# Understanding the Functional Components of Technology-Enhanced Learning Environment in Medical Education: A Scoping Review

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## Abstract
Increasing use of technology in medical education has caused concerns to medical teachers pertaining to the quality of digital learning environments. Thus, this review aimed to unearth the functional components of effective technology-enhanced learning environment in the undergraduate medical education context. The revised Arksey and O'Malley protocol was utilized that include identification of research question and relevant studies, selection of studies, data charting and collection, and collating, summarizing, and reporting results after consultation. We discovered nine components with 25 subcomponents of 74 functional elements found to be present in effective online learning environments. The nine components include cognitive enhancement, content curation, digital capability, technological usability, pedagogical practices, learner characteristics, learning facilitator, social representations, and institutional support. There is an interplay between these components, influencing each other in online learning platforms. A technology-enhanced learning in medical education (TELEMEd) model is proposed which can be used as a framework for evaluating online learning environment in medical education.

**Keywords** Digital learning · Effective online learning environment · Technology-enhanced learning environment · Undergraduate medical education

## Introduction

Learning environment plays a significant role in determining students' satisfaction with the learning experience [1]. It is considered a milieu for medical students because it influences their success and determines their quality of life [2]. It has been postulated that the learning environment acts as the main driver of the academic performance of students [3]. The influence of the learning environment on competency and identity formation of students in competency-based clinical education has been well documented [4]. The cultural climate provides a medium for students to interact in a community of practice and develop competency and self-efficacy. Recently, the learning environment has been proven to be a significant factor for ensuring student well-being and preventing burnout [4].

The World Federation for Medical Education [5] considers the learning environment as an essential component for evaluating medical education programs. The relationship between the educational environment and the achievement, satisfaction, and success of students in medical school have highlighted the need for evaluating the medical school environment [6]. This holds true not only for the traditional face-to-face school environment but also for the technology-enhanced learning environment in medical education (TELEMEd).

Owing to the recent medical education advancement in terms of using digital tools, the constructs of these learning environments have undergone significant evolution. Within a decade, various specialties have documented several forms of online teaching experiences, from supplemental courses

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to fully online courses in medical education [1, 7]. Additionally, the coronavirus disease (COVID-19) pandemic led to institutional closure, providing an opportunity for the use of online learning environments in all fields, including undergraduate medical education [8].

Apart from the previously known components of the learning environment (curriculum, learning outcomes, teaching strategies, learning methodologies, and assessments), online and distance education is also influenced by other factors including technical skills and resource management [9]. Thus, it is crucial to explore such factors when designing online courses to improve the quality of education in online platforms [10].

Despite the increasing use and applicability of virtual learning environments, there seems to be a limited work on online learning environment evaluation and measurement tools to measure the online learning environment, particularly in the medical education context. This review aimed to describe the functional components of effective online learning environments.

## Methods

### Scoping Review Protocol

Ethical Approval was obtained prior to the commencement of the review from Human Research Committee Universiti Sains Malaysia (USM/JEPeM/ 21050350). This scoping review utilized the Arksey and O'Malley framework, using its six steps: (i) identification of research questions; (ii) identification of relevant articles; (iii) selection of relevant studies; (iv) data collection and charting; (v) collating, summarizing, and reporting the results; and (vi) taking consultations [11].

### Step 1: Identification of Research Question

This scoping review aimed to discover the functional components of effective online learning environments in undergraduate medical education. Using the Population–Concept–Context model, the population was undergraduate medical students or faculty members, the concept was learning environment, and the context was technology-enhanced or digital learning.

This review aimed to answer one main research question, "What are the functional components of effective technology-enhanced learning environments?" For the review purpose, the operational definition of functional components of technology-enhanced learning environment is referred to the characteristics of educational environment that utilizes and/ or embeds technology for a meaningful learning experience,

encompassing any online, virtual, or digital integration in face-to-face, blended, or fully online courses. These characteristics have been shown to provide effective learning–either quantitatively or qualitatively or both–in relevant studies.

The outcome variables included students' learning experience, performance or perceptions, facilitators' perception of use, institution's experience, and expert judgement as well as other variables like usage analytics, engagement, participation, and interactions in technology-enhanced learning environments in undergraduate medical education.

### Step 2: Identification of Relevant Studies

Literature search was conducted, and original, peer-reviewed research articles published from January 2010 to March 2022 were identified. Five electronic databases (PubMed, Scopus, Science Direct, Education Resources Information Centre (ERIC), and Google Scholar) were utilized for literature search. Initially, keywords were used and refined after preliminary search, and they included ((learning environment) OR (educational atmosphere)) OR (educational climate)) OR (educational environment)) AND ((online)) OR (virtual) OR (digital) OR (technology-enhanced) OR (e-learning) AND ((medical education)) OR (health professions education)) AND (undergraduate)).

### Step 3: Selection of Relevant Studies

The articles retrieved from the databases were reviewed based on the eligibility criteria for the title, abstract, and full-text article selection to ensure robustness in selecting articles related to technology-enhanced learning environments. The shortlisted articles were reviewed by two independent researchers (MSBY and NK). A consensus was achieved in approving or rejecting the shortlisted articles based on predefined eligibility criteria with kappa value of 0.884. In case of disagreement, the articles were further reviewed independently by other independent researchers (HI and SNH) till consensus was achieved. Eligibility criteria based on title, abstract, and full-text screening were defined for selecting the articles (Table 1).

### Step 4: Data Charting

The final selected articles were reviewed, and their data was extracted on an Excel sheet to provide objective summary of the review. All the extracted information were organized according to (i) author, (ii) title of article, (iii) year of publication, (iv) country of publication, (v) aim of the study, (vi) research design, (vii) data collection tool, (viii) study population and sample size, (ix) intervention performed, and (x) any identified component, determinant, or parameter used in the study.

**Table 1** Eligibility criteria for article selection

| Eligibility criteria | Inclusion criteria | Exclusion criteria |
| --- | --- | --- |
| Title | – Articles published between January 2010 and March 2022<br>– Articles in English<br>– Title reflecting TELEMEd[a] | – Articles in languages other than English |
| Abstract | – Abstract reflects an original article<br>– Abstract tests/evaluates any online teaching methodology/tool related to TELEMEd<br>– Abstract provides a robust study design (qualitative, quantitative, or mixed-method approach)<br>– Abstract provides evidence of evaluation on online learning environments<br>– Measurable study outcomes ( quantitatively or qualitatively) | – Studies covering primary and secondary education<br>– Studies covering higher education other than undergraduate medical education<br>– Review articles, books, conference proceedings, short communication, research reports, letters to editor, and editorials will be excluded from search process |
| Full text | – The article elaborates on the elements/factors of effective TELEMEd<br>– Functional element proven to enhance learning<br>– The article uses a well-designed research methodology and/or intervention<br>– Context of undergraduate medical education<br>– The article is available as a full-text article | – Unrelated to technology-enhanced learning environment<br>– Articles focussing on tool instead of learning<br>– Full text not available |

[a]*TELEMEd* technology-enhanced learning environment in medical education

## Step 5: Data Collating, Summarizing, and Reporting the Results

Three independent researchers (SNH, IM, and NK) performed content analysis using Microsoft Excel, while three researchers (NK, MSBY, and HI) utilized Braun and Clarke's approach in the thematic analysis. Initial steps of content analysis allowed the researchers to get thorough understanding of the functional components of TELEMEd, while the thematic analysis focused on generating concepts related to effective technology-enhanced learning environments. The emerging main themes were defined by the researchers during thematic analysis along with their organization into themes and subthemes. Finally, two independent researchers (MSBY and NK) reviewed and finalized the formulated themes and subthemes after consensus.

