



A comparative study about attitudes towards the efficiency, effectiveness, and atmosphere of offline and online learning among medical students

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Background: In recent decades, the mode of education has changed, and online learning via the Internet has gradually entered the medical education system. During the Coronavirus disease 2019 pandemic, online learning rapidly became one of the main learning methods for medical students, this has impacted medical undergraduates and postgraduates to varying degrees; however, currently, little is known about its effectiveness as a learning mode.

Methods: This study included undergraduates and postgraduates in medical schools at some universities in China. The student participants were asked to complete a questionnaire survey in which they self-evaluated the learning effectiveness, learning efficiency, learning atmosphere, and other issues associated with online and offline learning. SPSSAU was used to analyze the acquired data.

Results: Most medical students expressed the view that offline learning was superior to online learning in terms of effectiveness, efficiency, and atmosphere. However, online learning was better in terms of the acquisition of learning resources and flexibility. The attitudes of medical undergraduates and postgraduates participating in this research were largely similar ($P>0.05$); however, undergraduates placed a higher value on offline learning than postgraduates ($P<0.05$).

Conclusions: Both online and offline learning have advantages and disadvantages. The differences between undergraduates and postgraduates may be related to subtle differences in the training objectives at these 2 levels of medical education. Combining the advantages of online and offline learning may improve the learning of medical students.

Keywords: Online learning; offline learning; medical undergraduate; medical postgraduate; learning effect

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Introduction

In recent decades, the mode of learning and education has changed (1), and online learning has become more common (2). This learning method uses electronic technology and media to provide, support, and enhance learning and teaching, and to achieve information exchange

between online learners and teachers (3).

A previous study (4) at Johns Hopkins University School of Medicine found that only 14% of medical undergraduates and 33% of medical postgraduates engaged in full-time online learning in 2019. Data from The National Center for Education Statistics (5) revealed that in 2019, only 20%

of American public schools offered any online learning. However, since the start of the Coronavirus disease 2019 pandemic, online learning has rapidly gained ground worldwide. Various educational activities in major countries around the world switched to online learning during the pandemic (6). Many students have been learning from home, via the Internet (7), which has significantly changed education activities (8,9). Some scholars believe that a large number of students will continue to choose online learning even after the end of the pandemic. These changes in education and behavior patterns may ultimately affect human behavior patterns (10,11). They may even change energy consumption in the education system, reversing the previous structure and habits related to energy use (12,13).

Given the popularity of online learning in medical schools, more scholars have begun to consider the effectiveness of online learning, because it is an pivotal factor that affects whether students can obtain good learning results. Even before the pandemic, the global shortage of medical teachers aroused widespread concern. During the pandemic, many doctors had to cease teaching to concentrate on clinical work due to the pressure placed on resources. Work and research also exacerbate the shortage of medical teacher resources (14,15). The proportion of online learning in medical curricula is thus rising. However, scholars who have compared online learning to traditional offline learning have concluded that traditional offline learning is more effective

(16-19), especially for medical majors.

The nature of medicine makes it difficult for medical students to learn some aspects of subjects effectively online. Al-Elq *et al.* (20) argues that mainstream online lectures and seminars cannot simulate face-to-face interactions between students and patients and that online education is thus not suitable for “bedside teaching” and training of practical skills (21). However, traditional learning also has a number of limitations, including that students and teachers must be in a specific place at a specific time (22), which limits learning flexibility. Conversely, online learning can transcend time and space and provide medical students with a personalized learning space and time, making learning ubiquitous (23-27). We have been unable to find any studies comparing offline and online learning between medical undergraduates and postgraduates. Thus, this study administered a questionnaire to investigate the views of medical undergraduates and postgraduates on the efficiency, effectiveness, and atmosphere of offline and online learning. We present the following article in accordance with the SURGE reporting checklist (available at <https://atm.amegroups.com/article/view/10.21037/atm-22-5112/rc>).

