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RESEARCH ARTICLE

The Effects of COVID-19 on Teaching Practices in Medical Education

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ABSTRACT

Purpose: This study investigates the transition to online teaching modalities in U.S. medical schools as reported in publicly available datasets before and during the COVID-19 pandemic. The study examines the number and types of graduate medical education (GME) programs and their instructional methods that might be appropriate for continued online teaching modalities as compared to trends in higher education, and in particular, trends in health communication instruction, such as skills training in provider-patient and medical team consultations.

Materials & Method: Studies investigating or reporting trends in medical education were culled from PubMed, and additional studies regarding trends in higher education were culled from Web of Science and Communication Abstracts using search terms "COVID-19" and "education." Publicly available data was collected from the Accreditation Council for Graduate Medical Education (ACGME) and Association of American Medical Colleges (AAMC) for years 2007-2021 (latest date available).

Results: Analysis of U.S. medical programs shows a clear trend toward modification of instructional methods to online modalities as a response to COVID-19 with some intent to continue utilizing these modalities post-COVID-19. Further analysis revealed a majority of utilized instructional methods which are adaptable to online teaching and learning, with certain instructional methods not easily adaptable comprising only 5.34% of the total. Growth in the number of graduate medical education programs and medical residents in the U.S. has steadily increased over the period, whereas the number of hours core medical faculty spend in teaching activities has decreased.

Discussion: Trends in medical education mirrored those in higher education in general during the period under investigation. Advances in instructional design can be applied to instructional methods used in medical programs. The greatest area of improvement gains could be attained in redesign of didactics.

Conclusions/Recommendations: Results indicate that medical schools were trending towards certain teaching methodologies which can be readily delivered in an online format prior to the COVID-19 pandemic. Given the development of new online teaching techniques resulting from the rapid transition to online teaching in 2020 throughout higher education institutions worldwide, it behooves medical societies and schools to invest in research and development of online teaching methodologies for future-proofing of graduate medical education.

Keywords: COVID-19, graduate medical education, health communication

Introduction

Universities and other institutions of higher education have been investing in the development of online education in the recent past. However, the onset of the COVID-19 pandemic accelerated that development[1]. The rapid transition to online learning resulting from the pandemic has affected both instructors and learners in profound ways. For example, instructors in higher education may have experienced some level of distrust regarding the motivation university administrations in the rapid transition to online education[2]. Although instructional technology played a major role in mitigating the effects of re-designing courses for online education in the response to COVID-19[3], rapidity of the transition required many instructors to utilize digital technologies with which they were inexperienced or unfamiliar. One consequence of the rapid transition to online education was the building of an information infrastructure and teaching reform within the education system[4]. Thus, online education is likely to persist post-pandemic[3].

The effects that the COVID-19 pandemic had on students and teachers within the higher education ecosystem have been well documented. For both groups, the rapid transition to new modalities of teaching and learning required substantial adaptation. In general, the pandemic reduced the frequency of study activities of college students, according to one study[5]. This negative impact was correlated with difficulties in workload management and interaction with other students, which may be influenced by students' inability to join synchronous tutorial sessions[5]. However, students affected by the switch to online learning were generally positive about their ability to adapt and cope, though the change also negatively affected their motivation to study[6]. Yet current research demonstrates that online teaching can result in positive learning outcomes for students[7]. For example, students who perceive that online learning is feasible within their fields of study are more likely to be motivated to learn in that modality[8]. This outcome appears to hold across disciplines. For example, conversion to online teaching correlated with perceptions of increased didactic quality in data science courses[9].

Faculty during the transition to online learning reported changes to their cognitive growth in knowledge about their profession, skills and perspectives[10]. To be sure, conversion to a new modality often requires faculty to revise lecture notes. Conversion from face-to-face presentation to online asynchronous presentation may require faculty to write out narration of their lectures. Fortunately, instructors at many schools received support to enroll in and attend courses in effective online teaching practices offered by the Association of College and University Educators[11].

