



Sustaining education in the age of COVID-19: a survey of synchronous web-based platforms

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The ongoing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic and the associated coronavirus disease 2019 (COVID-19) have had profound global and personal implications, with 5,701,337 confirmed cases and 357,688 confirmed deaths across 213 countries, areas, and territories at the time of writing (1). A concerted international response to the outbreak has focused on social distancing and quarantine measures through the closure of schools, workplaces, and community centers, in addition to household isolation, as a means of limiting human-to-human transmission and disease progression, thereby reducing the strain on the healthcare system. The novelty of the virus accompanied by its asymptomatic transmission and lack of a current treatment or vaccine highlights the importance of self-isolation to reduce global infection rates (2-4). Such techniques for the control of communicable diseases are not novel and have been successfully employed in previous outbreaks, notably the 1918 H1N1 pandemic and the 2003 SARS pandemic (5-8). Their efficacy has not only been shown in clinical studies but also in simulations and pandemic models (9,10). A modelling study conducted by Prem *et al.* investigated the efficacy of social distancing on the current SARS-CoV-2 pandemic and determined a projective reduction in median infection rates of 24%

by the end of 2020 following a staggered return to work commencing at the beginning of April 2020 (11).

Despite the demonstrated efficacy of social distancing measures, their use imposes significant economic costs and psychosocial challenges (8,12). Of significant concern is the disruption to education and training, with The United Nations Educational, Scientific and Cultural Organization estimating that 87.6% of enrolled learners have been affected by the pandemic (13). Many institutions, including our own, are turning to online teaching and educational platforms, many of which rely on synchronous videoconferencing (14). Due to the nature of medicine and the need to maintain the standard of patient care, maintaining the integrity and continuity of medical teaching is paramount when possible (15). We posit that videoconferencing tools are part of the solution towards this goal through their provision of educational content to students globally.

Videoconferencing is defined as “a conference in which participants in different locations are able to communicate with each other with both sound and vision” (16). This broader term encapsulates both meetings and web-based seminars (also known as webinars). The authors aim to mitigate the disruption of the current SARS-CoV-2

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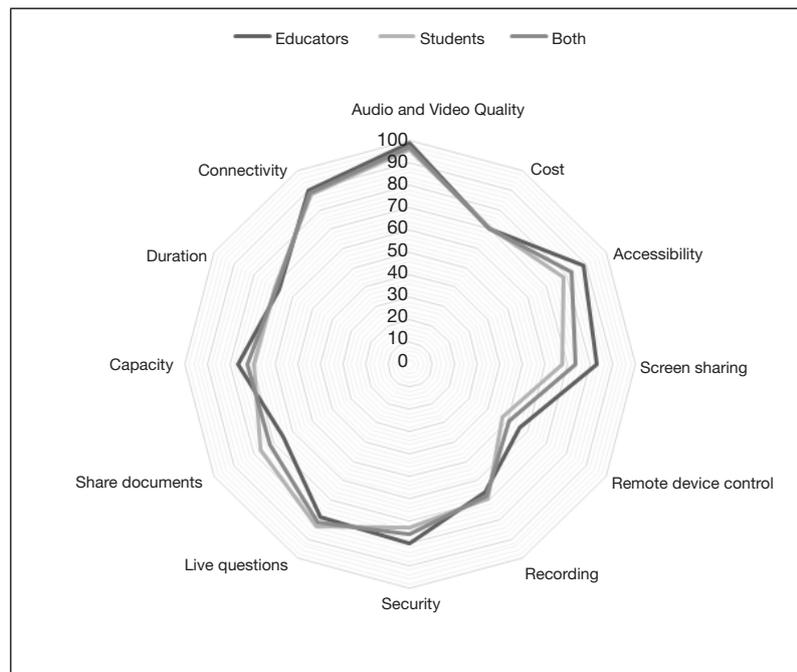


Figure 1 A radar plot showing the importance of different factors associated with videoconferencing tools.

pandemic on medical education by reviewing the available videoconferencing platforms and suggesting those most suited to educational use based on a set criterion as derived from a surveyed cohort of medical students and educators. By doing so, we aim to ease the transition from face-to-face to online teaching.

We evaluated 50 commonly used web-based videoconferencing platforms and selected the most suitable platforms from these based on core criteria of cost per month, capacity, accessibility, security, and minimum conference duration.

