive impact on national healthcare systems resulting in a considerable improvement in healthcare delivery, lowering at the same time healthcare-associated costs (Furlong and Smith, 2005). Analyzing the impact of the pandemics on the economical level of worldwide countries, the role of specialist nurses in clinical practice is no longer a debatable topic. The need for nurse practitioners emerged for the first time in the United States of America in the mid 1960s due to the wide-spectrum of medical specialties and the poor access to medical care (Pearson and Peels, 2002; Marsden et al., 2003). A few years later United Kingdom, Australia and New Zealand joined the concept of the US regarding the major role of specialist nurses in clinical practice (Furlong and Smith, 2005). Unfortunately, Romania is decades far from embracing and acknowledging the role of specialist nurses in clinical practice since in our country there is no available educational program for training and up-skilling student nurses or in-practice nurses in different medical specialties. Nevertheless, the impact of COVID-19 pandemics was strongly experienced by the Romanian medical community triggering the urgent need to design and implement a program for educating specialist nurses. Thus, we managed to team-up an international board with experienced training physicians from Romania, France, Greece, Lithuania, and Portugal involved in designing a complex international curriculum for up-skilling nurses in providing the best care possible for patients depending on their condition.

2 The innovative side of the teaching program

2.1 Teaching methods

The specialist nursing formation program is meant to bring innovation into the teaching process by using interactive, digital and virtual methods for enhancing the learning process of the future students. Therefore, we aim to implement as much as possible during this program the most recent teaching methods reported in the literature that are applicable to this teaching area. We are indeed aware by the fact that the implementation of digital education in the medical field, as well as replacing the traditional teaching methods with the new models of knowledge sharing might be really challenging.

The main step in implementation digital education will consist in using a complex e-learning platform which will allow the future students a synchronous access to the learning content. Moreover, the platform will allow trainers to develop and use interactive models of teaching based on graphical representations, videos,

figures, or standardized cases forcing the students to develop their critical thinking. Several types of innovative methods were reported such as learning management system, software for specialist learning like CMapTools (graphical tools for organizing and representing knowledge in an organized fashion), immersive virtual environments (e.g., SecondLife), but also some 3-dimensional (3D) anatomy models like Anatomage table (Jin and Bridges, 2014). Not without interest are also the new types of hardware used for teaching like interactive whiteboards (IWBs), which can be used to reshape the new forms of learning in both synchronous, and face-to-face cases (Bridges et al., 2010). In addition, there are a lot of teaching models focusing on distance education and providing at the same time a rich learning context with access to well-structured information and new spaces of knowledge collaboration (Liyanagunawardena and Williams, 2014). All these methods provide access to structured information, to a curriculum platform, a possible communication media, thinking tools, collaboration spaces, access to a perspective toolkit, etc.

A major asset of the recent medical teaching models is represented by the team-based and problem-based learning methods which allow students' engagement in knowledge enhancing the development of competencies in multiple medical contexts (Walker and Leary, 2009; Prosser and Sze, 2014). Both these methods involve the involvement of the students' creative and critical thinking testing at the same time their abilities to work in teams and to collaborate with their peer in solving the cases/problems. Moreover, using these methods, they will learn to follow their task without interfering with others or crossing their boundaries. The students will acknowledge their limits and the crucial role of active listening, facts that will further facilitate their professional pathway.

Interactive approach of the courses by developing "pros and cons" discussions between students and teachers related to the course content has recently become a hot topic among innovative teaching methods. The Audience Response System (ARS) technology, an interactive approach of the courses, was used for the first time used in 1960s at Cornell and Stanford universities (Kay and LeSage, 2009; Nelson et al., 2012) and more recently, this method was implemented in medical and dental schools, and health professions in order to improve learning outcomes. ARS was analyzed based on its benefits and drawbacks, evaluating the knowledge retention and results at exams (Subramanian et al., 2012; Mains et al., 2015; Benson et al., 2017). ARS method is a simple one consisting in clickers connected to a hardware device that contains software which collects the student answers in the classroom via the instructor's computer (Collins, 2008; Vana et al., 2011; Thampy and Ahmad, 2014). ARS can be used to help the teacher in identifying the students' understanding level, to evaluate the teaching performance, to increase the students' knowledge, to enhance the students' awareness and to provide good discussions in the class (Dufresne et al., 1996). The systematic review of Denkewicz (2019), evaluated the pros and cons of ARS, and reported accordingly that the benefits (Pros) of the ARS are: the increased students' engagement and attention, the improvement of learning outcomes, provides real-time feedback for teacher, increases peer interactivity & class participation, enables student anonymity, it is easy and enjoyable to use, encourages active learning and improves student attendance; while the Cons consist in increasing teacher's preparation time, the cost, the learning curve for use, technical malfunctions, reduced class time and students objections to being monitored (Denkewicz, 2019).