This study investigates the possible effects of changes to teaching modality (i.e., from face-to-face to online) in graduate medical education due to the onset of the COVID-19 pandemic. To accomplish this goal, pre- and post-trends in instructional methodologies both within medical programs and in higher education institutions in general will be examined. This study concludes with recommendations regarding the benefits of new teaching methodologies including application to teaching communication techniques to medical students (including doctor-patient, health teams, etc.) learned as a consequence of the rapid transition to online learning.

Trends in Medical Education

The public has a vested interest in the outcomes of graduate medical education (GME) including geographic distribution and specialty diversity of graduates[12]. Methods for meeting those twin goals involve transformation from in-person education to distance-learning and its variants. Practical application has demonstrated that in-person education can be adapted to online delivery, where feasible[13], and transformation of instructional modalities has been occurring in institutions of higher education including GME programs. Prior to the onset of the COVID-19 pandemic, GME in particular had been trending toward more technology-assisted training. The purposes for doing so were to enhance medical student learning and provide flexibility with both time and location of instruction. In the last several decades, researchers examining instructional methods in medical school have consistently shown positive outcomes with technology-based approaches. One possible reason for this may include student motivation.

One study demonstrated that students are generally dissatisfied with traditional lecture format instructional methods in dental education and prefer interactive and group discussion forms of learning[14]. This finding mirrors results in other fields in medical education, and in higher education in general. Medical researchers have argued for over three decades that technology can assist in enhancing active, motivated and self-directed learning among medical students[15]. Early studies demonstrated that learning styles did not differentially influence learning outcomes in online instructional methods among medical students[16]. Trends toward

increasing the use of technology-based instructional methods on laboratory techniques, in place of face-to-face techniques including cadaver dissection were recognized as early as 2012[17].

To counter the effectiveness, or lack of effectiveness, of lecture as an instructional method, early researchers in medical education demonstrated the effectiveness of self-instruction[18]. Self-directed learning has been shown to improve medical students interviewing skills[19] and can be enhanced through peer-learning strategies[20]. As well, experimental research demonstrates that technology-based instruction, such as self-instruction video, is as effective as face-to-face instruction in learning basic emergency medical skills[21]. Similar research demonstrated that modern self-instruction methods outperform conventional face-to-face instruction[22].

Other forms of technology-assisted instruction have been developed over the last several decades. For example, telementoring, or remote mentoring through the Internet, has been shown to be an effective instructional method for clinical applications[23]. Outcomes from technology-assisted instruction have also been investigated. For example, pre-clinical medical students utilizing computer-assisted training scored significantly higher on objective knowledge tests[24]. However, these outcome gains come with costs. Recent research has demonstrated that medical faculty teaching surgery technique to residents need to continually evolve their instructional methods toward residents[25]. The expansion of specific content in the medical school curriculum, such as digital imaging, may be cost prohibitive if designed for in-person instruction, whereas online instruction may be more cost-effective and also provide for distance learning opportunities[26]. Regardless, new machine-learning assessment methods in simulation-based training has been shown to be effective[27]. Positive outcomes with technology-assisted instruction are not universal for all instructional methods or content. Certain types of instruction, such as lumbar puncture instruction, produce better outcomes with hands-on simulation compared with virtual simulation[28].

COVID-19 Effects on Medical Education

The rapid transition to online learning in Spring 2020 leveraged many of these already developed technology-assisted forms of instruction. During the pandemic, medical programs were required to limit medical students' access to clinical training[29]. Meanwhile, research showed that medical students' attendance at face-to-face lectures had already been decreasing[29]. However, innovation in instructional methods in medicine has not been universal[30]. Traditional forms of instruction, such as face-to-face lecture continues to be a primary instructional method. To address the exigencies of the pandemic, medical programs and societies had to consider changes to instructional methods and curricula. The pandemic fostered the sharing of guidelines for remote working in Continuous Medical Education in the European Union[31].

One advance in medical education resulting from the rapid transition to online learning included the replacement of high-stakes assessment with multiple low-stakes assessment[32]. For example, the use of open-book exams as a response increased opportunities for medical students to use critical thinking skills and multiple resources to find answers compared to recall of information as required in traditional testing protocols[33]. The requirements of social distancing and transition to online learning due to the COVID-19 pandemic directly impacted hands-on training needed in fields such as pharmacy education[34]. The response to the onset of COVID-19 led to an overall decrease in clinical opportunities for medical students[35]. However, the response to the pandemic also provided opportunities for changes to medical school curricula including consideration regarding which students, or which level of student, should be involved in clinical rotations[36].