## Step 6: Consultation

For consultation, medical educationists were invited during the article selection process for review. Based on the experts' suggestion, three articles were handpicked to be included in the selected articles. The thematic analysis data was also triangulated among experts of qualitative research methods which allowed review of the list of open, axial, and selective coding, leading to finalization. Figure 1 shows the flowchart of study selection process for this scoping review.

## Results

### Literature Search

Figure 1 shows literature search process leading to thirty-nine articles selected for this review (see Annexure 1 for details of selected articles for this review).

### Study Characteristics

The selected 39 studies were published between January 2010 and March 2022 and included 10,841 (82%) students, 334 (17.9%) teachers, and 75 health professionals, educators, researchers, policy developers, and technical experts on technology-enhanced learning in undergraduate medical education (Table 2). Most of the articles were published in 2019 ($n = 10$). The studies included in this review were conducted in 19 different countries, including five articles each from the USA, Australia, and the UK, followed by three from Iran. Out of these 39 selected studies, 12 were quantitative, 13 were qualitative, and 14 adopted a mixed-method approach. In terms of the study population, 82% were undergraduate students, 17.9% were faculty members and teachers, and 15.3% were medical educators, technical experts, policymakers, and researchers (Table 2).

Various technology-enhanced platforms and tools were used in the different studies, namely, virtual patients (5.1%), mobile learning (7.7%), virtual learning environments (28.2%), and
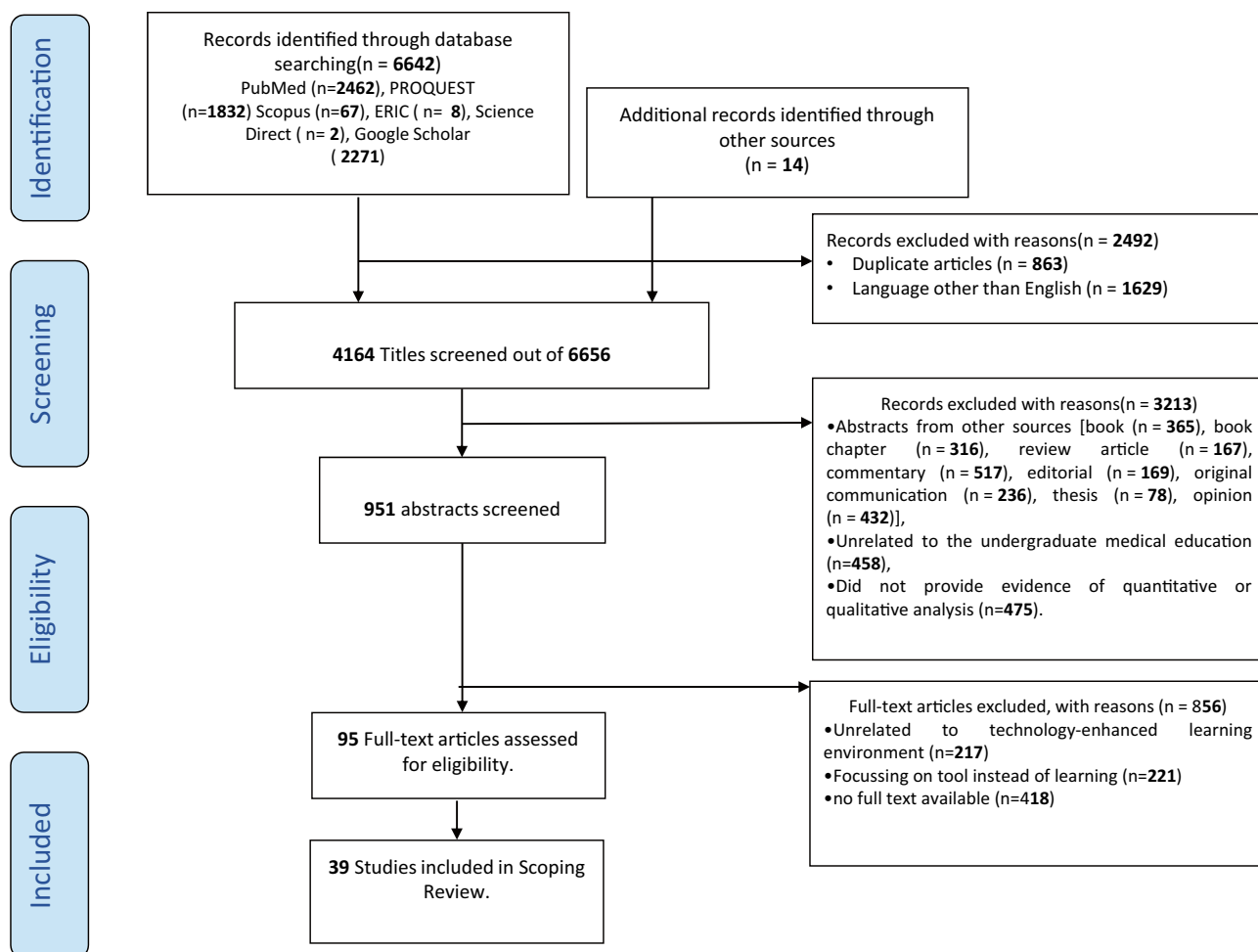
**Fig. 1** Article selection flow for scoping review

social networks (10.2%) along with web-based applications (20.5%).

## Identified Themes After Thematic Analysis

Thematic analysis unearthed nine main themes for effective technology-enhanced learning environments in undergraduate medical education: cognitive enhancement, content curation, digital capability, technological usability, pedagogical practices, learner characteristics, learning facilitator, social representations, and institutional support. See Table 3 for a list of identified themes, subthemes, and elements.

