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# Remote online learning reimagined: perceptions and experiences of medical students in a post-pandemic world

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## Abstract

**Background** Blended learning is a key educational methodology, particularly in medical education, and involves integration of online and face-to-face interactions to enhance flexibility and engagement. Blended learning gained increased popularity during the COVID-19 pandemic due to social restrictions. Following control of the pandemic, face to face teaching and learning activities have been restored. However, some institutions continue to deliver some teaching online. This study explores the perceptions and experiences of undergraduate medical students from 15 institutions across seven countries regarding remote online learning in the post-pandemic era.

**Methods** This cross-sectional study utilized an online survey to gather insights into the use of learning resources, interactivity in online sessions, barriers to online learning, and preferences for learning modalities. Descriptive data were summarized by frequency, categorical comparisons were assessed with chi-squared tests, and t-tests were used for continuous data.

**Results** The findings of the current study show a general preference for blended learning (47.78%) over traditional face-to-face instruction (41.48%). Key benefits of blended learning reported by the participants by comfort, flexibility, reduced travel, and ability to learn at own pace. The key barriers identified were internet connectivity issues and family distractions. The study also highlighted the limitations of online learning in replacing clinical experience and practical skills acquisition, with 69.26% of respondents affirming that online learning does not sufficiently substitute for direct patient contact.

**Conclusion** The findings underscore the importance of integrating face to face and remote online teaching and learning frameworks to align with educational objectives, particularly in fostering interactivity and practical skill development. The study suggests that while blended learning has many benefits, its effectiveness is highly context-dependent and requires thoughtful implementation to meet the diverse needs of medical education.

**Keywords** Blended learning, Online, Medical, Students, Undergraduate education, Post-pandemic education

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## Introduction

Blended learning refers to a combination of face-to-face education and remote online teaching and learning activities and represents an integration of traditional and e-learning (Kim, Bonk and Oh, 2008). This approach has facilitated the evolution of traditional face-to-face interactions in a confined physical space to sophisticated hybrid systems that integrate online and face-to-face interactions [21]. By merging synchronous and asynchronous activities from traditional and e-learning environments, blended learning offers flexibility and enhanced engagement [6, 22]. This explains its effectiveness in medical education and training as it allows students to navigate seamlessly between asynchronous self-paced online modules and interactive classroom experiences with instructors [21, 22]. This in turn has a profound impact on understanding and applying knowledge, evaluating and synthesizing the clinical evidence for better decision-making mastering clinical skills and internalizing professional values and attitudes [6, 17, 21].

The option of remote online teaching and learning activities has played a critical role in supporting the continuity of education during significant disruptions during the recent Covid-19 pandemic. Social distancing measures observed during the pandemic mandated education providers to introduce remote learning on an unprecedented scale in living memory. This shift has had a marked impact on the pedagogical landscape in health-care education and provided further compelling evidence to utilize remote, online learning. With rapid development of online learning platforms, blended learning offers numerous advantages for students, teachers and institutions and is now a well recognised mode of teaching and learning in contemporary education rather than just an emergency solution [26].

However, this transition to blended learning environments poses new challenges, including the need for significant resource allocation for sophisticated hybrid platforms, technological readiness and sustainability, and the adaptation of teaching strategies to fit e-learning systems. This challenge amplifies the need for institutions to design suitable educational frameworks that support the nuances of online and face-to-face integration and enhance the student learning experience through a thoughtful and effective alignment of teaching activities, assessment strategies with learning outcomes [3].

As educational institutions continue to navigate the post-pandemic landscape for an effective pedagogical approach that caters for different learner's styles and needs, the role of blended learning is expected to continue expanding. While the shift to blended learning has been extensively investigated, less is known about the perceptions of the key stakeholders directly engaged in the

process, the students and faculty, whose experiences and insights are paramount to the success of any educational approach. Many studies have also focused on immediate responses to the pandemic within specific institutional contexts, often overlooking the global implications and the sustained changes in educational strategies across various regions and medical education systems. The current study aims to explore the perceptions and examine the experiences of students in undergraduate medical education, using a unified research instrument. The study also analyzes global trends in blended learning and considers both pre- and post-covid-19 pandemic educational landscapes. It also assesses how these educational changes have been received and what implications they hold for the future of medical education [2, 5, 14, 15, 19, 24, 25, 27, 28].

## Conceptual framework

This study was grounded in Biggs' principle of constructive alignment, rooted in the constructivist theory of learning [8]. This principle proposes that knowledge is built through individual experiences and social interactions and emphasizes aligning intended learning outcomes (ILOs), teaching activities, and assessment tasks to foster deep learning [8]. In higher education, a contextual learning approach is employed to develop independent learners capable of adapting to diverse learning environments. By aligning ILOs, activities, and assessments, online remote learning can ensure that the constructive alignment principle is met, fostering meaningful and active learning experiences even in a virtual environment.