Methods

Research tools

The questionnaire used in this study was compiled with Questionnaire Stars. We used the “Guidelines for Educational Research Questionnaires” published by Harvard University Graduate School in 2014 (28) to compile a questionnaire for the “self-assessment of online and offline learning by medical undergraduates and postgraduates”. The questions covered the following 4 areas: basic information about students, learning effectiveness, learning efficiency, and learning atmosphere. There questionnaire comprised 33 items. All the items used a 7-point Likert-type scale (on which 1 indicated completely disagree and 7 indicated completely agree). A 7-point scale has a higher reliability and enables a more detailed trend analysis to be undertaken than a 5-point scale (29,30). It also provides more accurate results than a 9- or 11-point scale. Additionally, a 7-point scale does not affect the abstract thinking ability of the study participants and is more likely to reflect students’ views about the questions (31) than a 9- or 11-point scale.

Cronbach α The coefficient is 0.879, greater than 0.8, indicating that the reliability of the questionnaire is good;

Highlight box

Key finding:

- Overall, medical students think offline learning is better than online learning; In the comparison of undergraduate and graduate students’ views on online learning, undergraduate students believe that online learning is better.

What is known and what is new?

- Many scholars have studied the advantages, disadvantages and differences between online learning and offline learning before and have drawn their conclusions.
- Few scholars compare the learning of medical undergraduates and postgraduates in the context of online learning with offline learning.

What is the implication, and what should change now?

- There are still many problems in online learning, we hope to combine online learning with offline learning, this would provide the original advantages of offline learning, but add the flexibility of online learning, creating a more efficient and convenient education and learning system.

Table 1 Questionnaire composition

Questionnaire structure	Details	Number of issues involved (number)
Basic information for students	Gender, education, home location	7
Learning atmosphere	Teacher supervision	16
	Accompanying classmates	
	Communicate with teachers in real time	
	Class participation	
Learning efficiency	Flexibility of learning content	11
	Learning materials	
	Learning enthusiasm	
	Learning focus	
	Active learning	
Learning effectiveness	Learning breadth	14
	Learning depth	
	Personalized development training	
	Cultivation of creativity	

Table 2 Basic information about the participants in this study

Categorical variable	Frequency	Percentage, %
Gender		
Male	140	50.00
Female	140	50.00
Education		
Undergraduate	185	66.07
Postgraduate	95	33.93
Home location		
City	148	52.86
Village	132	47.14
Total	280	100.00

KMO value is 0.901, greater than 0.8, and the p value in Bartlett test is 0.000, <0.05, indicating that the validity is good.

After completing the first draft of the questionnaire, we conducted a small-scale experiment in which 8 medical students were asked to complete the questionnaire and provide comments on its contents. The questionnaire was then revised and adjusted. The specific composition of the questionnaire is shown in *Table 1*.

Research participants

The study participants were medical undergraduate and postgraduate students attending some universities in China. The basic information of subjects participating in the test is shown in *Table 1*. All the participants were randomly selected. All the participants were anonymous, and the questionnaire did not ask for any sensitive or identifiable personal information. We are of the view that the random nature of the selection of the participants did not have any adverse effects on the investigation or the participants. We obtained a total of 287 questionnaires, of which 7 were invalid; thus, 280 questionnaires were included in analysis, and the study had an effective response rate of 97.56%. *Table 2* sets out some basic information about the study participants.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Before the investigation and test, we ensured that all respondents have provided informed consent. Ethical approval was waived by the ethics committee of the Affiliated Hospital of Qingdao University Ethics Committee, because this study did not involve ethical issues. Our questionnaires are all about medical college students and graduate students. All questions are composed of online and offline learning information, excluding any clinical trial and clinical

Table 3 Comparison between online and offline learning for factors affecting learning results

Factors affecting learning results	Online		Offline		P
	M	SD	M	SD	
Learning efficiency	3.88	1.61	4.93	1.53	0.002**
Learning effectiveness	4.0	1.63	4.64	1.57	0.009**
Learning atmosphere	3.78	1.69	4.495	1.44	0.007**

**P<0.01. P<0.05 means there is a significant difference, P>0.05 means there is no significant difference. M, the mean; SD, standard deviation; P, the difference between online and offline learning.

observation, as well as any personal privacy issues.