### Theme 1: Cognitive Enhancement

Cognitive enhancement promotes information processing, knowledge application, analysis, and evaluation in learning environments. The first subtheme of cognitive enhancement is cognitive flexibility which is the ability to selectively switch metal processes to achieve desired outcomes. In online learning environments, students should be able to demonstrate attentional flexibility to focus on needed tasks [12, 13] and switch tasks when needed [14].

The second subtheme of cognitive enhancement is allowing cognitive engagement in online learning environments. To achieve meaningful learning in an online environment, the information provided to the students need to be relevant to their learning [15, 16]. Another important parameter of the learning construct is the extent of active learning by the student in online courses through engagement [16, 17]. Effective online learning environments should be able to promote volitional learning, thereby empowering learners to take decisions about their learning preferences [12].

The third subtheme of cognitive enhancement is the agentic engagement which refers to students' involvement in the flow of instruction to get maximal effect from the learning process. This can be achieved by providing personalized learning to the learners by understanding their needs and delivering the content accordingly [18, 19, 20]. Online learning

**Table 2** Characteristics of the selected studies in this scoping review ($n = 39$)

| Feature | Discipline | Number |
|---|---|---|
| | 2010 | 2 |
| | 2012 | 1 |
| | 2013 | 1 |
| | 2014 | 3 |
| | 2015 | 3 |
| **Year of publication** | 2016 | 3 |
| | 2017 | 1 |
| | 2018 | 1 |
| | 2019 | 10 |
| | 2020 | 2 |
| | 2021 (Jan) | 1 |
| | Australia, UK, USA | 5 each |
| **Country of publication** | Iran | 3 |
| | Finland, Ireland, India, New Zealand, Taiwan, Turkey | 2 each |
| | Botswana, Canada, Malaysia, Nepal, Saudi Arabia, Sweden, UAE | 1 each |
| **Study approach** | Quantitative | 12 |
| | Qualitative | 13 |
| | Mixed methods | 14 |
| **Methods of data collection** | Interviews | 11 |
| | Questionnaire | 9 |
| | Questionnaire + interview | 9 |
| | Survey | 6 |
| | Interaction analytics | 2 |
| | Pre- and post-knowledge test | 1 |
| | Reflective essays | 1 |
| | Anatomy, medical radiation | 3 each |
| **Medical discipline** | Clinical placements, English, faculty development, virtual learning environments | 2 each |
| | Biochemistry, diagnostic radiography, emergency medicine, growth and development, haematology and renal medicine, infectious diseases, medicine, oncology, optometry, orthopaedics, pathology, physiology, psychiatry, primary health care | 1 each |
| | Various specialties | 10 |
| **Study level (year)*** | 1st year | 6 |
| | 2nd year | 4 |
| | 3rd year | 4 |
| | 4th year | 5 |
| | 5th year | 3 |
| | 6th year | 1 |
| | Not mentioned | 9 |
| | Combined years | 5 |
| | Involving faculty | 7 |
| | Students ($n = 10,841$) | 32 |
| **Study participants** | Teachers ($n = 334$) | 7 |
| | Health professional, educators, technical experts, policymakers (75) | 6 |

*Some studies spanned 2 years

environments should offer various innovative and creative tools and techniques to students to allow collaborative and personalized learning [21]. With personalization, students can choose their course modules and learn on their own, thereby promoting flexibility in learning where desired [22]. Having personalized learning can promote self-directed learning by creating interest and motivation among the learners [17, 23, 24].

**Table 3** Identified themes, subthemes, and elements of technology-enhanced learning environments in undergraduate medical education

| Themes | Subthemes | Elements | Sources of reference |
|---|---|---|---|
| **Cognitive enhancement** | Cognitive flexibility | Attentional flexibility/switching | [12, 13] |
| | | Task switching | [14] |
| | Cognitive engagement | Personal relevance | [15, 16] |
| | | Active learning | [16, 17] |
| | | Learning autonomy | [12] |
| | Agentic engagement | Personalized learning | [18 |
| | | Self-directed learning | [17, 23, 24] |
| **Content curation** | Content creation | Contextualization | [12, 14, 16, 25] |
| | | Selection | [12, 14] |
| | | Organization | [24, 26] |
| | | Accessibility | [19, 24, 29, 30] |
| | Content deliverance | Creative | [18, 28] |
| | | Variety | [29, 30] |
| | | Accessibility | [20, 27] |
| **Pedagogical practices** | Instructional designs | Attention grabbing | [16, 22, 26, 31] |
| | | Clear learning outcome provision | [15, 16] |
| | | Meaningful | [19, 21, 31] |
| | | Interactive activities | [32] |
| | Instructional strategies | Tool selection | [33] |
| | | Synchronous lesson delivery | [16] |
| | | Asynchronous lesson delivery | [16] |
| | Learner assessment | Assessment tool selection | [34] |
| | | Scheduling flexibility | [35, 36] |
| | | Timely feedback | [15, 19, 37, 38] |
| | Program evaluation | Data analytics | [19, 33, 40] |
| | | Quality assurance | [34] |
| **Learner characteristics** | Learner affect | Emotional engagement | [16, 18, 29] |
| | | Self-efficacy | [13, 24, 41] |
| | | Supported learning | [25, 26, 28] |
| | | Stress management | [17, 27, 42, 43] |
| | Learner behaviour | Behavioural engagement | [32, 42, 43] |
| | | Control over learning | [17, 38, 40] |
| | | Task orientation | [24, 44] |
| | | Learner effort/participation | [15] |
| | Motivation | Intrinsic motivation | [17, 19, 35] |
| | | Extrinsic motivation | [14, 15, 19, 43] |
| **Digital capability** | ICT proficiency | Information, data, and media literacies | [13, 17, 23, 35, 36] |
| | | Data creation, innovation, and scholarship | [13, 17, 23, 35, 36] |
| | | Communication, collaboration, and participation | [15, 21, 23, 44, 46] |
| | Digital identity | User information | [22, 29] |
| | | Protected reputation | [14, 22, 44] |
| | Digital well-being | Personal management | [14, 17, 37, 44] |
| | | Well-conserved boundaries | [12] |
| | Cyber civility | Digital professionalism | [13, 28, 48] |
| | | Cyberethics | [19, 28, 34, 48] |
| | | Cyber safety | [16, 37] |
| | | Content authenticity | [18, 31] |