The COVID-19 pandemic highlighted the importance of responsive and flexible educational models to integrate face to face and remote online learning activities. This shift has also been marked with an increasing focus on adaptive teaching approaches that promote the development of self-directed learning, a skill which is essential for health professionals to continuously update their knowledge and skills throughout their professional journey [7, 11, 29].

## Methods

### Ethics approval and consent to participate

This study was conducted in compliance with the ethical principles outlined in the declaration of Helsinki for research involving humans, including research on identifiable human material and data. Ethical approval was obtained from the Institutional Review Board at Qatar University (Reference number: QU-IRB 1614-E/21). Participation in the study was voluntary and all participants provided an informed consent prior to their participation in the study.

### Study design and study setting

The research employed a cross-sectional online survey methodology. Invitations were sent to medical students through faculty members at the participating institutions. The invitations were accompanied by a participant information sheet explaining the purpose and scope of the study and that participation entailed completing an online survey.

### Sampling technique and participants

Undergraduate students were recruited through a convenience sampling approach. Potential participants were invited via email through professional channels within the respective institutions. The invitations included a participant information sheet detailing the study's objectives and scope.

### Research instrument

A previously used questionnaire aimed at exploring the experiences of online learning, and perceived benefits and barriers to online learning was used for data collection [12]. The survey inventory was based on 20 items consisting of a combination of closed and open-ended questions.

### Data collection

Participants were asked to fill out an online questionnaire via Google Forms. Before proceeding to the questionnaire, each participant had to electronically sign a mandatory consent form confirming their understanding of the study's objectives, the voluntary nature of their participation, and the anonymous processing of their data. Additionally, participants were required to confirm that they were providing their responses for the first time to prevent duplicate entries.

### Data analysis

Responses to these online questionnaires were processed and analysed using the R statistical computing environment. Where response options were descriptive, frequency-based summaries have been presented. Where response options were categorical and compared across multiple factors, chi-squared analyses have been used where appropriate. Where cross-tabulation of two factors resulted in small numbers of individuals in some subgroups, p-values were computed by Monte Carlo simulation with 10,000 replicates. However, unless these differed from the results of the unadjusted analyses, the unadjusted values are reported for simplicity. Where responses provide continuous values,

or groups are compared on a continuous scale, t-tests have been used to compare group means or change.

### Results

A total of 540 responses were received including 348 (64.44%) reported females, and 190 (35.19%) males. In addition, 2 (0.35%) participants either preferred not to say or did not respond. This latter group have been classified 'Missing' for the purpose of these analyses. Participants were from 15 institutions including Qatar (Qatar University); Sudan (University of Khartoum, National University-Sudan; University of Medical Sciences and Technology, and Ahfad University for Women); Saudi Arabia (King Saud Bin Abdulaziz University for Health Sciences, Hail University, and Qassim University); Sweden (Karolinska Institute); United Kingdom (Imperial College London, Kings College London, St George's University, and University of Leicester); France (Sorbonne University Paris); and Jordan (Hashemite University). The number of participants by institution, in decreasing order, are summarised in Table 1.

Participants were at different stages of their education and included interns, and fresh graduates recorded as 'Graduate.' Individual integers [X] and 'Year [X]' were recoded as 'Stage [X];' and 'Type 7' was recoded to 'Stage 7'. The distributions of participants by Stage and Gender are shown in Table 2. The Stage did not vary significantly by Gender ( $\chi^2_{(9)} = 11.85, p = 0.222$ ).

### Resource usage

Types of resources used by Gender are shown in Fig. 1; the types of resources used did not differ by Gender ( $\chi^2_{(6)} = 6.76, p = 0.344$ ).

### Resource effectiveness

Of the resources used, of those ranked 1–5, average ranks are shown in Table 3. Not all resources appeared in all respondents' rankings, as some respondents did not allocate resources to all ranks, and some provided multiple rankings for the same resource. Table 3 therefore presents the mean of all ranks provided for each resource so as not to make any assumptions about response patterns that may unjustly exclude valid data. 'Overall' includes rankings from the small number of respondents who did not indicate their gender. While Digital Flashcards and Online Question Banks had comparable average ranks, the category 'None' had the highest average rank at 4.62, indicating it was perceived as less effective compared to the other resources listed. This pattern is comparable across genders.