Statistical analysis

We used the *t*-test method via SPSSAU software to process and analyze the collected data. First, we compared online learning and offline learning among all students to examine learning efficiency, effectiveness, and atmosphere. We also compared the views of the undergraduates and postgraduates. In the process of the comparison, we summarized the advantages of online and offline learning. Subsequently, we summarized and compared the similarities and differences between medical undergraduates and postgraduates on online and offline learning, including the sense of classroom participation, learning atmosphere, peer-to-peer learning, and teacher supervision.

Results

Table 3 shows that the learning efficiency (3.88), effectiveness (4.0), and atmosphere (3.78) were all lower for online learning than offline learning (4.93, 4.64 and 4.50), and the differences were significant (P<0.01). This suggests that medical students may not yet be skilled or mature enough for online self-learning and teaching.

Table 4 shows that the scores for learning effectiveness, enthusiasm, and concentration were all significantly higher for offline than online learning. Both undergraduates and postgraduates thought that offline learning was more effective, and the scores were significantly higher from undergraduates (5.11) than postgraduates (4.66) (P<0.05). Both undergraduates and postgraduates thought that online learning had less classroom participation than offline learning. Most students believed that they would be more distracted by other applications during online than offline learning. This also suggests that online learning is not highly focused. Most students thought that the absence

of companionship during online learning would have a negative effect on their study. They also valued teacher supervision and real-time communication and believed that their absence would have a negative effect on learning. However, most students also thought that an online learning platform provided a broader learning horizon and easier retrieval of learning materials, and thus had a positive effect on their learning. Overall, most medical students valued offline learning over online learning, but recognized that online learning had obvious advantages in terms of obtaining learning materials and flexibility.

Discussion

Many studies have shown that before online learning, medical education resources were affected by the natural environment and human activities, resulting in an uneven distribution of resources (32-36). Online education models and tools can remove some of the restrictions of geography and environment. Thus, they may help to address the uneven distribution of medical offline education resources (2,37). For example, the University of Cleveland School of Medicine in the United States (38) developed 3-dimensional electronic anatomical software for the repositioning of bone models and uploaded a tutorial for medical students to study at home during the pandemic. The popularization and development of online education also enables students who cannot attend school to use the same educational resources (4,39).

Over the past decade, the effectiveness of online learning has greatly improved, but its limitations still restrict its use in medical teaching. We found that both postgraduates and undergraduates valued offline learning more than online learning; however, the difference was only significant among undergraduates (4.66 vs. 4.34, P>0.05 for postgraduates, and 5.11 vs. 4.04, P<0.005 for undergraduates). Thus, most medical students are of the view that offline learning is

Table 4 Comparison between medical undergraduates and postgraduates on issues related to online and offline learning

Question	Undergraduate		Postgraduate		P
	M	SD	M	SD	
Do you think your online learning is better than offline learning?	4.04	1.63	4.34	1.60	0.144
Do you think your offline learning is better than your online learning?	5.11	1.51	4.66	1.53	0.021*
Compared to online learning, do you think offline learning can give you a more solid grasp of knowledge?	5.32	1.36	4.91	1.53	0.020*
Do you think you are more motivated to learn online than offline?	3.94	1.60	4.09	1.71	0.457
Do you think your online learning is more focused than your offline learning?	3.72	1.68	3.91	1.74	0.387
Do you think online classes are more engaging than your offline classes?	3.65	1.63	3.69	1.55	0.820
Compared to offline learning, it is easier for you to open applications that are not related to learning during online learning?	4.72	1.57	4.81	1.57	0.663
Do you think your online learning is more efficient than your offline learning?	3.88	1.52	4.22	1.64	0.086
Does a lack of peer learning negatively affect you when learning online?	4.15	1.61	4.09	1.70	0.805
In your opinion, does not being able to communicate with your teacher in real time have a negative effect on your learning?	4.50	1.68	4.67	1.57	0.410
Do you feel that the absence of teacher supervision has a negative effect on your learning?	4.31	1.65	4.38	1.61	0.752
When learning new skills, do you have access to effective study materials online?	4.58	1.54	4.53	1.54	0.789
Can you get online access to effective study materials within your major?	4.76	1.58	4.74	1.62	0.921

*P<0.05. P<0.05 means there is a significant difference, P>0.05 means there is no significant difference. M, the mean; SD, standard deviation; P, the difference between online and offline learning.

better than online learning, even if the differences were not significant among the postgraduates. We think that there may be 3 main reasons for this.