**Table 3** (continued)

| Themes | Subthemes | Elements | Sources of reference |
| --- | --- | --- | --- |
| **Technological usability** | Dynamicity of platform | Easy upgradability | [34, 46] |
| | | Programmable automation | [35] |
| | Interface characteristics | Ease of access | [13, 29] |
| | | Offline learning capability | [19] |
| | | Interface Usability(simplicity/consistency) | [34, 46] |
| **Learning facilitation** | Course management | Goal setting | [23, 28, 46] |
| | | Managing cognitive load | [19] |
| | | Instructional tool selection | [17, 28] |
| | Educator skills | Positive encouragement skills | [20, 37] |
| | | Social interaction | [27] |
| | | Constructing knowledge | [28, 32, 48] |
| | | Information exchange (posts online) | [12, 15, 22, 41, 42, 49] |
| **Social representations** | Social presence | Sense of belonging | [14, 15, 23, 44, 50] |
| | | Academic discourse | [12, 15, 22, 25, 42] |
| | | Faculty disposition | [19, 25, 37] |
| | Interactivity | Netiquette | [19, 34, 51] |
| | | Digital interpersonal skills | [16, 33, 42] |
| | | Social networking | [39] |
| **Institutional support** | Institutional policies | Clarity | [24, 36, 44] |
| | | Dissemination | [22, 29] |
| | | Compliance | [23, 28] |
| | Program standardization | Accreditation with bodies | [22, 35, 46] |
| | | Curriculum integration/dynamic capability | [24] |
| | Systemic support | Resource provision | [19, 28, 33] |
| | | Capacity building | [23, 35] |
| | | Stakeholder acceptance | [33] |

## Theme 2: Content Curation

The content curation refers to discovering, selecting, and organizing relevant digital content in a meaningful format for learners to use. The first subtheme of content curation is content creation. The content needs to be contextual for learning [12, 14, 16, 25] and organized logically for maximal use by the students [24, 26]. Accessibility of the online content remains a vital factor in influencing students' learning on the go using mobile devices and tablets in clinical wards [20, 27].

The second subtheme of content curation is online content deliverance. It is recommended that creative content material in the form of enjoyable, attractive, and engaging designs should be used, for example, humour animation in anatomy [18, 28]. A variety of content can help accommodate learners' individual preferences [29, 30]. Opportunities for incidental learning (learning other things while engaging with the course contents) can also be provided to the students [14]. The content size should be carefully considered to avoid heavy cognitive load in the online platforms [19, 24, 29, 30].

## Theme 3: Pedagogical Practices

The component of pedagogical practices encompasses all those learning activities adopting technology, presented in meaningful instructional design to adopt strategies for instruction, assessment, and program evaluation. The first subcomponent of pedagogical practices is instructional designs. The instruction should be designed in a way to grab attention of the learners [16, 22, 26, 31]. It is recommended to provide clear learning outcomes to the learners [15, 16] in order to provide meaningful learning [19, 21, 31].

The second subtheme of pedagogical practices includes instructional strategies. Many online learning environments advocate constructivism as a pedagogical component to influence educational designs in online settings [32]. In addition, teaching activities are adopted to allow students to construct knowledge via inquiry-based learning and problem-solving. This holds true for most of the courses mentioned in this scoping review under the basic sciences. Many benefits are achieved by collaborative activities among the students in both synchronous and asynchronous mode [16]. Furthermore,

the pedagogical component can promote the integration and application of knowledge in the clinical sciences in the form of online case scenarios. Reflection by students over given clinical cases can be enhanced by the proper selection of teaching tools and user interfaces (virtual environments) [33].

Learner assessment is the third subtheme of pedagogical practices, with clear instructions regarding online assessments and flexibility in scheduling exams can ease the anxiety of the students, with careful use of added widgets such as online timer in online examinations [34]. A transparent online assessment policy can orient the students about the rules regarding online cheating and plagiarism [12]. A variety of online assessment tools can allow the facilitator to testing learners in different domains of knowledge, attitude, and skills [, 35, 36]. Also timely feedback should be encouraged for enhancing the learning process of the learners [15, 19, 37, 38].

The fourth subtheme of pedagogical practices is the program evaluation. The evaluation of online learning environments is different from that of traditional classrooms because it involves the use of learning analytics and social network analysis to measure and understand the learner's interactions with the content, peers, and facilitators [39]. In addition, an online presence can be measured in terms of the number of posts, replies given, and time spent in online discussion forums [19, 33, 40]. These parameters can measure interactivity in digital learning platforms and provide an indicator of quality measurement and assurance in the online course [34].

## Theme 4: Learner Characteristics

Learner characteristics encompass features related to learner affect and behaviour that promote effective learning in technology-enhanced learning environments. The first set of learner characteristics encompasses learner affect which refers to the acquired values, interests, and attitude of the learners in learning environment. For effective learning, the learners should demonstrate emotional engagement as a part of learner affect in online learning environments by demonstrating interest, enjoying the learning experience, and feeling as a part of learning community [16, 18, 29]. Emotional engagement can build confidence in learners, leading to self-efficacy which is another important feature in online learning environments [13, 24, 41]. In order to have emotional engagement, the learner should feel supported and valued in online learning environments [25, 26, 28]. It is also important to establish strategies for effective stress management in online learning environments to avoid online fatigue and burnout [17, 27, 42, 43].

The second subtheme of learner characteristics includes online learner behaviours in online learning environments. Behavioural engagement refers to learner's active participation in online learning activities. The activities should be designed in a way to allow easy completion of intended tasks [32, 42, 43]. The learners should also be given control over their learning regarding the choice of content and flexibility in learning [17, 38, 40]. The task value perceived by the students in the online course determines their engagement and performance in online learning [15]. Providing clear task orientation can allow the learners to easily navigate through the online platforms [24, 44]. Learner effort for learning and participation also determines successful learning in digital learning environments [15]. The effort put in by the students in these environments is directly related to their performance in the online medium and influenced by the motivation provided by the online instructor in the form of badges and gamification [45].

The last subtheme of learner characteristics is developing strategies to promote learner motivation in online learning environments. Strategies can be devised to allow students to perform tasks with predefined incentives to promote extrinsic motivation [14, 15, 19, 43] as well as to engage in tasks for inherent completion of tasks (intrinsic motivation) [17, 19, 35].

## Theme 5: Digital Capability

Digital capability refers to a set of knowledge and skills required for an effective learning experience in online digital platforms. The first subtheme of digital capability includes developing ICT proficiency. For conducive learning in online environments, it is important to attain various online information, data, and media literacies [13, 17, 23, 35, 36]. For facilitators, it is also recommended to learn about online data creation and innovative online teaching strategies and develop online scholarship [35, 36]. Proficiency should also be developed for online participation, communication, and collaboration [15, 21, 23, 44, 46].

The second subtheme of digital capability is establishing a digital identity on online platform. The user information on digital environments can help recognition [22, 29]. It is important to have protected reputation on online learning environments for both the learners and facilitators, the awareness of which needs to be created among the online users [14, 22, 44].