**Table 1** Responses by institution

Institution	Number (N)	Percentage %
Qatar University, Qatar	275	50.93
King Saud bin Abdulaziz University Saudi Arabia	84	15.56
National University of Sudan	38	7.04
Hail University Saudi Arabia	36	6.67
University of Medical Sciences and Technology Sudan	25	4.63
Khartoum University, Sudan	24	4.44
Karolinska Institute, Sweden	22	4.07
Sorbonne University, France	8	1.48
Imperial College London UK	7	1.30
St George's University, UK	7	1.30
Ahfad University, Sudan	6	1.11
Hashemite University, Jordan	2	0.37
Missing	2	0.37
Qassim University, Saudi Arabia	2	0.37
Kings College London, UK	1	0.19
University of Leicester, UK	1	0.19

**Table 2** Distribution of participants by stage and gender

Stage	Female		Male		Total	
	N	%	n	%	n	%
Stage 1	57	16.38	31	16.32	88	16.36
Stage 2	74	21.26	28	14.74	102	18.96
Stage 3	95	27.30	57	30.00	152	28.25
Stage 4	53	15.23	28	14.74	81	15.06
Stage 5	32	9.20	15	7.89	47	8.74
Stage 6	29	8.33	25	13.16	54	10.04
Stage 7	3	0.86	4	2.11	7	1.30
Graduate	4	1.15	0	0.00	4	0.74
Intern	1	0.29	1	0.53	2	0.37
Missing	0	0.00	1	0.53	1	0.19

### Session interactivity

Responses to the question “Are online teaching and learning sessions interactive?” showed mixed perceptions depicted in Table 4. Around 31.48% of participants felt most online sessions were not interactive, while 30.93% found them interactive. Interactivity ratings did not differ by Gender ( $\chi^2_{(4)} = 2.68, p = 0.612$ ).

### Elements that enhance interactivity in online learning sessions

Responses to the question “What makes your online learning sessions interactive?” revealed various responses presented in Table 5. The findings indicated that online session interactivity was mainly driven by the ability to interact via chatbox (52.59%) and verbally (51.85%). Live

quizzes were also found to play a role (44.26%). Responses did not differ by Gender ( $\chi^2_{(5)} = 6.30, p = 0.278$ ).

### Adherence to a pre-set curriculum in online learning

As indicated in Table 6, the majority of respondents (53.15%) to the question “Does your online learning follow a pre-set curriculum?” indicated that their online learning followed a pre-set curriculum. Another 32.59% reported a mix of pre-set content and student requests.

### Average weekly hours of online teaching delivered by various institutions

The data on weekly online teaching hours are shown in Table 7 and showed that a sizable proportion (42.46%) of institutions provided no online teaching. However,

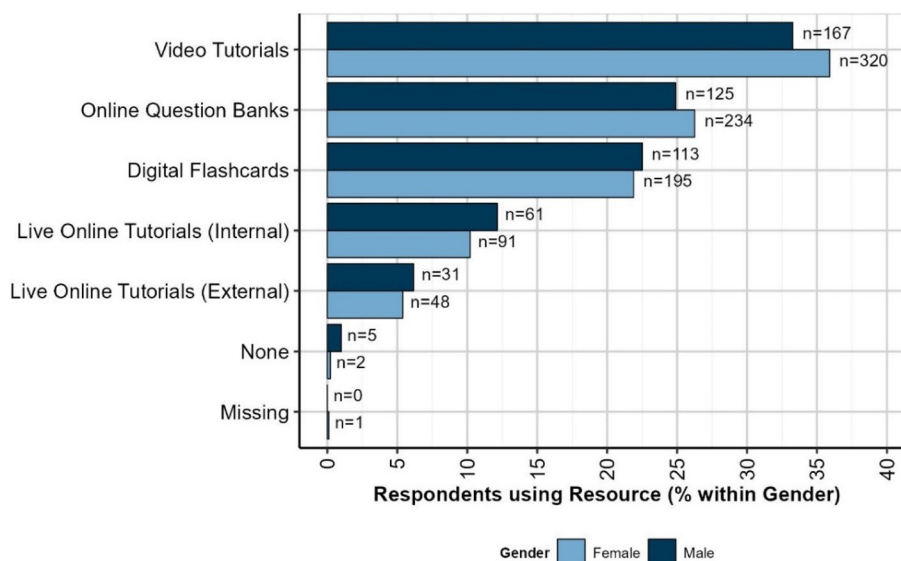


Fig. 1 Resource type usage by gender

Table 3 Mean resource effectiveness rankings

Resource	Mean Rank		
	Overall	Male	Female
Online Question Banks	3.46	3.60	3.51
Digital Flashcards	3.47	3.65	3.53
Video Tutorials	3.58	3.88	3.71
Live Online Tutorials (Internal)	3.80	4.03	3.88
None	4.62	4.77	4.80

Table 4 Session interactivity

Interactive	Number (n)	Percentage (%)
Majority are not interactive	170	31.48
Majority are interactive	167	30.93
Yes	100	18.52
No	89	16.48
Missing	14	2.59

26.26% delivered between 1–3 h per week, while 15.64% offered 4–6 h.

