Evaluating Online Learning Environment for Medical Students Using Digi-MEE Instrument: A Sequential Mixed-Method Study

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In light of the increasing use of online learning platforms in medical education, there is a critical need to assess the current state of online learning environments. Despite the global emphasis on digital education, limited studies have systematically explored how medical students perceive the effectiveness and quality of these environments, particularly in Pakistan. This study aims to fill this gap by evaluating medical students' experiences with their institution's online learning environments and identifying key strengths and challenges that impact learning outcomes.

A mixed-method, sequential exploratory design was used, starting with a quantitative assessment followed by qualitative inquiry. Data from 253 medical students were collected via a survey, and 30 focus group interviews were conducted to provide deeper insights into the challenges students face in navigating the online learning environment. The findings revealed critical areas in need of improvement, including digital infrastructure, student engagement, and the accessibility of online resources. Qualitative data highlighted the need for more interactive and student-centred approaches to online education.

By focusing on the status of online learning in medical education, this research provides valuable insights for educators and policymakers aiming to enhance the quality of digital learning environments. The study contributes to ongoing efforts to develop more effective, engaging, and responsive online learning strategies for medical students in Pakistan.

Keywords: *Online learning, Undergraduate Medical Education, Learning environment, Digi-MEE, Perception.*

Introduction

E-learning has emerged as a powerful tool that can provide students with access to valuable resources, such as video lectures and data analytics tools, while also allowing for greater collaboration among peers and educators through online discussion forums and virtual meetings (Bower, 2019). Additionally, e-learning has been shown to improve learner engagement by providing more interactive learning experiences than traditional classroom-based methods alone (Rhim & Han, 2020). The rapid integration of online learning into academic practices across undergraduate, postgraduate, and continuing medical education (CME) has fundamentally reshaped educational delivery, particularly in medical fields.

Despite its advantages, the transition from traditional to online learning presents challenges, burdening clinicians and facing user reservations. Medical students and educators face obstacles that include inconsistent internet access, feelings of physical and social isolation, and the loss of critical integrated bedside teaching. Additionally, digital literacy remains a barrier for both students and educators, hindering the full adoption of e-learning (Tekin *et al*, 2020). Research highlights the importance of connectedness and face-to-face interactions to ensure student well-being (Kamarudin *et al*, 2022; S E Mustafa & Hamzah, 2011). Many students report that the lack of personal interaction is a substantial barrier to fully embracing online learning as a standalone pedagogical approach (Azmat & Ahmad, 2022).

Current research often focuses on the impact of rapid e-learning policies during the pandemic, examining student perceptions of online learning's

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educational benefits and its implementation during lockdowns (Azmat & Ahmad, 2022; Suci *et al*, 2022). Although these studies have generally reported positive student feedback, the methodologies used to evaluate online learning environments are frequently limited. Commonly used educational tools, such as the DREEM, and other discipline-specific tools like the Anatomy Education Environment Measurement Inventory offer context-dependent insights that may not fully capture the diverse and evolving nature of online learning in medical education (Hadie *et al*, 2017; Rehman *et al*, 2017).

The need to evaluate the overall status of online learning environments has become increasingly urgent. As medical education continues to evolve in a digital context, it is essential to assess not only the technical and instructional aspects of online learning but also its impact on students' digital professionalism, ethics, behaviours, and well-being. A comprehensive understanding of these factors can inform future improvements and support the development of more responsive, student-centred digital learning strategies.

To address these gaps, this mixed-method study explores medical students' perceptions of their institution's online learning environment. By combining a quantitative assessment with qualitative inquiry, this research aims to provide a holistic understanding of the factors that influence student perceptions and identify areas for improvement. The use of both data-driven insights and personal reflections from students allows for a nuanced evaluation of the strengths and challenges of the current online learning environment in medical education.

Curriculum structure of MBBS programme of the Participating Institution

To provide a comprehensive understanding of the curriculum delivery method at the institution under study, we outline the structure of the MBBS programme over five years, emphasising the significance of this understanding in evaluating digital tools like the Digi-MEE instrument. The MBBS curriculum follows an integrated approach, structured into three key phases: the pre-clinical phase (Years 1 and 2), the para-clinical phase (Years 3 and 4), and the clinical phase (Year 5). The pre-clinical years focus primarily on basic medical sciences such as anatomy, physiology, and biochemistry, utilising a combination of traditional lectures, lab-based learning, and introductory problem-based learning sessions. During this period, digital resources, including online lecture recordings, digital anatomy platforms, and quizzes, are introduced to enhance theoretical understanding and foundational knowledge.

As students progress to the para-clinical years, the curriculum emphasises the integration of clinical skills with theoretical knowledge. This includes a blend of case-based discussions, clinical skill sessions, and small group tutorials. Digital learning tools become more interactive, with online modules, case-based assessments, and self-assessment tools introduced to supplement in-person training. By Year 5, students are primarily engaged in clinical rotations across various departments, focusing on the practical application of their medical knowledge. Here, e-learning supports case-based learning, clinical scenario discussions, and research activities.