The structured classroom debate (SCD) is an active learning method used in teaching in which students grouped in team-work discuss problems, viewpoints using evidence-based literature, persuasive communication in order to arrive to a logic agreement (Dy-Boarman et al., 2018; McGee et al., 2020). This method aims to integrate active learning methods, content integration, to develop skills and to apply the obtained skills in therapeutic decision-making (Nelson et al., 2012). SCD was used as a teaching tool in medical class and pharmacy education resulting in facilitation of the learning process, enhancement of the critical thinking development, and communication skills along with thorough analyze of the literature (Rubin et al., 2008; Lampkin et al., 2015; Dy-Boarman et al., 2018). "Fishbowl debate" is a type of SCD in which small group of students placed in a circle discuss responses or debate an assigned topic while the other students outside of the fishbowl, listen, and take notes (Sutherland et al., 2012). The benefits of this novel teaching approach were proven by certain authors indicating that the students understand better the topic if they participate to the debate (Griswold, 2000). Moreover, SCD as a teaching tool enabled the students to gain confidence in their ability to achieve the required skills, to perform various practical maneuvers, to have an effective communication with their peers, to improve the decision-making process, and to develop a complex set of problem-solving skills contributing to the creation of "practice ready" graduates due to its student-centered learning approach (McGee et al., 2020). SCD can be combined with other teaching/learning approaches such as mini-lectures, journal club, debate during a period of time observing the students' pre- and post-knowledge debate (Hidayat et al., 2012).

2.2 New roles of lecturers and trainers

It is true that "New times require new people," and therefore new teaching methods require "new," updated lecturers who are willing to change their perspectives and to adjust their former traditional teaching profile to these innovative methods that do not longer require the teacher to act as a governor, but rather as a mediator, a facilitator of the learning process. Thus, teachers should focus on providing students with three fundamental types of engagement: cognitive presence—ability to engage with others on a common topic, social presence—the ability to integrate with others and display personality in the class community, and teaching presence—a teacher acting as an instructor who can guide, question, and facilitate the learning process (Team, 2023). Therefore, the teacher should play the role of initiator of interaction, which is the core concept of learning both face-to-face and online which requires only the support of the teacher, not his fully active involvement (Office of Digital Learning System, n.d.). The most important interactions that facilitate the learning process are interaction between the student and content, interaction between the student and instructor and interaction among students (Office of Digital Learning System, n.d.). In fact, interaction is

fundamental for the educational framework, which established learning as the central piece of the educational puzzle and fosters social presence, teaching presence, and cognitive presence (Office of Digital Learning System, n.d.). Interaction might be defined as a triangle formed by social presence represented by the peers, teaching presence supported by the instructor, and cognitive presence defined by the content. The role of the instructor is to create all the necessary skills that allow and promote the three areas (Office of Digital Learning System, n.d.).

The digital environment fosters 4 roles of the online instructor: pedagogical, social and managerial (Office of Digital Learning System, n.d.). Although online teaching might not be the most effective or the preferred approach when it comes to learning, it is extremely useful when needed since it saves time and money, and if properly developed it allows for both instructor and students to have a meaningful experience. The innovative recent digital teaching methods are meant to facilitate as much as possible the online teaching/learning process and to make it more similar to the onsite process. The *pedagogical role* of the trainer is probably the most important consisting in creating discussions that focus energy on critical concepts, principles, and skills. Thus, the regardless of the online environment and the lack of face-to-face interaction, the teacher/trainer should be able to find the most effective teaching methods to facilitate the student's understanding of theoretical critical concepts and principles of the discussed topic, but also to achieve the practical skills on that particular topic. Canvas platform creates a proper online environment where the students can effectively interact with their peers, they can actively participate to the debates, to the discussions that can be customized to allow them to express their opinion regarding their peers' posts or to change roles in different assignments (Arbaugh, 2000). Additionally, this platform facilitates the students' active contribution to discussions and team-work, promoting public and private conversations between peers. The discussions can focus also on what they know about the discussed topic, what they want to know and what they have learned (Arbaugh, 2000; Office of Digital Learning System, n.d.). In terms of *social role*, the instructor must focus on creating a friendly and warm environment to foster, guide and promote sharing and learning (Office of Digital Learning System, n.d.). Thus, he should act like a social mediator in order to enhance social connections between students, but also establish social boundaries when needed. Moreover, the trainer must be aware that he is a role model for his students, and he must behave accordingly, avoiding sarcasm, using carefully humor and at the same time he should use a gentle tone when explaining (Blakeley and Curran-Smith, 1998; Office of Digital Learning System, n.d.). The *managerial role* is meant to clearly structure discussions, to establish objectives, procedural rules and timelines (Office of Digital Learning System, n.d.). Thus, the instructor must be aware that he needs to provide a clear communication, to express patience, to be responsive, to make sure that he is understood, and to anticipate what the students want to learn, to hear or to say (Swan, 2003). Although the process of designing, elaborating and distributing lectures materials might take more time than anticipated, the trainers must be sure that they provide comprehensive information (Swan, 2003; Office of Digital Learning System, n.d.). Regarding the technical role, the students must feel comfortable with the required tools for achieving the course goals, with the timelines for achieving their tasks, and the trainer should provide them with different options in order to be successful in accomplishing their goals (Office of Digital Learning System, n.d.). A good example is that the trainers should provide access to the online platform on both mobile and laptop devices where they will integrate all the required resources in formatting that match mobile and laptop-based applications. Moreover, they will also upload a required content in "Help" section where the students can find quick answers to the most frequent questions related to both the course content and the app (Office of Digital Learning System, n.d.). Complying to these essential four roles, the trainers will not only have the responsibility to be pedagogues, but they will also have to manage the course activity, to mediate an appropriate social environment for these activities, and to solve the technical issues that might occur during the course.