These criteria were based on the most important factors affecting the delivery of teaching via synchronous videoconferencing as determined by an international population of 30 surveyed medical students and 20 surveyed medical educators. The survey participants were asked whether they had used videoconferencing tools before, and if so, what they were; which criteria would be the most important for them when using such a platform; and the medical fields that they thought would be most suitable for teaching via videoconferencing. We also informed our criteria—namely those of cost, safety, equity, feasibility, and efficacy—from those of the standard health technology assessment (17).

We divided the platforms which fit these criteria into

those best suited to smaller, seminar-based teaching and those best suited to larger, lecture-based teaching. In terms of the smaller, seminar-based teaching, our selection criteria were a maximum of \$50 per month for a minimum of 50 people, Microsoft, iOS, Android and Linux compatibility, end-to-end encryption, and a minimum of 2 hours per meeting. In contrast, the criteria for larger, lecture-based teaching was \$75 per month with a minimum of 250 people, while keeping accessibility and safety criteria identical to both teaching methods.

Data collected from the survey of 50 medical students and educators shows that 92% had previously used an online, synchronous videoconferencing platform for teaching, and that 88% of those who had done so are comfortable with using them. Of the live platforms that the participants had already used, the three most commonly used were GoToMeeting, Skype, and Zoom. As can be seen in *Figure 1*, 97% determined audio and video quality to be the most important factor on average, whilst 57% said remote device control was the least important factor in determining the videoconferencing platform that they were most likely to use. Other factors judged to carry importance include screen sharing, speaker and organizer controls, background image quality, as well as the ability to have multiple hosts. It is important to note that one of the areas

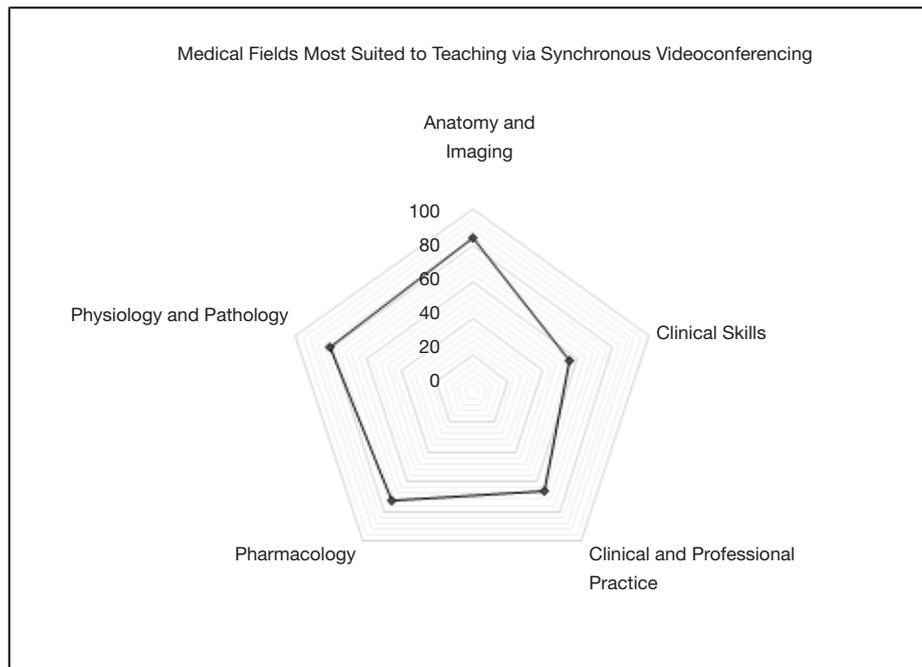


Figure 2 A radar plot showing the suitability of videoconferencing methods for the teaching of different medical subjects.

with the greatest difference in importance between medical students and educators was the ability to share notes and documents via the same platform, perhaps suggesting an overlooked area of potential support for the student.

There was an overall positive correlation between the amount participants were willing to spend per month and the maximum capacity of the videoconferencing platform, to a limit of \$50 per month. These values ranged between \$10 and \$20 for groups of less than 50 people, \$25 and \$45 for groups between 100–500, and up to \$50 for groups over 1,000 people. En masse, this data indicates that educators are willing to incur higher costs if able to reach wider audiences.

The medical fields thought to be most suited to teaching via synchronous videoconferencing were anatomy and imaging (83.6%) and physiology and pathology (80.4%), as shown in *Figure 2*. In contrast, fields associated with more substantial patient contact—clinical skills and clinical and professional practice—were thought to be less suited to online, remote teaching (55.2% and 66% respectively).