The curriculum's integration of digital learning tools is tailored to complement the evolving needs of

students at different stages of their medical training. In the pre-clinical years, digital platforms primarily support theoretical learning, while in the clinical years, they facilitate case-based discussions and patient management exercises. This phased approach to curriculum delivery offers valuable context for interpreting the findings of this study, as it highlights the alignment of digital tools with the specific learning requirements and skill development of students at each stage of their education.

Methodology

A sequential explanatory mixed method study was initiated after obtaining ethical approval from the Human Research Ethics Committee at University Sains Malaysia (USM/JEPeM/ 21050350) and from the Institutional Review Board of the participating institution (ERC 122/22/10) from January to July 2023. To maintain the confidentiality and privacy of the institution involved in the study, the specific name of the university is not disclosed. The medical curriculum at the selected institution primarily consists of in-person lectures, clinical rotations, and lab sessions. To supplement these traditional methods, an online learning component was introduced, offering lecture recordings, virtual discussions, and digital resources. While participation in online learning was generally encouraged, certain elements, such as virtual discussions and assignment submissions, were mandatory. This supplemental approach provides greater flexibility and accessibility to course materials beyond regular classroom hours.

In a cross-sectional survey, we invited 294 undergraduate medical students from the private medical university in Pakistan regarding their institution's online learning environment. Sample size was determined based on the total number of medical students eligible for the study (600). Using a 95% confidence interval and a 5% margin of error, a minimum sample size of 235 was calculated, following Krejcie & Morgan's (1970) guidelines. Accounting for an expected response rate of 80% (Fincham, 2008), the final target sample size was adjusted to 294 medical students. Inclusion criteria included undergraduate medical students with at least six months of online education in the university. New admissions or transfer students from other institutions were excluded from the study.

The study proforma included a section inquiring about the demographic data of the participants as well as the Digital Medical Education Environment (Digi-MEE) instrument. Serving as a validated instrument, Digi-MEE is designed to comprehensively evaluate and enhance online learning in the domain of undergraduate medical education. The Digi-MEE instrument is a 28-item questionnaire with a content validity index and face validity index of > 0.90 and 0.87, respectively, along with acceptable levels of the goodness of fit indices and overall Cronbach's alpha >0.90 (N-K Naeem, Hadie, *et al*, 2023). It covers the nine identified main domains of online learning environments (Content Curation, Cognitive Enhancement, Cybergogical Practices, Digital Capability, Social Representations, Platform Usability, Institutional Support, Facilitation Dynamics, and Learner Characteristics) (N-K Naeem, Yusoff, *et al*, 2023). Each of the 28 items has a rating of 1 – 4 on a Likert scale where 1 = "*strongly disagree*" and 4 = "*strongly agree*". Items rated 3 or more out of 4 are positive areas in online learning environments as rated by students, items rated 2–2.9 depict satisfactory

areas with minor improvement, and items rated <2 depict areas of concern in the online learning environment.

The participants were requested to fill out the form via online Google form after debriefing and taking informed consent (link: https://forms.gle/ZPL4qnN6Dxxkqo389). All data was kept anonymous and confidential.

Following the survey, we did five online focus group interviews using the Zoom platform (with six volunteer medical students from each MBBS class) with semi-structured questions to understand their experience and perceptions regarding the online learning environment in their institution. Probing techniques or prompts facilitated us in eliciting participants' reflections and discussions, especially in instances where there was a lack of sufficient dialogue. The initial questions were piloted on two participants and were refined to develop final questions as shown in Figure I.