The trainers of the digital era must also act as controllers in order to support and encourage the students in an effective way, as organizers making themselves responsible for the effective organization of the interaction between students, as well as assessors of the students' activity in an interactive manner. Thus, they will be the student's guides in exploring the course materials and in discussing the provided information (Team, 2023). Other authors reported five important roles of the "digital trainers": to be an effective coach of the students meaning that the instructor has to be proactive when recording or live-streaming lectures; to be an experienced curriculum designer for each course taking into account the curriculum objectives; to build and to organize online social communities using discussions boards or posting open-ended questions; to know the platform and to offer technical support to his students when needed; and to manage effectively the platform content such as presentations, tests, quizzes, assignments, new handouts and final exams (Team, 2023). Least, but not last, it is important to mention that the trainers should assume the ethical role in the teaching/learning activities of their students complying to their needs, behaving morally right since there are considered models and arbiters of ethical behavior (Dennen and Jones, 2023).

2.3 Virtual reality medical education

Virtual reality (VR), defined as the user's complete immersion into a virtual three-dimensional environment is used to simulate a situation or experience of interest within an interactive but computer-generated environment (Kanschik et al., 2023). VR is used in many areas of healthcare, including medical training for doctors and students, patient treatment, medical marketing, and education (Thomas, 2021). Current medical training uses this method to teach students achieve the useful skills and to arrive at a proper management strategy when faced with a given patient. This training includes problem-oriented learning, communication skills, and VR-based learning. Different types of medical situations can be simulated using VR, allowing the students to deal with real life before they enter real medical world (Thomas, 2021). Augmented reality (AR), is a rapidly developing technology that offer applications to experience digitally rendered content in

both physical and virtual space and retains the connection to the real world supplemented with virtual elements to increase information (Bruno et al., 2022; Kanschik et al., 2023). The use of these techniques in medical education result in a considerable improvement students' motor and cognitive skills (Silva et al., 2018; Kanschik et al., 2023).

2.4 New assessment models for students

Canvas platform fosters teaching, learning and evaluation processes. Thus, this complex platform is a real asset for the educational process, especially regarding the online environment. In terms of students' assessing methods, Canvas allows the trainers to design quizzes, individual, and team-assignments for a complex evaluation of the student's understanding levels of achieved skills on a certain discussed topic.

Objective structured clinical examination (OSCE) has been used to assess medical students' skills since 1970s, and nowadays it's utility has been expanded also in the nursing area and other allied health professions (Kay and LeSage, 2009). This type of examination mirrors the students' competences under a variety of simulated conditions, using real patients or actors to test students' skills in anamnesis, examination, treatment procedures, or interpretation of laboratory and radiological investigations. Thus, OSCE will be extremely valuable for the progress of this program since it will evaluate the acquired skills of the nurse students in an innovative way, being a major part of digital education implementation, and it will be in a specialized simulation center (Kay and LeSage, 2009).