The third subtheme of digital capability constitutes digital wellness. Negative peer attitudes, along with managing online activities alone, can cause learners to have a feeling of "being lost at sea", leading to negative learning experiences and stress, fear, and anxiety instead of a positive impact [29]. In addition, wasting time online can further raise time management issues in online learning environments due to distractions and can lead to digital burnout [47]. Hence, it is important for learners to learn online personal management with proper time distribution and minimal distractions while learning online [14, 17, 37, 44]. Also important is to

establish well-conserved boundaries while interacting with each other and the facilitators to prevent burnout [12].

Cybercivility, or having respectable online behaviour, is the fourth subtheme of digital capability which is important for effective online learning environments. It is important for the learners as well as facilitators to exhibit appropriate behaviours while using digital media (digital professionalism) [13, 28, 48]. Apart from being professional, one should follow ethical principles for dealing with the content and people online (cyberethics) [19, 28, 34, 48]. Giving unprofessional remarks on social networking sites stir unrest and leave a negative impression on the students [32]. To promote online professional behaviours, both students and teachers need to be oriented about netiquette for the understanding of acceptable online behaviours [19]. Also importance is laid on having safe online environments where learners feel secure to participate in discussion forums and other activities [16, 37]. There should also be safety regarding one's personal information and submitted assignments [18, 31, 41, 44]. Lastly, the content authenticity forms an important part in delivering reliable information to the learners [18, 31].

## Theme 6: Technological Usability

The technological usability refers to quality of user experience while using technology for learning in a technology-enhanced learning environment. The first subtheme of technological usability includes user interface characteristics that make the platforms user-friendly and simple to use [34, 46]. It is recommended for the user interface to be easily accessible [13, 29] with offline learning capability [19]. Dynamicity of the online platforms should be considered to make them as easily upgradable and near reality as possible and forms the second subtheme of technological usability in this review [34, 46]. Also program automation allows easily utility of the platform by learners and facilitators [35]. The interface should be designed in a simple and consistent manner to allow learners to use it efficiently [34].

## Theme 7: Learning Facilitation

Learning facilitation refers to the roles played by the instructor in online learning environments to facilitate learning for the learners. The first subcomponent of learning facilitation includes efficient course management in online platforms. The facilitators should be able to clearly state the intended goal of learning in online session [23, 28, 46].

The efficiency of the learning facilitator depends on his/her technical competence, training in the use of the prescribed learning management system, and innovation in selecting and using appropriate tools for various online [17, 28]. Managing content to minimize content load remains another important task of learning facilitator [19].

Furthermore, an online learning facilitator acts as a course designer and, more importantly, an efficient organizer to manage the logical sequence and instructional time and pace for each course content and activity [27].

The second characteristic of learning facilitation is having effective online teaching skills. The learning facilitator plays a significant role in maintaining a positive attitude in online courses to promote student motivation and learning. For starters, the facilitator acts as a tour guide to the students to orient and familiarize them with the usage and rules of the digital learning platform [23]. To keep online courses running smoothly, the facilitator also acts as the frontline troubleshooter to detect and resolve any issues related to the website and refer these issues to the IT department for resolution [28]. Learning facilitation provides positive encouragement to the learners in online classes, accounting for social presence along with individualized feedback provider and elaborator when the student is confused regarding the task and task orientation, as well as demonstrator of clinical and practical skills [20, 37].

Lastly, the roles of the learning facilitator vary according to the context in which he/she is in. For example, he/she can act as a conductor during a synchronous learning session and as a facilitator of an asynchronous online session, with the aim to construct learner knowledge [28, 32, 48]. Where discussion forums are present, the same facilitator may adopt the role of a silent observer or collaborator, promoting exchange of information with learners [12, 15, 22, 41, 42, 49].

## Theme 8: Social Representations

Social representations refer to the system of practices involving interactions between individuals, groups, institution, and content in online learning environments. The first subtheme of social representations is the social presence in online environments, meaning that having a subjective experience of being presents with a real person with access to his or her emotions and thoughts. For online learning, the learners need to have a safe sense of belonging in the digital platforms [14, 15, 23, 44, 50].

Next, having effective academic discourse promotes social presence of the learner and should be encouraged in online learning environments [12, 15, 22, 25, 42]. Also the faculty disposition about online learning will influence social presence of the students as well of the facilitators. It is recommended for faculty to have a positive attitude with encouragement of students to interact with each other and present themselves online [19, 25, 37].

The next subtheme of social representations is related to interactivity. This element explores the variety of interactions a learner can have in a technology-enhanced learning environment and the related factors. Interactions in online learning environments are given paramount importance

for providing support to the students by ensuring an online presence and creating a dynamic environment instead of a static one. These interactions are learner–learner, learner–instructor, instructor–instructor, instructor–content, and learner–content, and they can lead to increased student engagement and performance in online environments [22, 42, 50]. Peer learning in an online group discussion is one of the examples of user interactions that promote learning. It is the same as interactive construct, which is an important component of course evaluation via learning analytics and student network analytics, utilizing various forms of student centrality [39].

Apart from interactions, communication and announcements regarding courses can also prepare students for online learning and interaction with one another in the form of an online community, thereby enhancing digital interpersonal skills [16, 33, 42]. This participation in the online community through discussions and collaboration not only enhances the students' learning but also aids in the development of the students' online identities and digital footprints [23]. This holds true for social networking sites used for learning and collaboration as these sites allow students to express their voices and have a feeling of freedom [39]. On the contrary, a student may feel that his/her online privacy has been invaded with the presence of the teacher in his/her social media networks [18]. Similarly, the teacher may also report blurring personal and professional boundaries in social media networks, indicating a need for having a sense of netiquette in online learning environments [19, 34, 51].

### Theme 9: Institutional Support

The institutional support in this context refers to the organizational active encouragements in the form of policies, regulations, and monetary and non-monetary support that propel stakeholders to use online learning environments in a very effective and productive manner. Institutional policies form the first subtheme of institutional support for effective online learning environments [24, 36, 44]. Moreover, dissemination of policies and procedures regarding online learning should be done before initiation of online course [22, 29]. The students and faculty must be adequately orientated about the rules and regulations regarding the outcomes expected from them [44],online professionalism and ethical practices. Furthermore, online safety issues and concerns regarding student privacy when interacting in an online environment should be handled [14, 44]. A detailed guide regarding social media networking should be followed by ensuring compliance to these rules [23, 28].

The second subtheme of institutional support is program standardization. A well-disseminated and conveyed institutional policy for curriculum integration with best practices and standardized norms can aid in promoting teamwork and collaboration between the faculty, IT department, and related stakeholders [24]. Apart from having a leadership component, the institution must also update with the status of virtual education and its accreditation with the higher authorities [28]. Having a formal accreditation from higher authorities will validate the online courses offered by the institution and help in integration of online learning in curriculum [22, 35, 46].