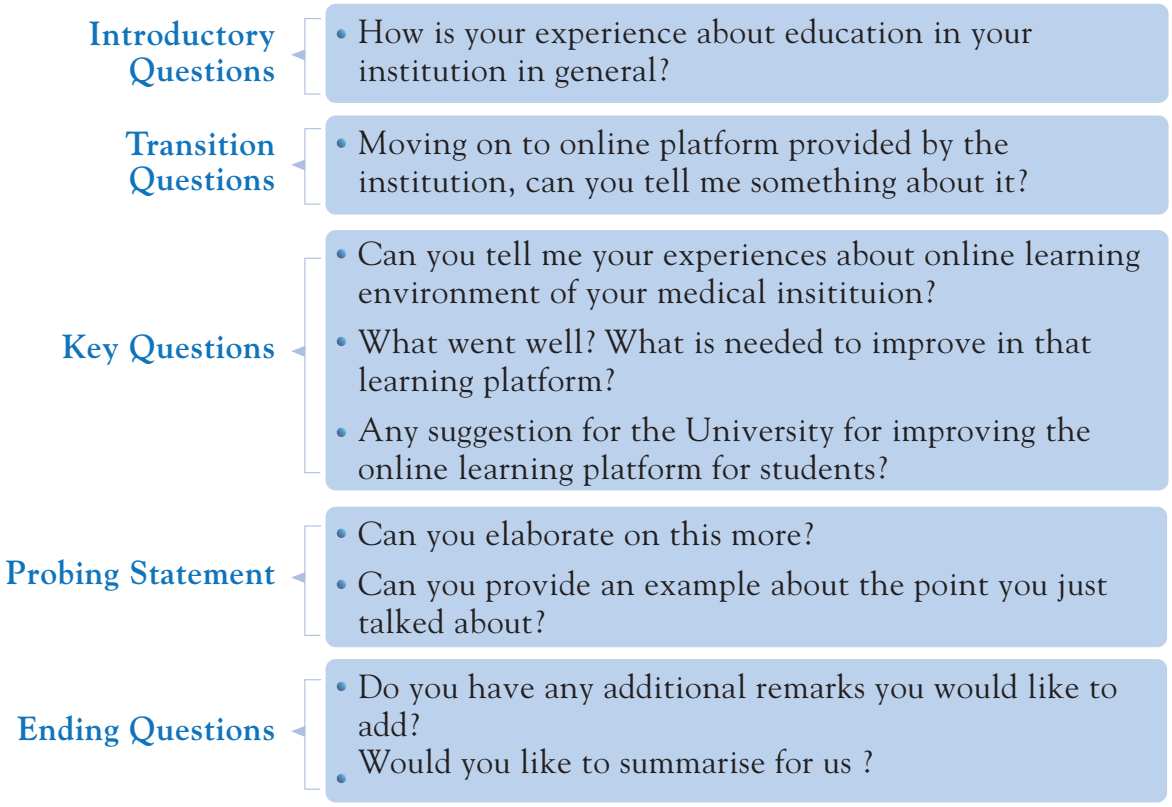

Figure I: Focus group interview questions

We performed descriptive statistical analysis for the cross-sectional survey using SPSS version 25.0 (IBM Corp, Armonk, NY, USA). Missing values were identified and addressed by replacing them with the median of the corresponding variable. All continuous data are presented as the mean ± SD, whereas categorical data are presented as proportions and percentages. The mean perceived expertise was calculated by averaging the scores assigned by participants to various statements related to their proficiency in using online platforms for education from a scale, ranging from 1 to 10.

Thematic analysis using Atlas.ti version 7.5.7 (Atlasti GmbH, Berlin, Germany), following Braun and Clarke's approach (Braun *et al*, 2019) with a- priori coding based on the components of the validated Digi-MEE instrument, involved a systematic process. Initial codes were generated based on pre-determined components, providing a structured foundation. Codes were collated into potential themes, considering both predefined components and emergent patterns by two independent researchers. This iterative process ensured an accurate representation of participants' perspectives. Intercoder reliability was performed to check the credibility and accurate representation of the data analysed (Kappa Index = 0.86). Atlas.ti facilitated systematic organisation and retrieval, enhancing analysis rigor and transparency. This approach allowed for a comprehensive exploration of predefined components while remaining open to the richness of participants' experiences.

Data from both the cross-sectional survey and focus group interviews were reviewed and combined to obtain a comprehensive understanding of the participants' perceptions of online learning environments in their medical school. The focus group interview findings also explained the results of the cross-sectional survey, giving a rich description of the participants' perspectives.

Results

Cross-Sectional Survey:

a. Demographic characteristics of the study participants:

Out of 294 medical students, 253 medical students completed the online survey questionnaire, yielding an overall response rate of 86.05% (See Table I). The mean age of the study participants was 22 ± 1.88 years. Fourth year MBBS students were 21.4% of the participants (highest proportion), while second year MBBS students were 18.5% of the total number (least proportion).

Table I: Demographic characteristics of study participants in the cross-sectional survey

DEMOGRAPHIC CHARACTERISTICS	STUDY PARTICIPANTS (n=253)	PERCENTAGE (%)
Gender		
Male	124	49
Female	129	51

Table I: Demographic characteristics of study participants in the cross-sectional survey

Age		
18- 20 years	59	23.3
21-23 years	141	55.7
24- 26 years	50	19.8
>26 years	3	1.2
MBBS Year		
1st Year	53	21.0
2nd Year	47	18.5
3rd Year	48	18.9
4th Year	54	21.4
Final Year	51	20.2

b. Perceived online learning expertise rating:

Participants rated their expertise in online learning on a scale of zero to 10. Two students rated their expertise to be 2 out of 10. The mean perceived expertise for using online platforms for education was 7.48 ± 1.93. As seen from Figure II, 49 students rated their expertise to be 7, 8 and 10 each, followed by 34 students rating their expertise 9 out of 10.