Class participation is insufficient online

Students obtain a sense of classroom participation when they “actively participate in the course activities and strive to obtain learning results in the course” (40). Hensley *et al.* pointed out that this participation directly affects the learning of medical students and plays a vital role in learning activities (40). When asked, “Do you think class participation is higher online than offline?”, 47% of students said “no”, and only 30% said “yes”; 23% were neutral.

Similarly, Thom *et al.* (38) concluded that most medical undergraduates thought that their participation was lower in online classes than offline classes. Some students even stated that this form of learning did not effectively help them to develop a comprehensive practical ability in which subject.

There may be several reasons for these results. The

first relates to the weakening of humanistic care. In online education, the transmission of knowledge remains, but the humanistic care and emotional communication between teachers and students are weakened by removing the learning activities from reality. In a meta-analysis, Pei *et al.* (2) found that in online medical education, the humanistic care received by both undergraduates and postgraduates was gradually decreasing. The second reason relates to a lack of self-control. Almost all the students in our study agreed or strongly agreed with the following question: “When you use electronic devices to learn, do you find that you can’t help opening entertainment or non-learning software?”. This suggests that the self-control of both undergraduates and postgraduates is still not ideal. There is seldom supervision in online learning, which may have a negative effect on learning. The third reason relates to the learning atmosphere. Our data showed that most medical students thought that the learning atmosphere of online learning was worse than that of offline learning. We believe that there are 2 main reasons for this. The first reason relates to the reduction in communication with teachers. Our data

showed that most students believe that the change in the teacher-student relationship as a result of online learning has had a negative effect on their learning activities. The second reason relates to the absence of mutual learning, as online learning represents a shift from “team” to “individual” learning. We believe that online learning weakens the interaction between medical students and has a negative effect on learning. This has adverse effects on the ability of students to accumulate knowledge at the undergraduate stage and on academic discussion and clinical practice at the postgraduate stage. This has led medical students to feel a low sense of participation of in online classrooms, which in turn has led to lower enthusiasm and concentration. These have had negative effect on learning efficiency and effectiveness. There is currently no formal consensus on students’ sense of participation in online learning (30), but most scholars appear to believe that it is lower for online learning than offline learning.

Online learning leads to a lack of discussion and cooperative learning

Discussion is perhaps the most important element of teaching in higher education. As students develop and are more able to learn by themselves, rigid indoctrination learning is not the best learning method for undergraduates and postgraduates (41). Some scholars believe that experiential learning and cooperation are the most effective learning methods during the resident stage of medical postgraduate education (42). Wang *et al.* (43) pointed out that problem- and case-based learning, which are both based on the idea of discussion learning, are better for comprehensive learning among medical students than traditional teaching methods. These methods also help to cultivate independent thinking and clinical analysis (43,44). However, most online learning is relatively passive, and involves activities such as consulting materials and watching online courses. Further, online learning tends not to involve active learning methods, such as group cooperative discussion and laboratory practice (45). This undoubtedly has a negative effect on the effectiveness of online learning for medical undergraduates and postgraduates.

Teachers may have problems teaching online

Our research showed that real-time communication with teachers and supervision by teachers had a positive effect on

the learning of medical students. This suggests that teachers are very important in the effective learning of medical students. However, medical teachers may find it difficult to adapt to online teaching quickly due to work and other reasons. Many medical teachers have insufficient online teaching experience, and the pandemic has left them with even less time and/or energy to learn new online teaching tools (1,45,46). This has led to a decline in teaching effectiveness.