The third subtheme of institutional support is in the form of systemic support. An institution is not only involved in providing appropriate infrastructure, resources, and funds [19, 28, 33]. It also plays a vital role in motivating its faculty through incentives to collaboratively work with the information and technology (IT) department and building digital capacity of the stakeholders [22, 29].

This educational leadership supports the faculty in developing competence in IT and technological skills [23, 35]. Ensuring stakeholder acceptance for using online learning environment is a vital step towards effective online learning environments [33].

## Discussion

This scoping review outlines nine themes of effective online learning environments in the undergraduate medical education context: cognitive enhancement, content curation, digital capability, technological usability, pedagogical practices, learner characteristics, learning facilitator, social representations, and institutional support. It is evident that effective online learning environments demands varying elements to be synchronized seamlessly for conducive online learning experiences. The results of the scoping review are presented in the form of TELEMEd model (Fig. 2) for the illustration of online learning environment themes. The proposed TELEMEd model describes the identified components in terms of how they influence each other in online learning environments.

The functional components of technology-enhanced learning environments in medical education are divided according to need for existence within the virtual learning interface. For this purpose, the computer screen in the model delineates the components in two categories: (i) components *outside* the virtual learning platform and (ii) components *within* the virtual learning platform.

### Components Outside the Virtual Learning Platform

These components include those existing in real world and outside the virtual learning platform. These components immerse themselves in the digital world for an online learning experience and include the learners, learning
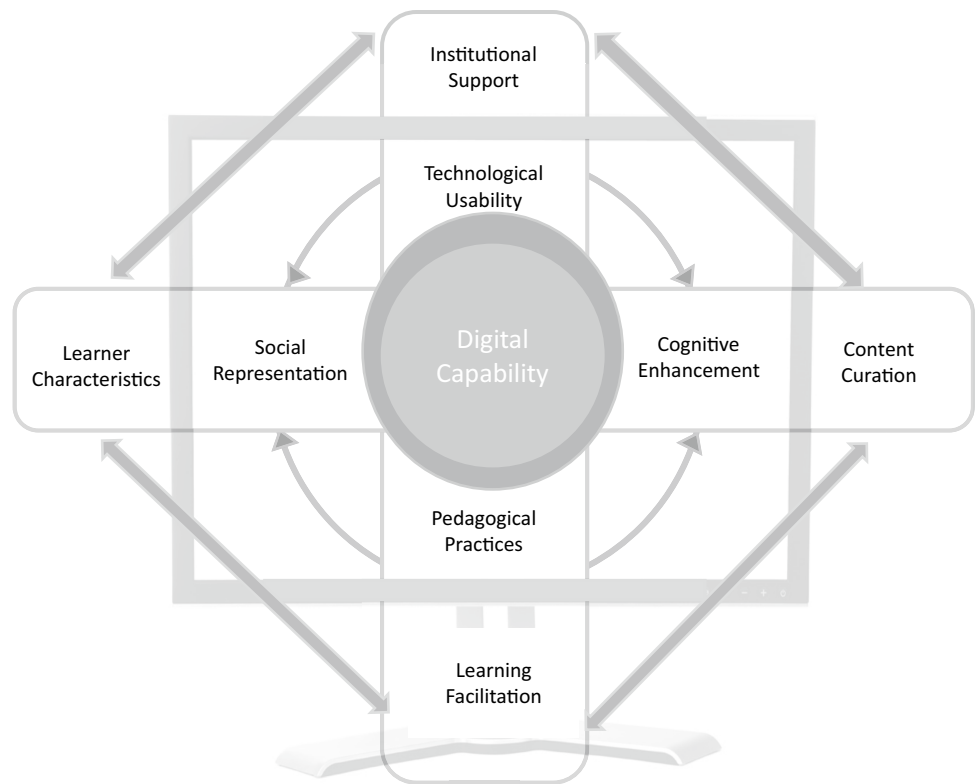
facilitator, content material, and institutions. The four
components are interacting with each other in any learning
environment, whether it is fully online, hybrid, or face-to-
face learning environments. Much work has already been
done regarding different types of interactions that are
found in the process of learning including interactions like
*learner–learner*, *learner–facilitator*, *learner–content*, *facil-
itator–content*, *learner–institution*, *facilitator–institution*,
and *content–institution* (see Fig. 3) [52, 53]. Such interac-
tions are paramount for successful learning outcomes and
positive learner perceptions.

The TELEMEd model highlights attitudes and motiva-
tion of the learner towards online learning as determining
factors for successful online learning. Learner motivation
in online platforms ranges from variety of extrinsic as well
as intrinsic factors. Among the intrinsic factors include
the learner interest, confidence, and excitement to learn
online which may in turn be influenced by variety of fac-
tors including content variety, ease of access, and degree
of engagement in online tasks [54]. Extrinsic motivating
factors may be present in form on reward, punishment, or
peer acceptance/appreciation [55].

The roles of virtual learning facilitator have expanded
from just being a teacher to assuming a variety of roles in
online learning environment (Fig. 4). The learning facili-
tator acts as a tour guide and frontline troubleshooter for

all matters related to the learning management system.
Also, support should be provided to promote higher order
thinking among learners in online tasks by elaborating and
demonstrating where needed and provided timely feed-
back to keep students motivated [56]. When dealing with
the content, the learning facilitator is involved in course
designs as well as course organization and selection of
appropriate tools. Cook elaborated the need to plan which
designing online courses with the right amount of content,
right tool selection, right timing, and right route [57].

The online pedagogical practices depend on the nature of
the synchronicity, and hence, the learning facilitator may act
as the conductor in synchronous session where the pedagogi-
cal practices focus on keeping students engaged in online
tasks to enhance learning. The facilitator may act as a col-
laborator or an observer in online discussion forums. All
these roles demand development of digital and non-digital
competencies for the learning facilitator related to online
course creation, organization, management, and evaluation
[58]. Provision of timely feedback is an important factor
influencing student' learning in online platforms [59].