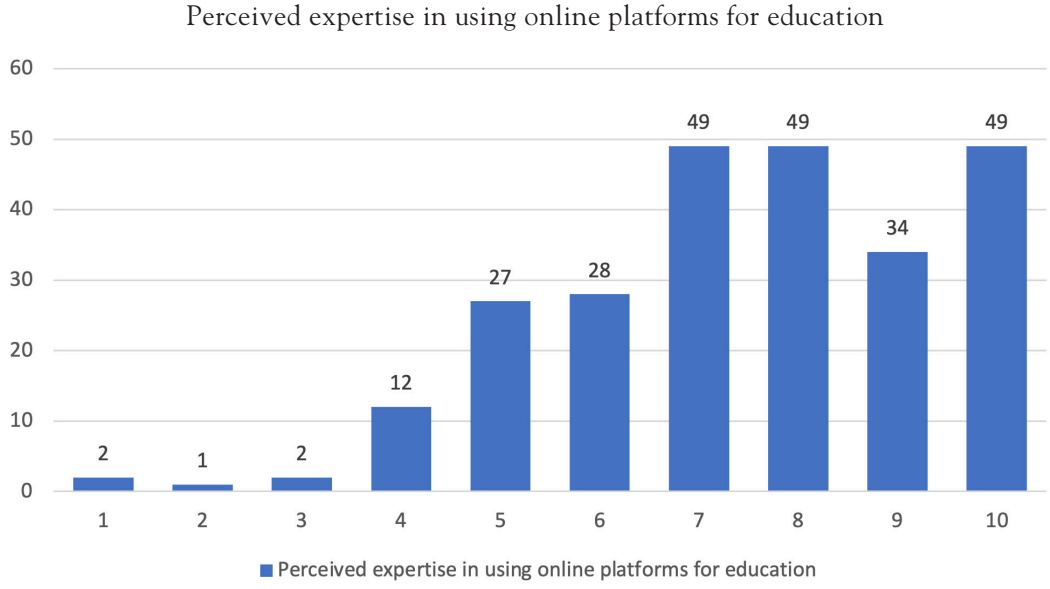

Figure II: Perceived expertise in using online platforms for education

c. Participants' item ratings using the Digi-MEE instrument:

Mean ratings for participants for their online learning environment in their institution are listed in Table II. Participants rated statement number 20, "*The online platform rules and regulations are informed to me*", the most from Component of "Platform Usability" (Mean ± SD = 3.13 ± 0.804), while statement number 12, "*I can manage my digital screen time on online learning platform*", was rated the least from the component of "Digital Capability" (Mean ± SD = 2.53 ± 0.967).

Table II: Mean individual item ratings by students using Digi-MEE Instrument

ITEM NUMBER	ITEM STATEMENT	Mean	SD
1	I feel this online platform being relevant to my learning needs.	3.01	.812
2	The online platform provides opportunities to promote my independent learning.	3.00	.861
3	The content is presented appropriately to enhance my understanding.	2.91	.854
4	I understand the orientation given before the task easily.	2.92	.869
5	The online learning platform provide clear learning outcomes for the given course I am enrolled in.	2.99	.852
6	My online activities with others are monitored in this online learning platform.	2.81	.918
7	The online platform allows me to exchange information with my peers/facilitators easily.	2.75	.957
8	The activities on online platform allow me to interact with others.	2.58	1.033
9	This online platform provides suitable assessment methods to facilitate my learning.	2.85	.942
10	I can communicate and collaborate with my peers/facilitators on this online platform easily.	2.66	.969
11	I can see my basic profile information, as well as that of my peers/facilitators on this online platform.	2.89	.872
12	I can manage my digital screen time on online learning platform.	2.53	.967
13	I feel I am part of online learning community.	2.72	.953
14	I am provided with timely feedback on my work.	2.75	.975

15	I give feedback about courses which I am enrolled in online learning platforms.	3.04	.856
16	The online platform encourages me to participate in online learning activities in professional and ethical manner.	2.79	.921
17	The online content can be accessed with ease.	3.12	.800
18	The platform interface is simple and follows a consistent design.	3.04	.833
19	The online platform usage policies are widely disseminated among students.	2.91	.857
20	The online platform rules and regulations are informed to me.	3.13	.804
21	The institution provides training to me for using online platforms appropriately.	3.01	.908
22	The online content is organised in engaging manner.	2.92	.880
23	The facilitator(s) selects appropriate tool for teaching us online.	3.04	.851
24	The facilitator(s) provides positive encouragement to me during classes.	2.94	.810
25	I show interest in learning about given topic in online learning platform.	2.84	.896
26	My learning is supported on this online learning platform.	2.88	.892
27	I try my best to put in effort during online activities.	3.02	.850
28	The online platform for learning is well accepted by me.	2.82	.938

d. Detailed Breakdown of Component wise Mean Ratings:

Figure III shows the mean ratings of the nine main components of online learning environments as identified in the Digi-MEE instrument. The Component of Platform Usability was rated the highest (3.07/4/00), while overall, students rated "Cybergogical Practices" the lowest (2.68/4/00).