Videoconferencing has been used as an educational tool since the 1960s for trauma, surgical procedures, and post-operative patient follow-up. Notably, in 1962, DeBakey's first demonstration of open-heart surgery in Texas was viewed by medical staff in Geneva (18). Since then,

synchronous videoconferences have facilitated national and international teaching across various specialties and have been cited as a significant possible solution for the expansion of medical education in less economically developed regions (19–22). Notably, it has also been shown that there is no significant difference in national licensing exam performance between medical students who receive the majority of their lectures online through the use of synchronous videoconferencing as opposed to those that receive it in-person (23).

One institution that recently reviewed the use of videoconferencing tools for anatomy teaching found connectivity issues and restrictions surrounding the Human Tissue Act to pose a challenge to the accessibility of all normally available face-to-face materials for the students (24). Similarly, we found that 89% of those surveyed reported connectivity to be one of the most important factors in the use of videoconferencing platforms for educational purposes. This stresses that, for educational material to be used effectively, students as well as educators must have an adequate ability to access the platform. In our study, we assume satisfactory connectivity and thus no effect on the choice of platform, but do acknowledge it to be a significant possible limitation to the accessibility of online teaching via such platforms.

Our survey found audio and video quality to be similar and sufficient across platforms and so they did not form part of our selection criteria, despite being ranked as the most important factor for those surveyed. Similarly, other features which placed highly amongst those surveyed—namely, screen sharing, recording, and the ability to ask live questions—were largely present across all platforms and so did not form part of our core criteria. The weight of importance attributed by students to these more interactive features supports recent literature which shows student interaction is higher in online teaching than in face-to-face teaching (25).

All of the platforms that fit our selection criteria were deemed to fall within the parameters for cost, capacity, accessibility, safety, and maximum duration as determined by our 50 surveyed medical professionals. These platforms are comprehensively reviewed in *Tables S1,S2* [currency conversions were performed using standardized rates (26)]. In order to differentiate further between them, we considered which platforms were the most cost-effective using the principles of cost-effectiveness analysis (27). We also considered any additional features the platform may have, particularly the ability to record meetings as this featured highly in importance for those surveyed.

For smaller, seminar-based teaching, this process yields BlueJeans, Blizz, Cisco Webex Meetings, Lifesize Meeting, GoToMeeting, and UberConference as similarly priced options with similar features, though Blizz and GoToMeeting are more cost-effective options due to their higher capacities. It also yields Click Meeting, Cyberlink U, EzTalks meetings Standard and Pro, EzTalks webinars, FreeConference, and VEEDDEO which sit at a higher price, but offer more features. Notably, there are also four free options that fit our criteria for smaller teaching sessions: Cisco Webex Meetings Free, ezTalks Meetings Starter, GlobalMeet, and Microsoft Teams. Of these, Microsoft Teams is the most cost-effective option due to its higher capacity and additional features.

For larger, lecture-based teaching, this process yields Amazon Chime, Blizz, and GoToMeeting as similarly priced options with similar capacities and capabilities. It also yields ezTalks Meetings Business as a more feature-rich alternative, albeit with the latter sitting at a higher price point. Microsoft Teams should be considered as a feature-rich free option in this bracket which meets all of our criteria and is, therefore, the most cost-effective option for a capacity of up to 250 people.

In both cases, we excluded WebinarJam from our final

selection as it runs on an annual payment which lengthens its time horizon and limits subscribers to their options should they not wish to continue with remote teaching after the current pandemic and the return to normal working (28). In addition, despite meeting all other aspects of our set criteria and having a capacity of 500 people, at the time of writing, Zoom did not meet our safety standards in terms of end-to-end encryption and so was not included in our final review (14,29). It has also recently become apparent that videoconferencing platforms may become the target of malicious intentions that aim to disrupt the teaching session (30). Steps can be taken to mitigate such acts including using secure links and limiting distribution of the link, password-protecting the event, ensuring participant registration and identity, muting all participants, closing chatrooms, and disabling annotations and screen sharing for all but the host.

It is important to note that more options were found for smaller capacity teaching sessions than for larger capacity teaching sessions and that beyond a capacity of 250 participants, cost was found to be the most significant barrier to videoconferencing platforms. However, it should be noted that higher-cost platforms typically provide additional features which may be of benefit to the student. Webinar options which greatly increase attendee capacity above 250 people are available but at a substantially greater cost often tailored to the individual and are, therefore, outside the scope of this article. Additional challenges to teaching via videoconferencing include ensuring student access to the technology and software sufficient to run teaching platforms as well as the delivery of content at an appropriate time across different time zones.