**Enjoyable aspects of online learning**

The most appreciated aspects of online learning included increased comfort (69.07%), flexibility (68.15%), and elimination of travel (66.11%). Additionally, the ability to learn at one’s own pace was valued by

Table 5 What makes sessions interactive?

Interactivity	Number (n)	Percentage (%)
Opportunity to interact via chatbox	284	52.59
Opportunity to interact via speech	280	51.85
Live quiz	239	44.26
Interaction during online teaching is difficult	153	28.33
Other	30	5.56
Missing	19	3.52

Table 6 The online curriculum

	Number (n)	Percentage (%)
Pre-Set	287	53.15
Part pre-set; part based on student requests	176	32.59
Based on student requests	48	8.89
[no response given]	29	5.37

Table 7 Weekly online hours

Hours	Number (n)	Percentage (%)
0	228	42.46
1	1	0.19
1–3	141	26.26
4–6	84	15.64
7–9	46	8.57
10 or more	37	6.89

**Table 8** Enjoyable aspects of online learning

Aspect	Number (n)	Percentage (%)
More comfortable	373	69.07
Flexibility	368	68.15
No travel	357	66.11
Ability to learn at own pace	342	63.33
Ability to ask questions	139	25.74
Interactive	101	18.70

63.33% of learners (Table 8). Responses did not differ by Gender ( $X^2_{(5)} = 2.87, p = 0.720$ ).

### Barriers to online learning

As shown in Table 9, the main barriers to online learning included issues with internet connection (57.96%) and family distractions (57.04%). Responses did not differ by Gender ( $X^2_{(6)} = 9.76, p = 0.135$ ).

### Impact of blended learning on clinical experience

When asked whether they thought online learning had replaced clinical learning experienced with direct patient contact, 69.26% ( $n = 374$ ) said No, 21.85% ( $n = 118$ ) said 'to some extent', and 8.15% ( $n = 44$ ) said 'Yes'. A small portion of participants (0.74%;  $n = 4$ ) did not respond. Responses did not differ by Gender ( $X^2_{(2)} = 3.31, p = 0.191$ ).

With respect to whether practical skills could be learnt through online teaching, 64.81% ( $n = 350$ ) said No, 25.00% ( $n = 135$ ) said 'to some extent', and 9.81% ( $n = 53$ ) said 'Yes'. Only two participants (0.38%) did not respond. Opinions differed statistically significantly, but mainly due to a change in Yes-No responses between genders; with 61.05%, 24.21%, and 14.74% of males, and 67.34%, 25.43%, and 7.23% of females responding 'No', 'to some extent', and 'Yes' respectively ( $X^2_{(2)} = 7.82, p = 0.020$ ).

**Table 9** Barriers to online learning

Barrier	Number (n)	Percentage (%)
Internet connection	313	57.96
Family distractions	308	57.04
Timing of tutorials	213	39.44
Lack of space	129	23.89
Lack of devices	84	15.56
Missing	24	4.44
Not Engaging	2	0.37

**Table 10** Assessment administration methods in the last year

	Method	n	%
Written	Face-to-face assessments	411	76.11
	Remote assessments	110	20.37
	Written assessments postponed	21	3.89
	Written assessments cancelled	12	2.22
Clinical	Face-to-face assessments	387	71.67
	Remote assessments	43	7.96
	Clinical assessments postponed	29	5.37
	Clinical assessments cancelled	13	2.41

### Administration of assessments in the last academic year

In the last academic year, the majority of written and clinical assessments were administered face-to-face (76.11% and 71.67%, respectively) (Table 10).

### Perceptions of online learning

Perceptions of online learning indicated that 51% of respondents felt that teachers were well prepared for online sessions, though 49% remained unsure or disagreed. There was a strong belief (66%) that online learning needs to be more interactive. In terms of effectiveness, only 27% viewed online learning as equally effective as face-to-face learning, while 56% disagreed, and 16% remained unsure. Internet connectivity was a significant challenge for 66% of learners. Although 40% found online learning stimulating, 38% did not. Enjoyment of online learning was reported by 45%, but 38% disagreed and 17% were unsure. A great deal of respondents (56%) felt well-prepared for their profession through online learning, and 64% were able to ask questions. Engagement with online sessions was easy for 40%, with 38% finding it challenging and 21% remained unsure (Fig. 2).