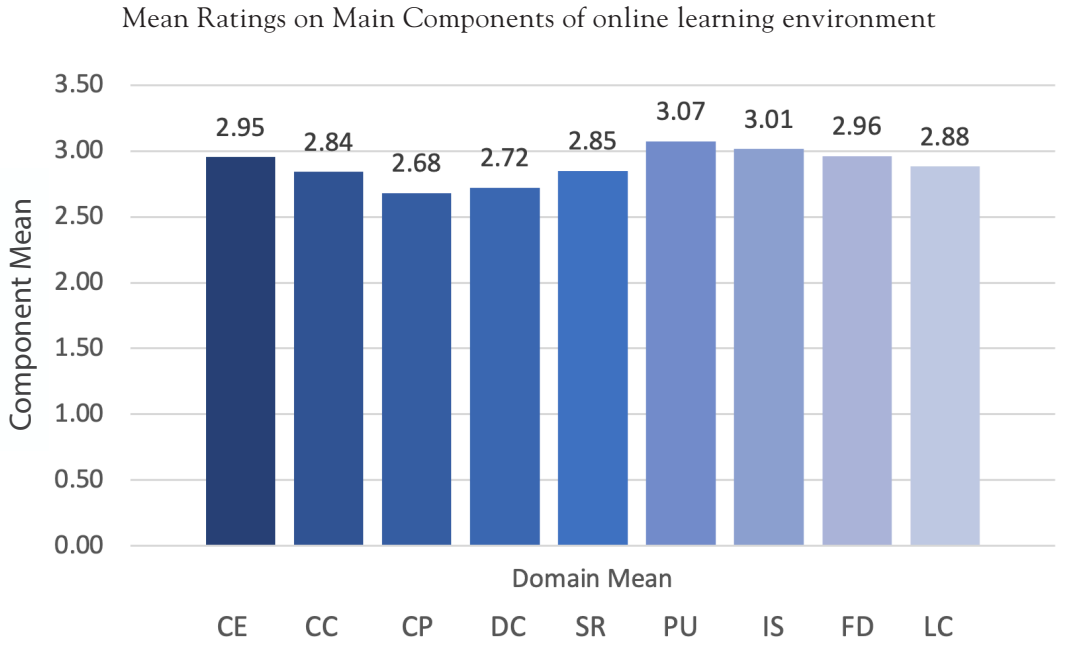

Figure III: Component wise mean ratings using the Digi-MEE instrument

KEY: CC: Content Curation, **CE:** Cognitive Enhancement, **CP:** Cybergogical Practices, **DC:** Digital Capability, **SR:** Social Representations, **PU:** Platform Usability, **IS:** Institutional Support, **FD:** Facilitation Dynamics, **LC:** Learner Characteristics

Focus Group Interviews

b. Demographic characteristics of the study participants in each group.

A total of 30 participants participated in five focus groups (one each for each of the five MBBS classes with six participants each) over the online meetings after checking the availability of the participants. Table III shows the demographic distribution of participants in the focus group interviews.

Table III: Demographic characteristics of study participants in focus group interviews

Demographic Characteristics	1st Year MBBS (n=6)	2nd Year MBBS (n=6)	3rd Year MBBS (n=6)	4th Year MBBS (n=6)	5th Year MBBS (n=6)
Gender					
Male	2	3	3	4	3
Female	4	3	3	2	3
Age					
18-19 years	4	-	-	-	-
20-21 years	2	6	-	-	-
22-23 years	-	-	5	1	-
23-24 years	-	-	1	5	5
25 years or more	-	-	-	-	1

c. Thematic analysis

Students expressed a positive outlook about their learning experience in the institution which was being used to complement their traditional mode of studies. They highlighted the optimised environment, good study experiences, and well-organised materials. The teachers and faculty were generally appreciated for their efforts. Table IV displays emerging codes for each of the nine domains of online learning environment highlighting the positive areas and areas needing improvement.

Table IV: Thematic analysis results of focus group interview sessions

Component	Participant Code	Code	Representative Quotations
Content Curation	M.1.3	Content Quality	*"The content is good… the majority of the content that is uploaded slides… Learning objectives are covered greatly."*
	M1.1	Ease of Access	*"…having the slides where I can open them at any laptop or phone… it is truly great in building your concepts…"*
Cognitive Enhancement	M.2.3	Minimal engagement	*"We have a sense, to download slides from there as well. In the first year, a physiology teacher offered a quiz there. She made a platform there. We can answer these questions. It was interactive. Otherwise, we don't use it that much."*
Cybergogical Practices	M.1.4	Lack of engaging practices	*"The engagement is not as much as offline learning… adding quizzes would engage students more."*
	M.3.5	Lack of interaction	*"We don't have a lot of activities on slate, it is more so used as a collection of learning material for revision… real-world application examples of what we've learned like case studies would be good interactive activities."*
Learner Characteristics	M.1.1	Need for self-regulation	*"Face-to-face lectures are much better than online classes if you don't develop interest. So, the problem is within the student to develop an interest in online learning."*
	M.2.6	Need for determination	*"You should be very focused and willing to learn whatever you are taught. I guess that's important."*
Digital Capability	M3.1	Digital skills training	*"I feel I have the proper skills and proficiency to take full advantage of all online learning tools provided… be given an overview of how to use it and what we are expected to use it for."*
	M.1.2	Lack of anonymity	*"I think most likely students that are at our level most probably have good digital capabilities… there should be a box where students could ask questions anonymously."*