We compared and analyzed the similarities and differences in attitudes of medical undergraduates and postgraduates to both online learning and offline learning. The 2 groups had similar attitudes toward most problems and issues. We thus believe that medical undergraduates and postgraduates have similar cognitive levels and learning ideas. There are subdivisions of research fields at the graduate stage, but most medical postgraduates and undergraduate share the same broad training objective (to become doctors), and thus often hold similar attitudes. However, there were differences across some individual issues. For example, when asked, “Do you think offline learning helps you to master knowledge better than online learning?”, both undergraduates (5.32) and postgraduates (4.91) agreed ($P<0.05$). Both undergraduates (5.11) and postgraduates (4.66) also thought that offline learning was more effective than offline learning ($P<0.05$). We believe that the main reason why medical undergraduates rated offline learning more highly than postgraduates was due to subtle differences in their learning modes and training objectives. Most medical undergraduates are still at a basic stage of learning, and their educational focus is the accumulation of basic knowledge. Conversely, medical postgraduates are more likely to focus on clinical experience and academic thinking and thus need to engage in more reflection and deeper thinking than undergraduates and need a relatively quiet environment. Online learning can meet these objectives. The independent learning atmosphere and the reduction of examination pressure (47) can help medical postgraduates to better acquire resources, think deeply, and reflect. However, as a result of the switch to online learning, medical postgraduates have lost the opportunity to accompany their teachers into workplaces, such as laboratories and wards, and engage in reduced communication with tutors. This has had a negative effect on their ability to develop the clinical skills required by doctors, including the ability to communicate with patients face-to-face (41,48-50).

Conclusions

In conclusion, there is no single form of learning that can meet all the needs of medical education. Both online and offline learning have their limitations, and no single mode can be maximally effective. We are of the view that the best form of medical education is mixed learning that combines traditional face-to-face teaching and online learning (51).

This would provide the original advantages of offline learning, but add the flexibility of online learning, creating a more efficient and convenient education and learning system. Several studies have shown that mixed learning has advantages over online or offline learning individually, and the mixed approach has great potential in medical education (52-57). Online and offline learning should clearly not be viewed as being in competition with one another; rather, they should be viewed as being in a cooperative relationship in which each method compensates for the other's weaknesses and draws on its own strengths to increase the efficiency and convenience of the learning of all medical students.

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Footnote

Reporting Checklist: The authors have completed the SURGE reporting checklist. Available at <https://atm.amegroups.com/article/view/10.21037/atm-22-5112/rc>

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Ethics Committee, because this study did not involve ethical issues.

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References

- O'Doherty D, Dromey M, Lougheed J, et al. Barriers and solutions to online learning in medical education - an integrative review. *BMC Med Educ* 2018;18:130.
- Pei L, Wu H. Does online learning work better than offline learning in undergraduate medical education? A systematic review and meta-analysis. *Med Educ Online* 2019;24:1666538.
- Howlett D, Vincent T, Gainsborough N, et al. Integration of a case-based online module into an undergraduate curriculum: what is involved and what is effective? *e-Learning* 2009;6:372-84.
- Thornton CP, Ruble K, Jacobson LA. Education for Children With Chronic Illness: Moving Forward in Online and Virtual Learning. *JAMA Pediatr* 2022;176:341-2.
- National Center for Education Statistics. Digest of Education Statistics. Updated May 25, 2021. Accessed October 1, 2021. Available online: <https://nces.ed.gov/programs/digest/index.asp>
- Murphy MPA. COVID-19 and emergency eLearning: Consequences of the securitization of higher education for post-pandemic pedagogy. *Contemp Secur Policy* 2020;41:492-505.
- Engelbrecht J, Borba MC, Llinares S, et al. Will 2020 be remembered as the year in which education was changed? *ZDM* 2020;52:821-4.
- Becker SA, Cummins M, Davis A, et al. Glesinger, Ananthanarayanan V. NMC Horizon Report: 2017 Higher Education Edition, The New Media Consortium, Austin, Texas, 2017.
- Aristovnik A, Keržič D, Ravšelj D, et al. Impacts of the COVID-19 pandemic on life of higher education students: A global perspective. *Sustainability* 2020;12:8438.
- Kalantzis M, Cope B. After the COVID-19 crisis: Why