This said, the extensive range of different platforms provide for a multitude of teaching methods with various additional features which add a greater variety and depth of communication that would otherwise not be possible. In addition, the use of recording methods further adds to remote learning, allowing students to revisit teaching content that would otherwise only be delivered on a one-off basis. The importance of this capability to student bodies is well described in the literature (31).

The main drawback of our study is that the survey relies entirely on self-reporting with a relatively small sample population (50 people). Hence, though we assume that the participants completed the survey in an honest and well-thought-out manner, the integrity of our results does lie with the honesty and accuracy of those surveyed. In addition, all respondents are from a medical background and

so our results may not be generalizable to other educational fields or teaching styles. We also recognize that it is essential to consider the innate advantages and drawbacks of each platform, such that an individual compromise must be reached depending on each user's needs.

In times of social isolation, videoconferencing should be seen as a powerful tool which enables educators to continue the delivery of their teaching to students worldwide and which works to ensure a physical distance whilst maintaining social connectivity.

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Footnote

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Ethical Statement: This service evaluation was approved by the institutional review board (reference number 2835). Consent was obtained from participants before commencement of the surveys.

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Supplementary

Table S1 A summary of the available platforms meeting our selection criteria for smaller, seminar-based teaching

Platform	Plan type	Cost per month (\$)	Cost per month (£)	Cost per month (€)	Capacity	Accessibility	Safety (E2E encryption)	Screen sharing	Take over screen	Record/storage-cloud	Maximum duration	Additional features
Blizz by TeamViewer	Company	14.00	11.30	12.68	300	Yes	Yes	Yes	No	Yes	Unlimited	50+ free local dial-in numbers, participant recording, team chat
BlueJeans	Meeting standard	9.99	8.06	9.05	50	Yes	Yes	Yes	Yes	5 hours	Unlimited	Smart meeting, video, web, mobile features, unlimited 1:1 meetings, unlimited group meetings
	Meeting Pro	13.99	11.29	12.67	75					25 hours		
Cisco Webex Meetings	Free	0.00	0.00	0.00	100	Yes	Yes	Yes	Yes	No	Unlimited	Unlimited meetings, call-in for audio, unlimited messaging and file sharing
	Starter	14.25 per host	11.50 per host	12.91 per host	50					5 GB		Application/file sharing, MP4 meeting recordings, customizable room link, integrations with other applications, administrative feature controls
	Plus	19.25 per host	15.53 per host	17.43 per host	100					5 GB		Customizable WebEx URL, assign alternate hosts, allow others to schedule meetings on behalf of the host, analytics and troubleshooting
Click Meeting	Live and automated plans priced on attendees	42.93 or 52.75 based on features	35.00 or 43.00 based on features	39.70 or 48.78	50	Yes	Yes	Yes	Yes	10 hours / 2 GB	Unlimited	Both live and automated have whiteboard, questions and answers, polls and surveys, private chat, real time chat translation, chat moderation, google analytics integration, custom branding, invitations, and payment options. Automated also has automatic follow-up email, certificates of attendance, and auto-streaming, auto-publishing of recordings to social media, YouTube, and Dropbox
Cyberlink U	Meeting Pro50	29.90	24.14	27.07	50	Yes	Yes	Yes	No	Yes	24 hours	
	Meeting Pro100	49.99	40.36	45.26	100					Yes	24 hours	Professional look webcam, analyze meeting data, monitor activity
	Webinar Pro100	49.99	40.36	45.26	100					2 GB	8 hours	
ezTalks Webinars	Standard	31.00	25.03	28.07	50	Yes	Yes	Yes	Yes	2 GB	Unlimited	50 participants, 500/month recording online views, live webinars
	Pro	40.00	32.30	36.22	100					4 GB		Redirect attendees, live webinars, on-demand webinars, Facebook and YouTube live, 2,000/month recording online views, 25 presenters
ezTalks Meetings	Starter	0.00	0.00	0.00	100	Yes	Yes	Yes	Yes	MP4 local recording	40 mins	Unlimited meetings, interactive whiteboard, 24/7 support, outlook plugins, vote and polling
	Standard	13.00	10.50	11.77	100					2 GB	Unlimited	Unlimited meetings, interactive whiteboard, 24/7 support, outlook plugins, vote and polling, 500 recording online views per month
	Pro	39.00	31.51	35.30	200					4 GB	Unlimited	Unlimited meetings, interactive whiteboard, 24/7 support, outlook plugins, vote and polling, 1,000 recording online views per month
FreeConference	Plus	24.99	20.19	22.62	50 web, 1,000 call	Yes	Yes	Yes	No	Yes	12 hours	Toll-free and international dial numbers (500 min/month), audio recording, smart summaries
	Pro	34.99	28.27	31.67	100 web, 1,000 call							Toll-free and international dial numbers (1,000 min/month), audio recording, smart summaries
GlobalMeet	Basic meeting	0.00	0.00	0.00	≤125	Yes	Yes	Yes	Yes	Yes	Unlimited	Microsoft outlook calendar integration
GoToMeeting	Professional	14.00	11.30	12.67	150	Yes	Yes	Yes	Yes	Unlimited	Unlimited	Admin reports, diagnostic reports, single sign-on
	Business	19.00	15.33	17.19	250							
Lifesize Meeting	Standard	16.95	13.68	15.33	100	Yes	Yes	Yes	No	Unlimited	24 hours	≥1 host
Microsoft Teams [†]	Office 365 A1	0.00	0.00	0.00	250	Yes	Yes	Yes	Yes	Unlimited	Unlimited	Background blur, scheduled meetings, create assignments, gradebook tracks student performance and progress, chat with file sharing, collaboration on Office documents, OneDrive storage, usage reporting and 24/7 customer support
UberConference	Business	20.00	16.15	18.09	100	Yes	Yes	Yes	No	Unlimited	5 hours	Unlimited conferences, call in numbers, call recording
VEEDEEO	Team	14.35 per user billed annually or 18.23 per user billed monthly (both with a minimum of 2 users) 38.63 per meeting room with unlimited users	11.58 per user billed annually or 14.71 per user billed monthly (both with a minimum of 2 users) 31.18 per meeting room with unlimited users	12.99 per user billed annually or 16.50 per user billed monthly (both with a minimum of 2 users) 35.00 per meeting room with unlimited users	30	Yes	Yes	Yes	No	1 GB	Unlimited	Calendar scheduling, collaboration tools, lock room, layout control, permanent virtual room link
WebinarJam*	Basic	41.58	33.5	37.54	500	Yes	Yes	Yes	Yes	Yes	2 hours	Flexible scheduling, attendee spotlight, flexible scheduling, page builder, e-mail and SMS system, polls and surveys, handouts, pre-recorded videos, drawing board, active offers and bidding, paid webinars, live chat