The disruption of COVID-19 on education in neurology also spurred innovation which resulted in increased student satisfaction, engagement in learning and faculty-student rapport[37]. For example, online presentations and demonstrations have been shown to be effective in dental education, as has teledentistry in virtual clinical practice[38]. In the subfield of surgery, basic surgical skills taught remotely were successfully demonstrated during the COVID-19 pandemic[39]. Other changes to way medicine is taught resulting from the needs presented by the pandemic also directly affected the subfield of surgery where hands-on training is highly prioritized. Multi-faceted approaches which included audience response systems and small group discussion platforms within a virtual space were successfully employed in surgical education during the pandemic[40].

However, not all medical educators are convinced that virtual simulation can replace face-to-face clinical training[41]. Despite these misgivings, positive outcomes in the response of medical educators and students to the pandemic can be seen in what has been achieved over the past two years. Increases in

teamwork to combat the pandemic were seen worldwide. Interestingly, final year medical students increased their volunteerism to work on the front lines of the pandemic[42]. These opportunities may have presented themselves as one of the consequences to the rapid transition to online learning. To investigate the effects of teaching modality changes due to COVID-19 on medical schools, the following research questions are proposed:

RQ_1 What percentage of medical schools (US and Canada) changed their curriculum to include online learning modalities as a consequence of the COVID-19 pandemic?
RQ_2 What percentage of medical schools (US and Canada) intend to maintain some degree of online learning modalities post-COVID-19?
RQ_3 What percentage of GME instructional methods may be appropriate for conversion to online learning modalities?
RQ_4 What percentage of faculty time is spent per week on teaching activities which may be converted to online learning modalities?
RQ_5 How many GME programs may be affected by curricular changes due to post-COVID-19 student expectations regarding availability of online learning modalities?

Materials and Methods

Studies investigating or reporting trends in medical education were culled from PubMed, and additional studies regarding trends in higher education were culled from Web of Science and Communication Abstracts using search terms "COVID-19," "education," and "active learning." The total number of articles in these databases that met the search criteria included: PubMed (N = 39,566), Web of Science (N = 33,033), and Communication Abstracts (N = 278). A small subset of each of these databases, germane to the research questions for this study included 75 articles, including datasets sponsored by the American Medical Association and the Association of American Medical Colleges[43,44].

Publicly available data was collected from the Accreditation Council for Graduate Medical Education (ACGME) for years 2007-2021 (latest data available) and Association of American Medical Colleges (AAMC) for years 2012-2021 (latest date available). Variables were selected from these datasets to answer the research questions and reorganized by year over a multi-year period prior to and during the COVID-19 pandemic to assess trends in teaching methods. Multiple tables from these datasets were combined and re-organized into a single dataset for analysis (data available by request).

Data Analysis

According to the data from the LCME Annual Medical School Questionnaire Part II[45], 97.39% of U.S. medical schools changed at least some part of their face-to-face teaching methods to virtual methodologies starting March 2020. For the 2020-2021 academic year, 96.05% of U.S. medical schools retained those changes. During AY 2020-2021, curriculum committees discussed retaining the changes going forward in 53.90% of the schools surveyed, and in 35.71% of U.S. medical schools surveyed such changes were retained for the 2021-2022 academic year. Data reveal specific changes made to instructional methods in surveyed U.S. medical schools [Table 1].

Table 1. Changes made to instructional methods in U.S. medical schools: 2020 and 2021.