Aguilar-Peña et al. have emphasized on the changing role
of content curation from content creation in recent online
learning [60]. Further, they emphasize on the need to have
proper *selection* of content after online *search* to enhance
the learning and avoid unnecessary cognitive load. Next is

**Fig. 3** Variety of interactions seen in online learning environments
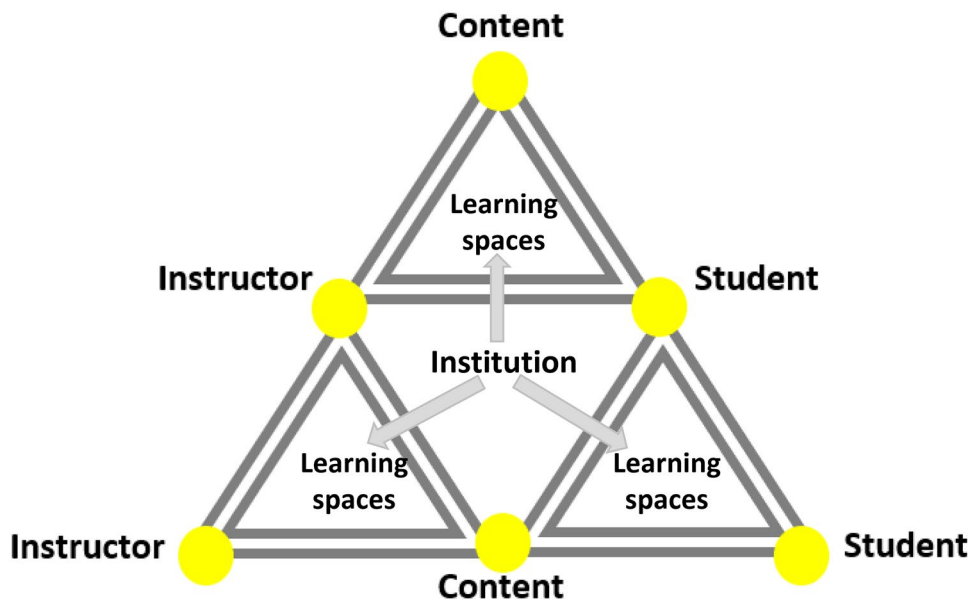


an important step of *sense-making* and finally *sharing* the curated content via an appropriate means. Content variety can ensure content presentation in different forms and can cater variety of learners [58].

Important component of online learning environment is provision of institution support regarding the program standardization as well as development of institutional policy and rules and regulations regarding use of online learning platforms [61]. Not to mention is the fact that it is the responsibility of the institution to provide necessary resources (human and non-human) to establish effective learning environment for students. These resources can determine the selection of learning management systems and technological usability by the student and ensure that interfaces used by the platforms are user-friendly and dynamic that can be upgradable with time.

## Components Within the Virtual Learning Platform

Within the online environment, there are five factors which are virtually present including the technological usability, cognitive enhancement, pedagogical practices, and social representations in the online environment. Central to all these factors is the digital capability which forms the vital component in the virtual learning environment for effective learning experience.

Digital capability forms the central part of the virtual learning environment and involves the knowledge, attitude, and practices of the online user of online learning environment for getting conducive experience. Digital capability has shown to improve the digital performance and hence the overall learning experience in online platforms [62]. In the era of virtual communities, digital identities have

**Fig. 4** Roles of online facilitator in virtual learning environments
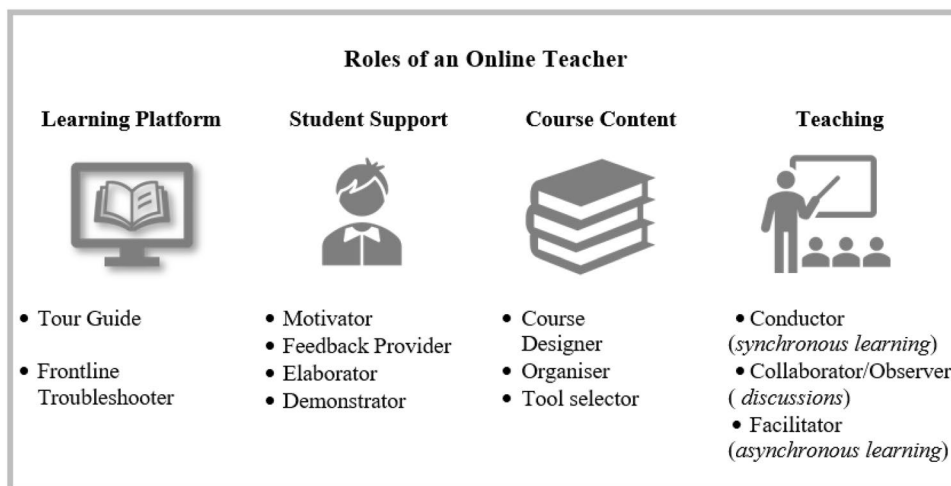
developed with the need to secure their access and monitoring via various policies [63]. It is important to know how to behave in these environments, and hence, digital civility is another paradigm which has come up with increasing use of technology and social media for education. Further, the norms and practices of using online platforms have led to defining digital professionalism and ethics, in terms of understanding ethical practices and showing respect for others in online platforms [64]. Dumus et al. discussed the need for respecting other's views as well as time to avoid blurring of boundaries, highlighting the need to ensure digital well-being in online learning platforms [65].

Active cognitive enhancement in online learning environments is influenced by the content curation and has already been discussed. Another determining factor for cognitive enhancement is the degree of cognitive flexibility which allows the learner in an online medium to adjust one's mental processes according to the content and activity presented [66]. With distractions online, cognitive flexibility is an important factor influenced by curated content and technological usability [67]. Cognitive enhancement is also promoted by effective technical interface which allows learning to navigate the online site with ease of use and access. The clarity, consistency, and simplicity in the interface can aid the learner in avoiding unnecessary cognitive load and focus on the needed tasks [68]. This shows that there is an intensive interplay between the identified functional components of TELEMEd model within the virtual learning platform. The use of interface is in turn determined by appropriate online pedagogical approaches by the learning facilitator and course designers who curate the content as well as organize and present it in a user-friendly manner.

Social representations form a vital component of online learning environment which includes different types of interactions as defined in literature including peer interaction as well as interaction with the facilitator [69]. These interactions allow the leaners to have a sense of community with peer learning in a constructive manner. The social representations also represent the digital identity of the student which is again important to develop as a part of professional identify formation [63].

## Limitations and Future Directions

The main limitation of this scoping review is the selection of only 39 primary studies. With the rapid increase in research related to online learning, more targeted reviews can be carried out focusing on individual identified components of online learning environments. Although few studies recorded feelings of fear and anxiety among medical students who use online learning environments, digital

well-being has not been explicitly explained in the literature considered in this review. Also emerging paradigms like cybercivility and e-professionalism especially in context of medical education need to be studied. Additionally, most of the studies explored online learning platforms in terms of a single course, giving a snapshot of the results. A more prolonged longitudinal study can be undertaken to study the issues in each component that may arise in the TELEMEd model.

## Conclusion

In this scoping review, we explored the existing knowledge about functional components of TELEMEd including cognitive enhancement, content curation, digital capability, technological usability, pedagogical practices, learner characteristics, learning facilitator, social representations, and institutional support. We also proposed a model for TELEMEd, delineating components present *outside* and present *within* the virtual learning platform. There is interplay between these components, influencing each other in online learning platforms. The proposed TELEMEd model, though requiring validation, can used for as a part of framework for online learning environments.