†, free for the duration of the SARS-CoV-2 pandemic; *, annual payment.

Table S2 A summary of web-based synchronous videoconferencing platforms meeting our selection criteria

Platform	Plan type	Cost per month (\$)	Cost per month (£)	Cost per month (€)	Capacity	Accessibility	Safety (E2E encryption)	Screen sharing	Take over screen	Record/storage-cloud	Maximum duration (hours)	Additional features
Amazon Chime	Pro	15.00 per user	12.11 per user	13.57 per user	250	Multi-platform	Yes	Yes	Yes	Yes	24	Lock meetings, chat rooms, personalize link, schedule meetings, assign delegates
Blizz by TeamViewer	Company	14.00	11.3	12.67	300	Multi-platform	Yes	Yes	No	Yes	Unlimited	50+ free local dial-in numbers, participant recordings, team chat
ezTalks Meetings	Business	50.00	40.31	45.28	300	Multi-platform	Yes	Yes	Yes	10 GB	Unlimited	Unlimited meetings, team chat, interactive whiteboard, 24/7 support, outlook plugins, vote and polling, 300 recording online views per month
GoToMeeting	Business	19.00	15.31	17.20	250	Multi-platform	Yes	Yes	Yes	Unlimited	Unlimited	Admin reports, chat room, diagnostic reports, single sign-on
Microsoft Teams [†]	Office 365 A1	0.00	0.00	0.00	250	Multi-platform	Yes	Yes	Yes	Yes	Unlimited	Background blur, scheduled meetings, create assignments, gradebook tracks student performance and progress, chat with file sharing, collaboration on Office documents, OneDrive storage, usage reporting and 24/7 customer support
WebinarJam*	Basic	41.58	33.46	37.58	500	Multi-platform	Yes	Yes	Yes	Yes	2	Flexible scheduling, attendee spotlight, flexible scheduling, page builder, e-mail and SMS system, polls and surveys, handouts, pre-recorded videos, drawing board, active offers and bidding, paid webinars, live chat
	Professional	58.25	46.96	52.74	2,000	Multi-platform	Yes	Yes	Yes	Yes	3	

[†], free for the duration of the SARS-CoV-2 pandemic; *, annual payment.