Platform Usability	M.1.4	Limited personalised feedback	*"There should be a platform for a detailed marked sheet of all the work you have done throughout the year… only visible to that one student."*
	M.2.5	Need for enhanced question banks	*"I guess they should provide the question bank and also the summary of what type of questions. Papers with answers so that you can practice."*
Facilitation Dynamics	M.3.4	Good content organization	*"Facilitators are mostly performing their role fine, but sometimes they upload lecture slides late, the material is indexed properly and kept in a structured way to make it accessible easily, but we should be given an overview of how to use it and what we are expected to use it for." "Teachers should ask questions and give quizzes so that students remain attentive."*
	M.1.6	Limited interactions	
Social Representations	M.1.5	Limited communication	*"There should be a separate platform for contacting and interacting with your teachers… apart from Moodle, while you are away from college."*
	M.2.4	Lack of training to use the platform for interaction	*"On Moodle, we have the opportunity to text our teachers. I think we can mail them, but I don't know how to approach our teachers and friends because we haven't had much experience using it."*
Institutional Support	M.1.4	Need for switching to application	*"A special app can be introduced via slides and other information can be put up rather than a website… students in Pakistan are using mobile."*
	M.2.4	Lack of training	*"I think, we don't have much knowledge about Moodle because our university hasn't trained us in that way, like how to use it and what we can do."*

Discussion

This study sought to evaluate the online learning environment at a private medical university in Pakistan, focusing on the students' perceptions across different academic years. The findings reveal that while students generally rated their digital capabilities and platform usability positively, significant challenges remain, particularly in terms of social interaction and institutional support. In alignment with a Kirkpatrick Level 1 evaluation, the study assesses students' initial reactions to their educational experience (Sridharan & Nakaima, 2011).

Cross-Sectional Survey

When placed within the context of the five-year MBBS curriculum at the institution under study, the study's findings highlight the evolving demands of each academic phase on digital learning tools. The MBBS programme is structured into three phases – pre-clinical, para-clinical, and clinical – each demanding different levels of digital integration. In the pre-clinical years, students primarily focus on acquiring foundational knowledge in basic sciences through lecture-based and lab-based learning. Here, digital tools are leveraged to complement traditional

teaching with recorded lectures, online quizzes, and digital anatomy modules, facilitating independent study and reinforcing theoretical concepts. This approach aligns with the study's findings, where students rated their perceived expertise in using online platforms for education at 7.48 ± 1.93 out of 10. This perception echoes results from other institutions like Dubai Medical College, where 70% of students reported no difficulty accessing online learning systems (Eldeeb, 2014).

As students progress into the para-clinical and clinical phases, the curriculum at UCMD emphasises the integration of clinical skills with theoretical knowledge through small-group discussions, case-based learning, and clinical rotations. The increasing complexity of training at these stages correlates with the study's findings that revealed a drop in student satisfaction with platform interactivity. For instance, statement number 8 in the Digi-MEE tool, related to peer interaction, was rated low by students. These observations align with previous research highlighting social isolation as a key drawback in e-learning environments (Back *et al*, 2016). To address this challenge, the study recommends enhancing interactive components such as scenario-based learning, quizzes, and case-based discussions to foster cognitive engagement and collaboration among students.

Similarly, when asked about the important characteristics of online learning that make it more conducive to learning, 92.5% of students involved in another study concluded that ease of use and subsequent acquisition of usage expertise were some of its most supporting aspects (Back *et al*, 2016). In contrast, a systematic review shed light on several papers raising technological or IT-based concerns, as many learners are not fully equipped with the expertise to handle e-learning methods, as foundational technological skills remain lacking due to several sociocultural factors (Docherty & Sandhu, 2006; Khasawneh *et al*, 2016; N Naeem & Khan, 2019). However, the relation of perceived technical expertise with perceived knowledge acquired was a gray area. A 76-participant study by Song et al. pointed out that comfortableness with and expertise over online technologies significantly impacted the overall success of online education (Song *et al*, 2004). Stein *et al*, concluded in their study aimed at bridging the transactional gap in online learning that technical expertise had no effect on overall satisfaction and knowledge perceived (Stein *et al*, 2010).

Statement number 8, "*The activities on the online platform allow me to interact with others*", was rated low on the Digi-MEE tool. A study employing another online learning evaluation tool, "DREEM", concluded that although students were generally satisfied with the environment in different domains, social self-perception was negatively based on the lack of opportunities to develop interpersonal skills (Al-Naggar *et al*, 2014). Our results suggested that students in earlier years of the medical programme were more likely to report challenges related to social isolation and a lack of interaction, as reflected in low ratings for the "interactivity" component of the Digi-MEE tool. Built on exploring the advantages and disadvantages of distance learning, one study revealed that 44% of junior medical students (years 1-3) and 35% of senior medical students (years 4-6) believed social isolation to be a major drawback of e-learning, which was considered less effective in terms of increasing social competencies (Bączek *et al*, 2021).