There were statistically significant differences in agreement between genders for all items except "I am able to ask questions", "the teachers are well prepared for online teaching sessions", and "I am being prepared well for my professions". The results are depicted in Fig. 3. Despite the statistical significance of the variation by gender, the pattern of responses is similar and the variation in agreement responses is small overall.

### Responses to open-ended questions

The first open-ended question related to the participants' preferred modes of teaching and learning: face-to-face, online, or blended. The highest preference was observed for blended learning with 47.78% ( $n = 258$ ; 88 male, 169 female) responses followed by face-to-face learning as indicated by 41.48% responses ( $n = 224$ ; 74 male,

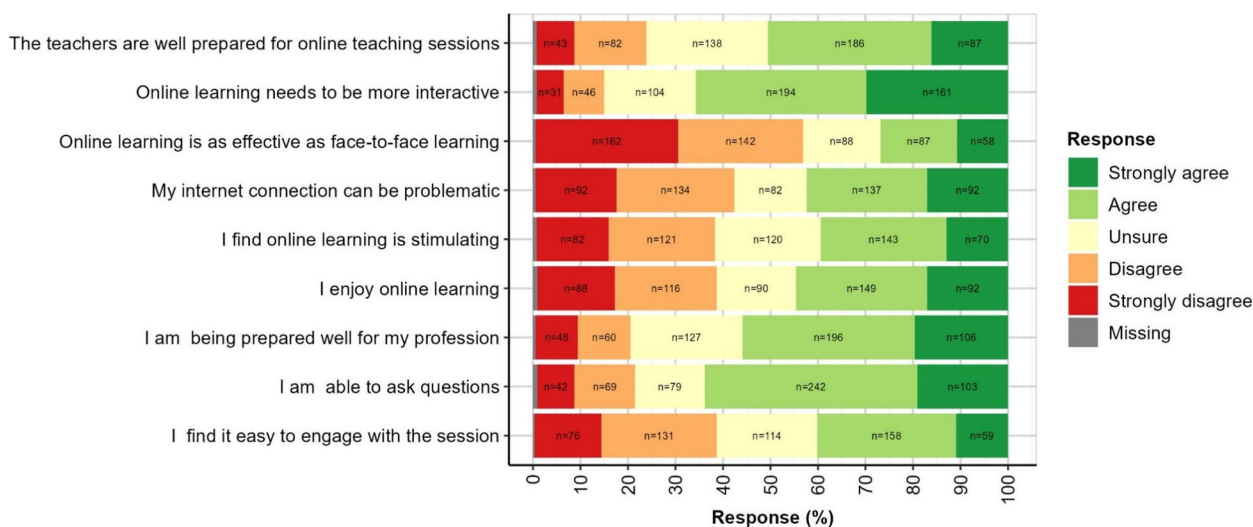


Fig. 2 Perceptions of online learning

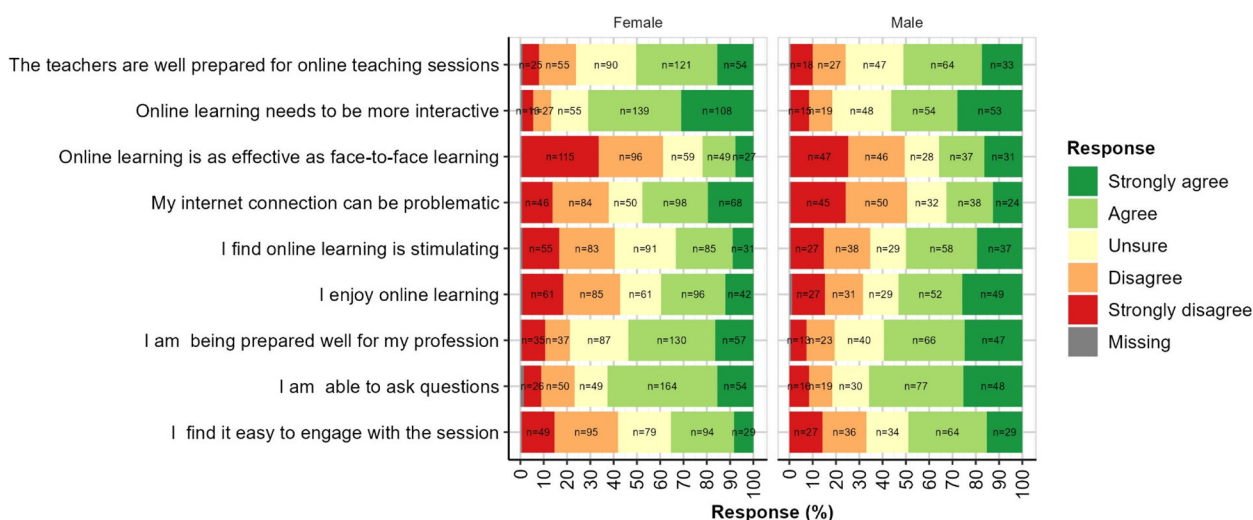


Fig. 3 Perceptions of online learning by gender

150 female). The participants across the board regarded face-to-face learning as the most appropriate method for clinical and practical skills. Online learning alone was the least favored method.