3 Conclusions

Trainers of online education must develop the required skills to model and mediate the online environment and the student's activity being defined as "artists of digital education." Although their task is probably more difficult, they should be aware of their complex role and they should learn to act an orchestra conductor and guide every student to perform individually but also to belong to a team. The implementation of current trends in education in the field of medical education based on the aforementioned concepts is definitely not a simple action. Nevertheless, medical curriculum designers should be aware of the importance of addressing the contemporary needs in terms of healthcare systems and should tailor the training of medical specialists to fill in the existing gaps in both medical education and medical practice that were recently revealed by the COVID-19 pandemics.

Author contributions

COM: Conceptualization, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. LEM: Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. AMV: Supervision, Validation, Writing – review & editing. AA: Validation, Writing – review & editing. CA: Validation, Writing – review & editing. AB: Validation, Writing – review & editing. CT: Supervision, Writing – review & editing. RL: Validation, Writing – review & editing. LA: Supervision, Validation, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

The authors thank Erasmus+ Programme of the European Union, "Curriculum development for up-skilling Specialist Nurses (SN) and Advanced Practice Nurses (APN)," project number: 2022-1-RO01-KA220-HED-000087854 for the support.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Arbaugh, J. (2000). Virtual classroom versus physical classroom: an exploratory study of class discussion patterns and student learning in an asynchronous internet-based MBA course. *J. Manag. Educ.* 24, 213–233. doi: 10.1177/105256290002400206

Benson, J. D., Szucs, K. A., DeIuliis, E. D., and Leri, A. (2017). Impact of student response systems on initial learning and retention of course content in health sciences students. *J. Allied Health* 46, 158–163.

Blakeley, J. A., and Curran-Smith, J. (1998). Teaching community health nursing by distance methods: development, process, and evaluation. *J. Contin. Educ. Nurs.* 29, 148–153. doi: 10.3928/0022-0124-19980701-04

Bridges, S. M., Botelho, M. G., and Tsang, P. C. S. (2010). PBL.2.0: blended learning for an interactive, problem-based pedagogy. *Med. Educ.* 44:1131. doi: 10.1111/j.1365-2923.2010.03830.x

Bruno, R. R., Wolff, G., Wernly, B., Masyuk, M., Piayda, K., Leaver, S., et al. (2022). Virtual and augmented reality in critical care medicine: the patient's, clinician's, and researcher's perspective. *Crit. Care* 26:326. doi: 10.1186/s13054-022-04202-x

Collins, J. (2008). Audience response systems: technology to engage learners. *J. Am. Coll. Radiol.* 5, 993–1000. doi: 10.1016/j.jacr.2008.04.008

Denkewicz, R. (2019). Pros and cons of audience response systems in the education of health professionals. *MedEdPublish* 8:182. doi: 10.15694/mep.2019.000182.1

Dennen, V. P., and Jones, M. K. (2023). "The role of the online instructor," in *Handbook of Open, Distance and Digital Education*, eds. O. Zawacki-Richter and I. Jung (Singapore: Springer Nature), 1073–1088.

Dufresne, R. J., Gerace, W. J., Leonard, W. J., Mestre, J. P., and Wenk, L. (1996). Classtalk: a classroom communication system for active learning. *J. Comput. High. Educ.* 7, 3–47.

Dy-Boarman, E. A., Nisly, S. A., and Costello, T. J. (2018). It's no debate, debates are great. *Curr. Pharm. Teach. Learn.* 10, 10–13. doi: 10.1016/j.cptl.2017.09.016

Furlong, E., and Smith, R. (2005). Advanced nursing practice: policy, education and role development. *J. Clin. Nurs.* 14, 1059–1066. doi: 10.1111/j.1365-2702.2005.01220.x

Griswold, L. A. (2000). Debate as a teaching strategy. *Am. J. Occup. Ther.* 54, 427–428.

Hidayat, L., Patel, S., and Veltri, K. (2012). Active-learning implementation in an advanced elective course on infectious diseases. *Am. J. Pharm. Educ.* 76:87. doi: 10.5688/ajpe76587

Jin, J., and Bridges, S. M. (2014). Educational technologies in problem-based learning in health sciences education: a systematic review. *J. Med. Internet Res.* 16:e251. doi: 10.2196/jmir.3240

Kanschik, D., Bruno, R. R., Wolff, G., Kelm, M., and Jung, C. (2023). Virtual and augmented reality in intensive care medicine: a systematic review. *Ann. Intens. Care* 13:81. doi: 10.1186/s13613-023-01176-z

Kay, R. H., and LeSage, A. (2009). Examining the benefits and challenges of using audience response systems: a review of the literature. *Comput. Educ.* 53, 819–827. doi: 10.1016/j.compedu.2009.05.001