An overwhelming 70% of first-year medical students in a similar Indian study felt that their online teaching programmes are indeed greatly beneficial, whereas 45% of students in the same study felt the lack of social interaction and inability to meet peers online was greatly challenging (Ramachandran & Kumar, 2021). Thus, the study concluded in favor of the widely accepted view that e-learning has very much the capacity to be detrimental towards development of social skills. This gave the researchers a perspective to focus on recommendations made via the Digi-MEE component of social representation, mainly to encourage student participation and create a separate platform outside Moodle for mutual interaction.

The study data provided strong evidence to conclude that the mean ratings of different years of undergraduate medical education were not equal, supporting the idea that there were notable variations in the ratings among the different MBBS classes as measured by the Digi MEE instrument. A DREEM study conducted to see the Malaysian medical students' perception of their e-learning environment showed significant differences in scores depending upon the year of study (Al-Naggar *et al*, 2014). Differences in the perceived disadvantages of online learning models by a group of Polish medical students were highlighted by the academic years, as students in the first three years more often chose social isolation, lack of technological expertise and self-discipline, whereas senior students in years 4–6 more often chose lack of interaction with patients as the most pressing obstacle (Bączek *et al*, 2021). At the University of Sharjah, senior students were found to have better perceptions of online learning as a pedagogical model compared to sophomores, who found hybrid learning to be more ideal (Osaili *et al*, 2023).

Qualitative Exploratory Study

Qualitative findings further underscore the need to align digital learning strategies with the curriculum's evolving demands. Senior students, who engage heavily in clinical rotations, expressed the necessity for communication tools that support case discussions and collaborative decision-making. This reflects a gap in the current digital environment, where the mere delivery of lectures is deemed insufficient. Consistent with these insights, previous studies have emphasised the importance of feedback, interactive assessments, and structured support systems to enhance learning outcomes (AlFaris *et al*, 2014).

The study also points to significant variations in the perception of the digital learning environment across different academic years, suggesting the need for a tailored approach. Senior students rated platform usability and digital capabilities more positively than their junior counterparts, who reported challenges related to the lack of social interaction and unfamiliarity with digital tools. This variation mirrors the findings of a DREEM study conducted in Malaysia, which showed differences in e-learning perceptions based on students' academic progression (Al-Naggar *et al*, 2014). In the current case study, this indicates the importance of introducing targeted interventions, such as specialised training on digital platforms in the early years and advanced modules on collaborative learning and clinical case discussions in the later years.

Participants also recommended the integration of interactive sessions, scenario-based assessments, and improved facilitation dynamics to enhance cognitive engagement, supporting the need for more active learning strategies in online environments. A literature review states that e-learning methods that are less

interactive are less favourable and that their success is more likely when social interaction, communication and need assessment are prioritised (Cook & Steinert, 2013). The term "interactive sessions" is rather vague and can receive more definition from a new and promising method called "gamification", in which game design elements are used in a nongame context, allowing students to extract cognitive value from an engaging means of study such as flash cards and Kahoot (Dupret, 2022). Another notable method is branching scenarios, which require the learner to make clinical decisions based on a scenario producing further challenges awaiting being solved, engaging students online (Cook *et al*, 2010).

Institutional support plays a pivotal role in optimizing the digital learning environment across all phases of the MBBS programme. Despite students' overall confidence in their digital capabilities, persistent issues related to login difficulties, limited search functionality, and the absence of structured feedback were highlighted in the study. Addressing these issues requires institutional investment in robust digital infrastructure, continuous faculty training, and the development of dedicated spaces for peer and instructor interaction. Previous research underscores the value of feedback and collaborative learning, emphasising that well-designed communication tools are essential for fostering a sense of community within digital learning environments (Garrison *et al*, 2010).

Furthermore, adequate interaction must manifest itself in the form of institutional support, platform improvement and prompt facilitation dynamics, as participants in our study viewed the mere deliverance of lectures as academically unproductive. This was also manifested in the results of a study in Saudi Arabia where students rated the "good support system" on a very low side, thus highlighting its deficiency (Al-Hazimi *et al*, 2004). Learning has indeed been shown to be a social phenomenon such that the embedment of feedback and evaluation in the core of teacher-learner interaction generates the most productive academic dialogue (Kropf, 2013). The role of teachers in all learning models is crucial, as they not only deliver knowledge but also impart skills, qualities and competencies to the students (Capone *et al*, 2017). One study aimed to discover how a teacher-centered medical school curriculum may result in a negative perception of the educational environment and effectively concluded that poor teaching skills and lack of feedback were the top contributory factors (AlFaris *et al*, 2014). Eighty-four percent of students and 58% of residents participating in a study based in Cameroon, Africa, had never had access to e-learning resources reiterating the need for institutional support and strategy to deploy key skills in this domain (Bediang *et al*, 2013).