	2020			2021		
Instructional Method	Changes	N	%	Changes	N	%
Clerkship	88	123	71.545%	94	123	76.423%
Didactic	124	153	81.046%	132	153	86.275%
Pre-Clerkship Clinical	138	146	94.521%	121	146	82.877%
Pre-Clerkship Lectures	148	152	97.368%	146	152	96.053%
Pre-Clerkship Small Group	148	154	96.104%	147	154	95.455%
Clinical Encounters	91	137	66.423%	88	137	64.234%
Intent to Retain Change	Schools	N	%			
Discuss Retaining Changes	83	154	53.896%			
Retain Changes	55	154	35.714%			

The Association of American Medical Colleges catalogs the types of instructional methods in use at U.S. medical schools. For the academic years 2012-2014, and 2017-2020, on average 98.0% of schools surveyed utilized lectures for instruction, as well as other instructional methods[46] [Table 2]. According to the data from the AAMC Curriculum Inventory[47], 31 different instructional methods were

utilized by U.S. medical schools for academic years 2012-2013 through 2019-2020. Of those listed, lecture comprised 54.86% of instructional methods utilized. Laboratory, discussion, case-based instruction, and independent learning comprised an additional 26.58% of utilized instructional methods for a total of 81.44%. The listed types which may not be appropriate for conversion to virtual learning methodologies including clinical experience, patient presentation, and ward rounds, comprise only 5.34% of utilized instructional methods over the period reviewed [Table 3].

Table 2. Percentage of medical schools surveyed utilizing instructional methods by academic year.

Academic Year	Lectures	Conferences	Ward Rounds	Standardized Patients	Team-based Learning	Case-based Learning	Problem-based Learning	Small Group Discussion	Simulation
2012-2013	99.26%	93.38%	97.06%	91.91%	63.97%	88.24%	48.53%	93.38%	94.12%
2013-2014	97.86%	94.29%	97.14%	95.00%	62.14%	89.29%	45.71%	95.00%	94.29%
2017-2018	99.32%	93.20%	99.32%	94.56%	49.66%	90.48%	44.22%	95.24%	96.60%
2018-2019	96.69%	91.39%	98.01%	96.69%	51.66%	90.73%	46.36%	94.70%	96.69%
2019-2020	96.73%	92.81%	98.04%	98.69%	53.59%	96.73%	44.44%	96.08%	96.73%
Average	97.97%	93.01%	97.91%	95.37%	56.20%	91.09%	45.85%	94.88%	95.68%

Table 3. Percentage of time devoted to instructional method.

Instructional Method Name	Average %	Cumulative %
Lecture	54.86%	54.86%
Laboratory	5.69%	60.55%
Discussion, Small Group (<=12)	5.64%	66.19%
Discussion, Large Group (>12)	5.35%	71.54%
Case-Based Instruction/Learning	5.06%	76.60%
Independent Learning	4.84%	81.44%
Clinical Experience - Inpatient	2.26%	83.70%
Simulation	1.93%	85.63%
Team-Based Learning (TBL)	1.85%	87.48%
Clinical Experience - Ambulatory	1.80%	89.27%
Problem-Based Learning (PBL)	1.76%	91.03%
Workshop	1.70%	92.73%
Self-Directed Learning	1.43%	94.17%
Conference	1.05%	95.22%
Demonstration	0.70%	95.92%
Patient Presentation - Faculty	0.63%	96.55%
Preceptorship	0.53%	97.08%
Tutorial	0.50%	97.59%
Peer Teaching	0.40%	97.98%
Reflection	0.36%	98.34%
Patient Presentation - Learner	0.33%	98.67%
Research	0.21%	98.88%
Ward Rounds	0.20%	99.08%
Journal Club	0.17%	99.25%
Mentorship	0.16%	99.42%
Service Learning Activity	0.14%	99.56%
Role Play/Dramatization	0.14%	99.70%
Patient Presentation-Patient	0.12%	99.82%
Games	0.07%	99.89%
Team-Building	0.07%	99.96%
Concept Mapping	0.04%	100.00%

Despite the growth in programs and number of residents, the number of hours core medical faculty spend on teaching-related activities ($M = 34.13$, $sd = 4.24$), and on lecturing ($M = 3.92$, $sd = 0.43$) has decreased between 2010 and 2020, the period data is available[48-58], [Table 4], [Figure 1].