The second open-ended question was about the challenges of blended learning. The participants reported experiencing a variety of challenges, which are summarised in Table 11.

**Discussion**

The aim of our study was to explore the perceptions and experiences of undergraduate medical students regarding blended learning in medical education. This includes

an attempt to understand how blended learning has been received in educational settings across 15 institutions from seven countries (Qatar, Sudan, Saudi Arabia, Sweden, United Kingdom, France, and Jordan) in the context of the COVID-19 pandemic. The study also sought to analyze global trends in blended learning and compare pre- and post-pandemic educational landscapes, with an eye on future implications for medical education.

Overall, the findings of our study highlight potential benefits of blended learning and areas where it may fall short, from the perspectives of medical students. The study revealed that blended learning was generally preferred among respondents (47.78% preferred a blended

**Table 11** Challenges of blended learning

Theme	Sub-themes	Frequency*
I. Limited social interaction	<ul style="list-style-type: none"> <li>o Inadequate opportunities for interactions with teachers and peers</li> <li>o Limited time to ask questions</li> <li>o Difficult to stay engaged</li> <li>o Unsuitable for learning practical skills</li> <li>o Does not replace interactions with patients in clinical environment</li> </ul>	++++
II. Technical challenges	<ul style="list-style-type: none"> <li>o Internet connectivity</li> <li>o Quality of voice</li> <li>o Teachers may lack technical expertise to utilise the technology efficiently</li> </ul>	++++
III. Domestic distractions	<ul style="list-style-type: none"> <li>o Family distractions</li> <li>o Home environment not ideal to focus on learning activities</li> </ul>	+++
IV. Time management	<ul style="list-style-type: none"> <li>o Poor scheduling may adversely affect time management and student attendance</li> </ul>	++

Each + represents 10% participants

approach to learning while 41.48% favored face-to-face instruction). This aligns with previous literature where blended learning was valued for its flexibility, accessibility, and ability to combine the best elements of online and traditional face-to-face education [1, 10, 35].

The results also showed that while medical students appreciate the flexibility and convenience of online learning, traditional face-to-face learning still holds significant appeal, particularly for clinical training and practical skills. This is consistent with other studies that found a stronger preference for face-to-face learning, as students valued direct interactions with lecturers, group work, and peer engagement, all of which are perceived to be limited in blended learning environments [4, 23] also reported a preference for online learning among faculty members, whereas more than half of the students favored face-to-face learning. Notwithstanding the benefits of online learning, face-to-face learning may be more appropriate in certain educational contexts, particularly those involving practical skills. Similarly, Ruiz et al. [30] argues that while online learning components can enhance flexibility and access, they are often viewed as supplementary rather than a replacement for direct, experiential learning. The literature also converges on the fact that a stronger favorable stance towards online learning hinges on a developed digital infrastructure and well-prepared faculty [13, 33]. The mixed reception in this study suggests that the effectiveness and acceptance of blended learning are both highly context-dependent and may vary considerably based on local resources, faculty readiness, student demographics, and social environment [34].

There were gender differences in resource usage, albeit lacking statistical significance. Our observation is consistent with findings from Venkatesh et al. [34], who reported that male students demonstrated higher computer self-efficacy and hence overall greater satisfaction with blended learning. Participants used a range

of online resources, with online question banks, digital flashcards, and video tutorials receiving similar effectiveness rates, while live tutorials were less favored. This is consistent with findings from literature that reported the popularity of these resources in enhancing student learning [18, 20, 36, 37]. The lower preference for live online tutorials suggests that synchronous components may not be as valued, possibly due to technical difficulties or perceived lack of engagement. This in turn reinforces the need for careful planning and alignment of teaching and learning resources with student needs and learning outcomes.

Participants identified key barriers to effective online learning, including internet connectivity issues (57.96%), family distractions (57.04%), and inconvenient timing of tutorials (39.44%). They also reported that the lack of space, devices, and engagement hindered the success of blended learning. Similar challenges were reported by Aji et al. [1] where students and teachers experienced difficulties due to network issues. These technological limitations may undermine the potential benefits of blended learning. It is also important to note that geographical and socioeconomic factors may play a significant role in shaping the experiences and perceptions of blended learning including the reported challenges.