- higher education may (and perhaps should) never be the same. Access: Contemporary Issues in Education 2020;40:51-5.
11. Dodzi A. COVID-19: An unexpected and unusual driver to online education. *International Higher Education* 2020;102:12-4.
 12. Yang Y, Yu HY, Lu G, et al. Interview on the unprecedented changes of energy geopolitics and national energy security. *J Nat Resour* 2020;35:2803-20.
 13. Yin Z, Jiang X, Lin S, et al. The impact of online education on carbon emissions in the context of the COVID-19 pandemic - Taking Chinese universities as examples. *Appl Energy* 2022;314:118875.
 14. Jayaram M, Shields G, Buisman-Pijlman F. Novel methods of teaching psychiatry to medical and postgraduate students. *Curr Opin Psychiatry* 2021;34:491-6.
 15. Samuel N. Surgical Residents at the Forefront of the COVID-19 Pandemic: Perspectives on Redeployment. *Ann Surg* 2021;274:e383-4.
 16. Fernández-Lao C, Cantarero-Villanueva I, Galiano-Castillo N, et al. The effectiveness of a mobile application for the development of palpation and ultrasound imaging skills to supplement the traditional learning of physiotherapy students. *BMC Med Educ* 2016;16:274.
 17. Johnston R, Hepworth J, Goldsmith M, et al. Use of iPod™ technology in medical-surgical nursing courses: effect on grades. *Int J Nurs Educ Scholarsh* 2010;7:Article43.
 18. Perkins GD, Fullerton JN, Davis-Gomez N, et al. The effect of pre-course e-learning prior to advanced life support training: a randomised controlled trial. *Resuscitation* 2010;81:877-81.
 19. Noll C, von Jan U, Raap U, et al. Mobile Augmented Reality as a Feature for Self-Oriented, Blended Learning in Medicine: Randomized Controlled Trial. *JMIR Mhealth Uhealth* 2017;5:e139.
 20. Al-Elq AH. Simulation-based medical teaching and learning. *J Family Community Med* 2010;17:35-40.
 21. So HY, Chen PP, Wong GKC, et al. Simulation in medical education. *J R Coll Physicians Edinb* 2019;49:52-7.
 22. Kemp N, Grieve R. Face-to-face or face-to-screen? Undergraduates' opinions and test performance in classroom vs. online learning. *Front Psychol* 2014;5:1278.
 23. Bediang G, Stoll B, Geissbuhler A, et al. Computer literacy and E-learning perception in Cameroon: the case of Yaounde Faculty of Medicine and Biomedical Sciences. *BMC Med Educ* 2013;13:57.
 24. Choules AP. The use of elearning in medical education: a review of the current situation. *Postgrad Med J* 2007;83:212-6.
 25. Yu S, Yang KF. Attitudes toward Web-based distance learning among public health nurses in Taiwan: a questionnaire survey. *Int J Nurs Stud* 2006;43:767-74.
 26. Peng Y, Wu X, Atkins S, et al. Internet-based health education in China: a content analysis of websites. *BMC Med Educ* 2014;14:16.
 27. Moreira IC, Ventura SR, Ramos I, et al. Development and assessment of an e-learning course on breast imaging for radiographers: a stratified randomized controlled trial. *J Med Internet Res* 2015;17:e3.
 28. Artino AR Jr, La Rochelle JS, Dezee KJ, et al. Developing questionnaires for educational research: AMEE Guide No. 87. *Med Teach* 2014;36:463-74.
 29. Saris W, Gallhofer I. Design, Evaluation, and Analysis of Questionnaires for Survey Research. 2nd edition. Hoboken: Wiley, 2007.
 30. Stoehr F, Müller L, Brady A, et al. How COVID-19 kick-started online learning in medical education-The DigiMed study. *PLoS One* 2021;16:e0257394.
 31. Krosnick J, Presser S. Question and Questionnaire Design. *Handbook of Survey Research*. 2nd Edition. San Diego: Elsevier, 2009.
 32. Milanovic B, Lindert PH, Williamson JG. Pre-industrial inequality. *Econ J* 2011;121:255-72.
 33. Quarles CL, Budak C, Resnick P. The shape of educational inequality. *Sci Adv* 2020;6:eaz5954.
 34. Coupet S. International health electives: strengthening graduate medical education. *J Am Osteopath Assoc* 2012;112:800-4.
 35. Brahmapurkar KP, Zodpey SP, Sabde YD, et al. The need to focus on medical education in rural districts of India. *Natl Med J India* 2018;31:164-8.
 36. Somera Dos Santos F, Osako MK, Perdoná GDSC, et al. Virtual Microscopy as a Learning Tool in Brazilian Medical Education. *Anat Sci Educ* 2021;14:408-16.
 37. Xie H, Zheng Q, Yin B. Research on Multi Co-governance Model of "Internet + Education" Based on Regressive View of Knowledge. *Research on Audio Visual Education* 2020;41:56-62.
 38. Thom ML, Kimble BA, Qua K, et al. Is remote near-peer anatomy teaching an effective teaching strategy? Lessons learned from the transition to online learning during the Covid-19 pandemic. *Anat Sci Educ* 2021;14:552-61.
 39. Kay D, Pasarica M. Using technology to increase student (and faculty satisfaction with) engagement in medical education. *Adv Physiol Educ* 2019;43:408-13.