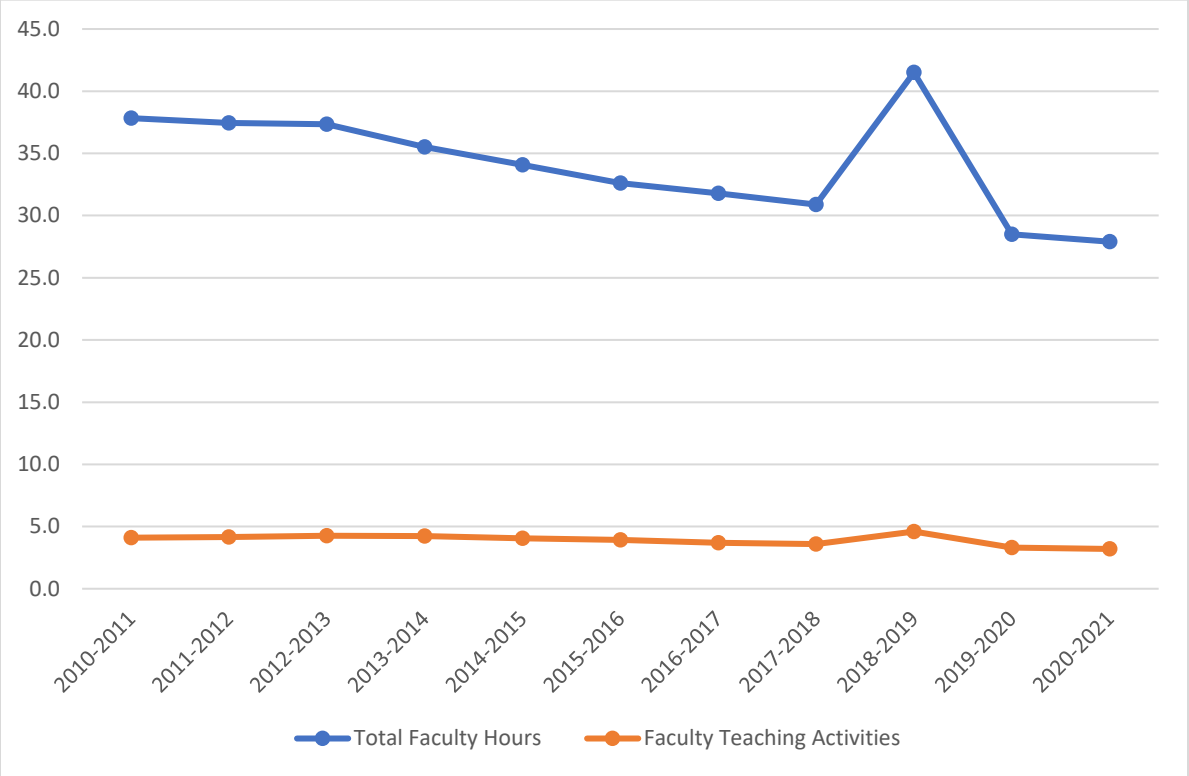

Figure 1. Decreasing trend of core medical faculty hours in teaching-related activities.

Table 4. Core medical faculty hours per week spent on teaching-related activities.

Academic Year	Total Faculty Hours	Faculty Teaching Hours
2010-2011	37.8	4.1
2011-2012	37.5	4.1
2012-2013	37.3	4.3
2013-2014	35.5	4.2
2014-2015	34.1	4.1
2015-2016	32.6	3.9
2016-2017	31.8	3.7
2017-2018	30.9	3.6
2018-2019	41.5	4.6
2019-2020	28.5	3.3
2020-2021	27.9	3.2
M	34.13	3.92
sd	4.24	0.43

Within the U.S., the number of graduate medical education programs has been growing from 8,490 in 2007 to 12,420 in 2020[54,58], on average by 2.98% per year. During that same time period, specialty medical programs have grown from 4498 in 2007 to 6934 in 2020[54,58], on average by 3.39% each year. The number of residents, specialty residents, program graduates, and specialty program graduates have grown as well and at similar rates [Table 5].

of particular interest to this researcher is the priority given to interpersonal communication skills (ICS) training in medical programs. The Accreditation Council for Graduate Medical Education reported in 2016 that 99.9% of U.S. and Canadian medical specialty programs assessed ICS[54]. In these programs, the mean number of evaluators was 8.2, and the mean number of assessment measures was 3.7[54].