Interactivity in online teaching sessions was another area of mixed feedback; 31.48% of respondents found sessions lacking in interactivity, while 30.93% considered them interactive). Opportunities to interact via chatbox, speaking directly, and live quizzes were identified as key conducive elements for interactivity. Engagement during virtual sessions was a notable concern, mirroring in findings from other studies such as Ali et al. [2] where only 25.6% of students rated online sessions as sufficiently interactive. Zhang et al. [39] also observed that offline learning creates a more conducive environment for real-time interaction, which is often lacking in online settings.

This suggests the need for intentional design to enhance the interactivity of online learning.

A significant proportion of respondents (69.26%) felt online learning did not sufficiently replace clinical experiences involving direct patient contact, and 64.81% asserted that practical skills could not be effectively learned online. Atwa et al. [4] stated that while online learning can be useful for theoretical instruction, it falls short when it comes to clinical skills development, which requires direct, in-person interaction. This points to limitations in current blended learning models in that they complement traditional clinical training, but they may not fully replace the hands-on experience necessary to develop and master practical skills. Zhang et al. [39] also noted that online education, while flexible, cannot fully replicate the hands-on and interactive nature required for effective clinical teaching. A similar skepticism was expressed by educators who noted that teachers in blended learning environments frequently voiced doubts about the capability of online methods to match the learning outcomes of traditional face-to-face interactions [31].

When gauging participants' preferences and satisfaction levels with specific aspects of online learning, respondents appreciated the comfort (69.07%), flexibility (68.15%), and the elimination of travel (66.11%) but fewer found it engaging (18.70%) or stimulating (13%). This is corroborated by previous studies which showed that blended learning often lacks social elements, such as peer engagement and class involvement, aspects which are naturally embedded in face-to-face environments [23]. Consistent with our study, Atwa et al. [4] also found that both students and faculty members experienced significant limitations with online learning, especially regarding interaction and achieving intended learning outcomes. Aji et al. [1] also noted that students and teachers perceived challenges in maintaining interaction and engagement, suggesting that blended learning models must incorporate more social elements to enhance student experience. This was also mirrored in the study conducted by Shelly et al. [32] where students noted that e-learning platforms often lacked sufficient interactive elements and synchronization. Venkatesh et al. [34] also echoed this trend and reported that limited opportunities for social interaction in blended learning environments could lead to student frustration and a diminished sense of community. This common concern points to the need to design online learning experiences that are not only convenient but also highly engaging. Indeed, educational strategies must go beyond mere content.

The findings of the current study offer some important insights when viewed through the lens of constructivist learning theory. Online activities allow incorporation of

constructivist practices and with appropriate planning and delivery, educators can ensure that students not only achieve the ILOs but also engage meaningfully with the learning process. Our results suggest that online learning supports flexible, self-directed learning, which promotes autonomy, critical thinking, and deeper learning [8]. Tools like video tutorials and online question banks, perceived in our study as highly effective, have been previously shown to enhance understanding and accommodate different learning styles, paving the way for a more inclusive and learner-centered educational experience [16].

The lack of interactivity in online sessions could impact the alignment between intended learning outcomes and the instructional methods in blended environments as it may not sufficiently support the social constructivist aspects of learning provided by traditional peer engagement and face-to-face interaction. The same argument can be extended for blended learning falling short of replacing the experiential learning required to develop practical skills and clinical competencies. It is paramount that blended learning approaches enhance interaction and meaningful engagement for deeper learning as emphasized by Biggs' framework [9]. Constructive alignment between ILOs, teaching and learning activities, and assessments requires careful consideration of which elements can be achieved remotely and may need to be limited to didactic teaching, and knowledge-based assessments, and written assignments. Face-to-face learning environment is essential for learning and assessment of practical skills, and clinical experience with real patients.

This study also sheds light on shifts in perceptions and experiences of remote online learning in medical education between pre- and post-COVID-19 phases. Before the pandemic, blended learning was often seen as complementary approach to traditional education, with a potential to become a predominant model [10]. The onset of COVID-19 dictated a rapid shift towards online learning to comply with social distancing, which profoundly altered attitudes toward these models. According to a comprehensive bibliometric analysis, research on blended learning has surged in recent years, especially from 2019 onwards, due to the growing need for flexible and adaptive learning environments [33]. The mixed reception to blended learning from our participants highlights persistent reservations about online learning's effectiveness, particularly for clinical training in the post-pandemic landscape. Taken together, these findings suggest that there is a need for a balanced and contextualized approach that aligns with local contexts and infrastructural capabilities.