40. Hensley A, Hampton D, Wilson JL, et al. A Multicenter Study of Student Engagement and Satisfaction in Online Programs. *J Nurs Educ* 2021;60:259-64.
41. Brown A, Lafreniere K, Freedman D, et al. A realist synthesis of quality improvement curricula in undergraduate and postgraduate medical education: what works, for whom, and in what contexts? *BMJ Qual Saf* 2021;30:337-52.
42. Gaffan J, Dacre J, Jones A. Educating undergraduate medical students about oncology: a literature review. *J Clin Oncol* 2006;24:1932-9.
43. Wang H, Xuan J, Liu L, et al. Problem-based learning and case-based learning in dental education. *Ann Transl Med* 2021;9:1137.
44. Kim S, Phillips WR, Pinsky L, et al. A conceptual framework for developing teaching cases: a review and synthesis of the literature across disciplines. *Med Educ* 2006;40:867-76.
45. Farooq F, Rathore FA, Mansoor SN. Challenges of Online Medical Education in Pakistan During COVID-19 Pandemic. *J Coll Physicians Surg Pak* 2020;30:67-9.
46. Perlman RL, Christner J, Ross PT, et al. A successful faculty development program for implementing a sociocultural ePortfolio assessment tool. *Acad Med* 2014;89:257-62.
47. Stowell JR, Bennett D. Effects of online testing on student exam performance and test anxiety. *J Educ Comput Res* 2010;42:161-71.
48. Patow CA, Karpovich K, Riesenber LA, et al. Residents' engagement in quality improvement: a systematic review of the literature. *Acad Med* 2009;84:1757-64.
49. Wong BM, Etchells EE, Kuper A, et al. Teaching quality improvement and patient safety to trainees: a systematic review. *Acad Med* 2010;85:1425-39.
50. Baqir SM, Mustansir F. Online Medical Education and Examinations during COVID-19: Perspectives of a Teaching Associate. *J Coll Physicians Surg Pak* 2021;31:S16-8.
51. Kim KJ, Bonk CJ, Oh E. The present and future state of blended learning in workplace learning settings in the United States. *Perf Improv* 2008;47:5-16.
52. Rowe M, Frantz J, Bozalek V. The role of blended learning in the clinical education of healthcare students: a systematic review. *Med Teach* 2012;34:e216-21.
53. McCutcheon K, Lohan M, Traynor M, et al. A systematic review evaluating the impact of online or blended learning vs. face-to-face learning of clinical skills in undergraduate nurse education. *J Adv Nurs* 2015;71:255-70.
54. Cook DA, Levinson AJ, Garside S, et al. Internet-based learning in the health professions: a meta-analysis. *JAMA* 2008;300:1181-96.
55. Jwayyed S, Stiffler KA, Wilber ST, et al. Technology-assisted education in graduate medical education: a review of the literature. *Int J Emerg Med* 2011;4:51.
56. Liu Q, Peng W, Zhang F, et al. The Effectiveness of Blended Learning in Health Professions: Systematic Review and Meta-Analysis. *J Med Internet Res* 2016;18:e2.
57. Wu JH, Tennyson RD, Hsia TL. A study of student satisfaction in a blended e-learning system environment. *Comput Educ* 2010;55:155-64.

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