Table 5. Growth in U.S. medical programs, academic years 2007-2008 through 2020-2021.

Academic Year	Total Programs N	%Δ	Specialty Programs n	%Δ	Total Residents N	%Δ	Specialty Residents n	%Δ	Total Graduates N	%Δ	Specialty Graduates n	%Δ
2007-2008	8490		4498		107851		90462		33873		25289	
2008-2009	8734	2.87%	4714	4.80%	109482	1.51%	91384	1.02%	34314	1.30%	25346	0.23%
2009-2010	8814	0.92%	4811	2.06%	111386	1.74%	92590	1.32%	34871	1.62%	25531	0.73%
2010-2011	8887	0.83%	4867	1.16%	113142	1.58%	93959	1.48%	35594	2.07%	25863	1.30%
2011-2012	9022	1.52%	4962	1.95%	115293	1.90%	95551	1.69%	36543	2.67%	26414	2.13%
2012-2013	9265	2.69%	5181	4.41%	117717	2.10%	97155	1.68%	37316	2.12%	26795	1.44%
2013-2014	9527	2.83%	5393	4.09%	120108	2.03%	98811	1.70%	38286	2.60%	27218	1.58%
2014-2015	9645	1.24%	5474	1.50%	121599	1.24%	100108	1.31%	39395	2.90%	27859	2.36%
2015-2016	9977	3.44%	5653	3.27%	124409	2.31%	102442	2.33%	39810	1.05%	28107	0.89%
2016-2017	10672	6.97%	5968	5.57%	129720	4.27%	107013	4.46%	40545	1.85%	28911	2.86%
2017-2018	11214	5.08%	6198	3.85%	135326	4.32%	111758	4.43%	42411	4.60%	30177	4.38%
2018-2019	11685	4.20%	6473	4.44%	140391	3.74%	115992	3.79%	44043	3.85%	31440	4.19%
2019-2020	12092	3.48%	6723	3.86%	144988	3.27%	119743	3.23%	45101	2.40%	32229	2.51%
2020-2021	12420	2.71%	6934	3.14%	149200	2.91%	123279	2.95%	46401	2.88%	33242	3.14%
M	10031.71	2.98%	5560.64	3.39%	124329.43	2.53%	102874.79	2.42%	39178.79	2.45%	28172.93	2.13%
sd	1340.45	1.74%	788.26	1.36%	13555.07	1.06%	10923.02	1.22%	4095.89	0.98%	2660.44	1.28%

Discussion

The data utilized in this study did indicate that medical programs in the U.S. (and Canada) adjusted instructional methods and curricula to respond to the exigencies of the COVID-19 pandemic. Findings suggest that many of these changes will be carried forward as innovation in teaching. This carry-forward may require additional future teaching activities preparation to be successful. Recent research in teacher preparation has demonstrated that teacher self-efficacy for emergency remote instruction is positively associated with prior professional development in online teaching modalities[59]. These findings suggest that institutes of higher education should encourage professional development of online instruction in advance of any potential future disruptions in education. In medical education, the greatest area of potential improvement can be in converting face-to-face lecture to asynchronous online content. Currently, lecture comprises the largest portion of instructional methods, and face-to-face lecture is time bound for both instructors and students.

With the rapid onset of COVID-19, medical educators had to convert traditional face-to-face lectures to online lectures. Some medical educators found that students' academic achievement was stronger and student attitudes more positive when instructors used traditional face-to-face lecture format compared to online asynchronous lecture format[60]. However, this comparison involved asynchronous lecture format that did not follow best practices in instructional design but rather involved long videos of PowerPoint presentations with background narration[60]. Recent development of best practices in instructional design for didactic methods of teaching include more sophisticated multi-media presentation of content, and research tends to support positive outcomes for those approaches. For example, students engage more with videos that include the instructor as a "talking head" compared to videos of slide presentations alone[61].