Other aspects brought to light in the study included learner characteristics and platform usability. Students recognised the importance of active engagement and self-discipline as essential antidotes to online learning distractions. Participants from Taiwan's higher education institutions agreed that motivation had a direct impact on learning engagement and an indirect impact through practicing self-monitoring (Alemayehu & Chen, 2021). Motivational regulation strategies are shown to be highly strategic for a good online learning experience for medical students as well as enhancement of cognition (Wang *et al*, 2021).

There is a dire need to integrate such strategies in online curricula to boost productivity. In addition, although students considered themselves fully digitally capable of using online learning platforms, usability remained an issue as login problems, and a lack of search options and progress clarity were still evident. The qualitative data in our study revealed ongoing usability issues, such as login difficulties and limited search functionality, echoing similar concerns identified in other studies. A relevant study reviewed the usability of an experimental e-learning tool, *Learning Moment (LM)*, which had certain features that maximised its adoption: it included target users, maximised simplicity, allowed diversity and could be incorporated into daily workflows (Yun *et al*, 2021). Similar blueprints that attribute e-learning platform usability to effectiveness, satisfaction and ease of use can be cultivated in practice to gauge this problem actively (Abulafia & De Quincey, 2018).

Garrison *et al*, argued that effective learning can take place from the sufficient interactions of students with peers, teachers and content (Garrison *et al*, 2010). Keeping in like with this principle, students in the study recommended a separate platform for contacting instructors outside of the e-learning platform. As the physical separation of learners from students is an obvious caveat in online learning, technology plays a pivotal role in providing an experience closely matching that of a face-to-face class (Sher, 2009). One review revealed that despite efforts to understand the social setbacks entailed by online education, little work has been done to connect these concepts to produce better learning (WALLACE, 2003). This strongly suggests the need for communication tools to be incorporated into a digital learning environment.

In conclusion, this study demonstrates that while the digital learning environment at the institution offers flexibility and ease of access, it also poses challenges that compromise key elements of social learning and interaction. To address these challenges, the institution should consider tailored digital strategies that align with the curriculum's structured delivery and evolving demands. Incorporating interactive learning elements in the pre-clinical years and enhancing communication tools in the clinical years could significantly improve student engagement and collaboration. Moreover, the integration of scenario-based assessments and real-time case discussions would bridge the gap between theoretical knowledge and practical application, enhancing learning outcomes across all phases of the MBBS programme.

By aligning digital strategies with the structured delivery of the MBBS curriculum, the institution under study can create a more supportive and engaging online learning experience that adapts to the specific needs of students at different stages of their medical training. Future research should explore the long-term impact of these interventions on student satisfaction, social connectedness, and overall learning outcomes.

Limitations of the study

Although this study benefits from incorporating both qualitative and quantitative data from participants, it has some limitations. First, it was conducted at a single institution and only at one point in time, which may limit the generalisability of the findings. Further in-depth qualitative studies are necessary to explore students' perceptions across different institutions and regions, allowing for a more comprehensive understanding of online learning environments in medical education.

Additionally, the usability and applicability of the validated Digi-MEE instrument should be tested in multiple institutions providing online medical education to determine its broader relevance. Future research should also aim to assess the test-retest reliability of the Digi-MEE instrument by replicating this study within the same settings over time. Moreover, the instrument's validation should be extended to other educational contexts beyond undergraduate medical education to ensure its versatility in different online learning environments.

Furthermore, the use of a 4-point Likert scale in the Digi-MEE instrument, intentionally designed to avoid neutral responses, presents a potential limitation. In this study, a score of 3 was considered indicative of positive perceptions, but a higher threshold, such as 3.5, is often preferred in research to denote strong agreement. This difference could affect the interpretation of scores, and future studies may benefit from exploring additional statistical measures like median or mode to provide a more nuanced understanding of the findings.

Conclusion

This study provides valuable insights into the perceptions of medical students regarding their online learning environment, revealing both strengths and areas for improvement. While students report high levels of digital capability and generally find the platform usable, the lack of social interaction and limited institutional support remain key challenges. These findings underscore the need for medical institutions to enhance the interactive elements of their online learning platforms and offer more structured support systems to mitigate the negative impacts of social isolation.

Additionally, the significant variations in perception across different academic years suggest that tailored approaches may be necessary to address the unique needs of students at different stages of their medical education. To further enhance the effectiveness of online learning, institutions should explore the incorporation of interactive learning strategies, such as gamification and scenario-based assessments, and develop communication tools that facilitate better engagement between students and instructors.

Future studies should explore the long-term impact of these interventions on student satisfaction and learning outcomes, as well as the role of social connectedness in maintaining a productive and supportive online learning environment.

Abbreviations

Dig-MEE: Digital Medical Education Instrument
CC: Content Curation
CE: Cognitive Enhancement
CP: Cybergogical Practices
DC: Digital Capability
SR: Social Representations
PU: Platform Usability
IS: Institutional Support
FD: Facilitation Dynamics
LC: Learner Characteristics

Statements and Declarations

Ethical Approval:

1. Human Research Ethics Committee, University Sains Malaysia (USM/JEPeM/ 21050350)
2. Human Research Ethics Committee, University of Lahore, Pakistan (ERC 122/22/10)

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