For medical educators, the successful and effective integration of online and face-to-face components

requires thoughtful design that employs evidence-based strategies in active learning environments. An example is the flipped classroom model where preparatory content is delivered online, which creates more opportunities for interactive activities with deeper learning during in-person sessions [38]. Educational institutions should prioritize training faculty, allocating sufficient resources, including technical support, and ascertaining technological readiness to support effective blended learning. The substantial barriers reported herein, including internet connectivity issues and lack of devices, suggest that equitable access to reliable digital infrastructure is crucial. Our findings could also help in shaping future educational policies by putting more emphasis on flexible curriculum design that adapts to different learning styles and environments. Policies should also support collaborative networks among institutions to share best practices and resources.

A key strength of this study is that it offers a broad, multi-institutional perspective on blended learning in medical education, with data drawn from multiple geographic regions, including Europe, the Middle East, and Africa. This element enhances the generalizability of the findings and their relevance across different contexts. The study also offers an opportunity to understand the shifts in perceptions and adaptations of blended learning in response to global crises.

However, several challenges and limitations warrant acknowledgment. First, the use of convenience sampling introduces the risk of sampling bias. Participants were selected based on accessibility and their availability rather than adopting a randomized sampling approach, which could impact the representativeness and generalizability of the findings across broader populations. The scope of the study was limited to specific institutions, potentially overlooking other variations and adaptations in blended learning experiences in other parts of the world. This limited focus may reduce the applicability of the findings to global settings. The reported levels of engagement, satisfaction, or challenges with remote online learning were analyzed from self-reported data, which could skew the collated perceptions given the potential of overestimation or underestimation. This aspect could impact the reliability and accuracy of the data, particularly in areas where there is a social desirability bias. It is also noteworthy that, while the study provides key cross-sectional insights, it does not capture the longitudinal impact of blended learning on educational outcomes.

Future research can effectively build on our findings by conducting longitudinal studies that track the medium- and long-term effects of remote online learning. Moreover, data collection tools which encompass learner experiences in both face-to-face and remote

online learning more comprehensively should be used. This will help in gaining deeper insights into how sustained exposure to blended learning environments affects student performance and levels of engagement and interaction. Such studies will also help in guiding interventions to maximize the long-term benefits and overcome the identified barriers. Qualitative studies that explore both student and faculty perceptions and experiences in-depth could offer valuable perspectives that complement the cross-sectional survey approach, particularly when investigating the specific challenges and opportunities to enhance the effectiveness of blended learning environments. To advance the global applicability and scalability of blended learning, we recommend conducting studies on specific populations or regions that were not included in the current study. This will help educators, institutions, and policymakers to identify more relevant best practices and design contextualized blended learning frameworks.

## Conclusions

This study provides critical perspectives on the perceptions and experiences of undergraduate medical students regarding blended learning in medical education across multiple institutions from different countries with varying educational contexts. Blended learning offers marked benefits including flexibility, accessibility, and versatility through integrating diverse teaching modalities.

It is important to stress that the effectiveness of blended learning remains highly context dependent. The findings of this study show that blended learning cannot fully replace face-to-face interactions and hands-on experiences essential for clinical training and developing professional competences.

Barriers to the effective adoption of blended learning include insufficient digital infrastructure, limited interactivity, and low engagement. These call for a strategic, evidence-based approach that prioritizes a balanced integration of online and face-to-face components, and which considers both local contexts and global best practices. Future research should prioritize longitudinal studies to assess the sustained impact of blended learning and explore further region-specific adaptations that will shape the future of medical education.

## Abbreviations

COVID-19	Coronavirus Disease 2019
ILO	Intended Learning Outcome
IRB	Institutional Review Board
QU	Qatar University
SPSS	Statistical Package for the Social Sciences
UK	United Kingdom
WHO	World Health Organization

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**Declaration of generative AI in scientific writing**

Generative AI was not used for any aspect of this study including drafting of the manuscript.

**Authors' contributions**

MSA contributed to study conceptualization, data collection, and drafting the manuscript. AS contributed to data collection and drafting the introduction and discussion. DZ analyzed the data. SA contributed to data collection and drafting the introduction. RS, AN, NS, AS, KA, SB, OA, RB, and EM contributed to data collection. KA conceptualized the study, developed the methodology, and contributed to editing the manuscript. All authors reviewed the manuscript.

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**Data availability**

The data underlying this article will be shared on reasonable request to the corresponding author.

**Declarations****Ethics approval and consent to participate**

This study was conducted in compliance with the ethical principles outlined in the declaration of Helsinki for research involving humans, including research on identifiable human material and data. Ethical approval was obtained from the Institutional Review Board at Qatar University (Reference number: QU-IRB 1614-E/21). Participation in the study was voluntary and all participants provided an informed consent prior to their participation in the study.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declare no competing interests.

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