Lampkin, S. J., Collins, C., Danison, R., and Lewis, M. (2015). Active learning through a debate series in a first-year pharmacy self-care course. *Am. J. Pharm. Educ.* 79:25. doi: 10.5688/ajpe79225

Liyanagunawardena, T. R., and Williams, S. A. (2014). Massive open online courses on health and medicine: review. *J. Med. Internet Res.* 16:e191. doi: 10.2196/jmir.3439

Mains, T. E., Cofrancesco, J., Milner, S. M., Shah, N. G., and Goldberg, H. (2015). Do questions help? The impact of audience response systems on medical student learning: a randomised controlled trial. *Postgrad. Med. J.* 91, 361–367. doi: 10.1136/postgradmedj-2014-132987

Marsden, J., Dolan, B., and Holt, L. (2003). Nurse practitioner practice and deployment: electronic mail Delphi study. *J. Adv. Nurs.* 43, 595–605. doi: 10.1046/j.1365-2648.2003.02758.x

McGee, E. U., Pius, M., and Mukherjee, K. (2020). Assessment of structured classroom debate to teach an antimicrobial stewardship elective course. *Curr. Pharm. Teach. Learn.* 12, 220–227. doi: 10.1016/j.cptl.2019.11.016

Nelson, C., Hartling, L., Campbell, S., and Oswald, A. E. (2012). The effects of audience response systems on learning outcomes in health professions education. A BEME systematic review: BEME Guide No. 21. *Med. Teach.* 34, e386–405. doi: 10.3109/0142159X.2012.680938

Office of Digital Learning System (n.d.). *The Role of the Instructor in Online Learning*. Available at: http://www.ou.edu/digitallearning/resources/Webinars/role-of-the-instructor-online-learning.html (accessed July 26, 2024).

Pearson, A., and Peels, S. (2002). Advanced practice in nursing: international perspective. *Int. J. Nurs. Pract.* 8, S1–4. doi: 10.1046/j.1440-172x.2002.00361.x

Prosser, M., and Sze, D. (2014). Problem-based learning: student learning experiences and outcomes. *Clin. Linguist. Phon.* 28, 131–142. doi: 10.3109/02699206.2013.820351

Rubin, R. W., Weyant, R. J., and Trovato, C. A. (2008). Utilizing debates as an instructional tool for dental students. *J. Dent. Educ.* 72, 282–287. doi: 10.1002/j.0022-0337.2008.72.3.tb04494.x

Silva, J. N. A., Southworth, M., Raptis, C., and Silva, J. (2018). Emerging applications of virtual reality in cardiovascular medicine. *JACC Basic Transl. Sci.* 3, 420–430. doi: 10.1016/j.jacbts.2017.11.009

Subramanian, A., Timberlake, M., Mittakanti, H., Lara, M., and Brandt, M. L. (2012). Novel educational approach for medical students: improved retention rates using interactive medical software compared with traditional lecture-based format. *J. Surg. Educ.* 69, 449–452. doi: 10.1016/j.jsurg.2012.05.013

Sutherland, R., Reid, K., Kok, D., and Collins, M. (2012). Teaching a fishbowl tutorial: sink or swim? *Clin. Teach.* 9, 80–84. doi: 10.1111/j.1743-498X.2011.00519.x

Swan, K. (2003). "Learning effectiveness online: what the research tells us," in *Elements of Quality Online Education, Practice and Direction*, eds. J. Bourne and J. C. Moore (Needham, MA: Sloan Center for Online Education), 13–45.

Team, M. (2023). *What Is the Instructor's Role in Online Learning for Higher Education? Caduceus International Publishing*. Available at: https://www.cipcourses.com/blog/what-is-the-instructors-role-in-online-learning-for-higher-education/ (accessed July 26, 2024).

Thampy, H., and Ahmad, Z. (2014). Use audience response systems. *Educ. Prim. Care* 25, 294–296. doi: 10.1080/14739879.2014.11494296

Thomas, T. (2021). *Applications of Virtual Reality in Medicine*. News-Medical. Available at: https://www.news-medical.net/health/Applications-of-Virtual-Reality-in-Medicine.aspx (Accessed July 26, 2024).

Vana, K. D., Silva, G. E., Muzyka, D., and Hirani, L. M. (2011). Effectiveness of an audience response system in teaching pharmacology to baccalaureate nursing students. *Comput. Inform. Nurs.* 29, TC105-113. doi: 10.1097/NCN.0b013e3182285d71

Walker, A., and Leary, H. (2009). A problem based learning meta analysis: differences across problem types, implementation types, disciplines, and assessment levels. *J. Problem-Based Lear.* 3, 12–34. doi: 10.7771/1541-5015.1061