However, the nature of the student population should be taken into account. Some research demonstrated that the use of asynchronous online lectures may adversely affect students with less academic ability compared to synchronous online lectures, although no such differences were found with high achieving students[62]. Where traditional lectures online are less effective than traditional face-to-face lectures, interactive asynchronous methods which employ active learning strategies are more effective than traditional lecture in either face-to-face or online modalities[63]. Advances in didactics as applied to asynchronous online teaching modalities have shone great gains recently.

For example, students may report feeling less learning occurred in active learning environments compared to passive environments, such as traditional lecture style, while evidence has shown that students actually perform better in testing of knowledge when engaged in active learning environments[64]. Asynchronous online lecture modality can be very effective and lead to strong student satisfaction and positive learning outcomes if attention is paid to development of an engaging style of communication of course content and the type of video production utilized[65]. When students

expect certain teaching modalities, engagement in those modalities increase. Students are better prepared to engage with active learning when they are coached in advance about the value of increased cognitive efforts required in this learning environment[64].

Learning with video lecture is stronger when technology is used to infuse content with engaging activities such as the ability to rewind and playback video, engaging with other students about the video with discussion, highlighting and note-taking within the video player software, and other active learning options[66]. Recent research has demonstrated that students prefer mini-lectures with automatically-graded embedded questions for interactivity [67]. The format of video content and the purpose of its integration influences student engagement in asynchronous online courses[68]. More specifically, video length is an important factor influencing student engagement, with shorter videos associated with higher levels of engagement[61]. Traditional lecture style, particularly face-to-face and online synchronous lecture typically follows a pre-determined time slot of 45 minutes to an hour and a half per meeting session. Shorter asynchronous, interactive content offers benefits not available to live synchronous lecture. With asynchronous, interactive content students have the ability to choose when and how to engage the content. Interestingly, research shows that students rewatch tutorial (procedural) videos more often than lecture (conceptual) videos[61]. Although passive learners perform better with immediate fact recall, active learners perform better with strategies for searching for information[69]. Regardless, the benefits to learning outcomes with asynchronous interactive content may outweigh the costs. To be sure, assessment strategies should be aligned with the teaching method[69].

Other advances in instructional design can be applied to medical education. For example, the use of open educational resources and educational technologies during the pandemic can be further utilized to create video-based skills training, online lecture modules, simulation and virtual (ward) rounds in medical education[70]. The use of asynchronous content can assist students in managing time by saving time during activities assigned to a synchronous space[71]. Additionally, medical educators can utilize knowledge gained in instructional design from other disciples. In the field of Communication, researchers have developed a model of communication competencies for faculty engaging in face-to-face (or online) teaching which include immediacy, affinity-seeking, relational power, credibility, clarity, and humor[72]. These communication skills for instructional personnel apply to students in professional training, including medical students preparing for provider-patient communication, as well as in team consultations. Communication skills training has also been recommended for inclusion in veterinary curricula[73].

Faculty with less experience in instructional design for remote learning may be reticent to convert traditional forms of instruction to technology-assisted due to concerns regarding student perceptions of their teaching which may impact merit evaluations at their institutions. However, concerns regarding the effect on faculty evaluations from converting instructional methods from traditional face-to-face to online are unfounded[74]. Interviews with medical students demonstrated variation in understanding regarding the items in course evaluations[75], regardless of teaching modality. It is more likely that students will appreciate the flexibility provided by remote learning, provided such instruction includes direct support and frequent communication from instructors.

Conclusions and Recommendations

Post-COVID-19 online learning modalities are a trend that will continue in higher education institutions, including graduate medical schools. Trends in research-based teaching and learning continue to emphasize effective teaching methods that can be applied to online learning. Recent research has demonstrated the online learning can be effective even for complex skill development, including skills within medical fields. Recent research has also demonstrated that faculty who are effective at teaching online modalities are recognized by students through positive course evaluations. Therefore, it behooves medical programs to leverage knowledge gained from the rapid transition to online learning within their institutions, as well as through collaboration with other institutions to advance the goals of medical education.

Conflict of Interest

The author has no conflicts of interest to declare.

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