## Declarations

## References

1. Pai PG, Menezes V, Srikanth, Subramanian AM, Shenoy JP. Medical students' perception of their educational environment. J Clin Diagnostic Res. 2014;8(1):103–7. https://doi.org/10.7860/JCDR/2014/5559.3944.
2. Genn JM. AMEE medical education guide no. 23 (part 1): curriculum, environment, climate, quality and change in medical

education - a unifying perspective. Med Teach. 2001;23(4):337–44. https://doi.org/10.1080/01421590120063330.

3. Genn JM. AMEE medical education guide No. 23 (part 2): curriculum, environment, climate, quality and change in medical education - a unifying perspective. Med Teach. 2001;23(5):445–54. https://doi.org/10.1080/01421590120075661.

4. Holden M, Buck E, Clark M, Szauter K, Trumble J. Professional identity formation in medical education: the convergence of multiple domains. HEC Forum. 2012. https://doi.org/10.1007/s10730-012-9197-6.

5. World Federation for Medical Education. (2015). Basic Medical Education: WFME Global Standards for Quality Improvement, World Federation for Medical Education. 2015:36. Available at http://www.imeac.org/wpcontent/uploads/2017/07/06_WFME_2015.pdf

6. Bakhshialiabad H, Bakhshi G, Hashemi Z, Bakhshi A, Abazari F. Improving students' learning environment by DREEM: an educational experiment in an Iranian medical sciences university (2011–2016). BMC Med Educ. 2019;19(1):1–10. https://doi.org/10.1186/S12909-019-1839-9/TABLES/5.

7. Bakshi SG, Bhawalkar P. Role of WhatsApp-based discussions in improving residents' knowledge of post-operative pain management: a pilot study. Korean J Anesthesiol. 2017;70(5):542–49. https://doi.org/10.4097/kjae.2017.70.5.542.

8. Ahmed H, Allaf M, Elghazaly H. COVID-19 and medical education. Lancet Infect Dis. 2020. https://doi.org/10.1016/s1473-3099(20)30226-7.

9. Hutchinson L. Educational environment. BMJ. 2003;326 (7393):810. https://doi.org/10.1136/bmj.326.7393.810.

10. Haron S, Suzana Ariffin A, Idrus D. Validating the development of instrument for measuring nurses' performance scale. J Manag Info. 2019;6(1):31–8. https://doi.org/10.31580/jmi.v6i1.495.

11. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol Theory Pract. 2005;8(1):19–32. https://doi.org/10.1080/1364557032000119616.

12. Dash S. Article Google Classroom as a learning management system to teach biochemistry in a medical school. Biochem Mol Biol Educ. 2016;47(4):404–7. https://doi.org/10.1002/bmb.21246.

13. Han H, Nelson E, Wetter N. Medical students' online learning technology needs. Clin Teach. 2014;11:15–9.

14. Kabilan MK, Ahmad N, Jafre M, Abidin Z. Internet and higher education Facebook: an online environment for learning of English in institutions of higher education? Internet High Educ. 2010;13(4):179–87. https://doi.org/10.1016/j.iheduc.2010.07.003.

15. Peacock JG, Grande JP. An online app platform enhances collaborative medical student group learning and classroom management. Med Teach. 2016;38(2):174–80. https://doi.org/10.3109/0142159X.2015.1020290.

16. Bridge P, Trapp JV, Kastanis L, Pack D, Parker JC. A virtual environment for medical radiation collaborative learning. Australas Phys Eng Sci Med. 2015;38(2):369–74. https://doi.org/10.1007/s13246-015-0348-3.

17. Iqbal S, Ahmad S, Willis I. Influencing factors for adopting technology enhanced learning in the medical schools of Punjab, Pakistan. Int J Inf Commun Technol Educ. 2017;13(3):27–39. https://doi.org/10.4018/IJICTE.2017070103.

18. Jaffar AA. Exploring the use of a Facebook page in anatomy education. Anat Sci Educ. 2014;7(3):199–208. https://doi.org/10.1002/ase.1404.

19. Adibi P. Preferences of the medical faculty members for electronic faculty development programs (e-FDP): a qualitative study. Adv Med Educ Pract. 2019;10:515–26.

20. Roskvist R, Eggleton K, Goodyear-Smith F. Provision of e-learning programmes to replace undergraduate medical students' clinical general practice attachments during COVID-19

stand-down. Educ Prim Care. 2020;31(4):247–54. https://doi.org/10.1080/14739879.2020.1772123.

21. Sapkaroski D, Mundy M, Dimmock MR. Radiography virtual reality versus conventional clinical role-play for radiographic positioning training: a students ' perception study. Radiography. 2020;26(1):57–62. https://doi.org/10.1016/j.radi.2019.08.001.

22. Hyll M, Schvarcz R, Manninen K. Exploring how medical students learn with the help of a digital presentation: a qualitative study. BMC Med Educ. 2019;19:210.

23. Gillingham K, Eggleton K, Goodyear-Smith F. Is reflective learning visible in online discussion forums for medical students on general practice placements? A qualitative study. Teach Learn Med. 2020;32(4):434–41. https://doi.org/10.1080/10401334.2020.1730184.

24. Id MLA, et al. Student acceptance of e-learning methods in the laboratory class in optometry. PLoS ONE. 2018;13(12):e0209004.

25. Chen H, Liao L, Chang Y, Hung C. Factors influencing technology integration in the curriculum for Taiwanese health profession educators : a mixed-methods study. Int J Environ Res Public Heal Artic. 2019;16:1–16.

26. Ryan E, Poole C. Impact of virtual learning environment on students' satisfaction, engagement, recall, and retention. J Med Imaging Radiat Sci. 2019;50(3):408–15. https://doi.org/10.1016/j.jmir.2019.04.005.

27. Attardi SM, Choi S, Barnett J, Rogers KA. Mixed methods student evaluation of an online systemic human anatomy course with laboratory. Anat Sci Educ. 2016;9(3):272–85. https://doi.org/10.1002/ase.1584.

28. Mojtahedzadeh R, Mousavi A, Shirazi M, Mohammadi A. Factors creating an educational atmosphere in cyberspace: a qualitative study. Strides Dev Med Educ. 2017;14(2):e66898. https://doi.org/10.5812/sdme.66898.Research.

29. Reid HJ, Thomson C, Mcglade KJ. Content and discontent: a qualitative exploration of obstacles to elearning engagement in medical students. BMC Med Educ. 2016;16:188. https://doi.org/10.1186/s12909-016-0710-5.

30. Webb AL, Choi S. Interactive radiological anatomy elearning solution for first year medical students : development, integration, and impact on learning. Anat Sci Educ. 2014;7:350–60. https://doi.org/10.1002/ase.1428.

31. Koj URI, Ad MOHAMM, Alegh AH, Ava K, Naja S, Pou FI. Experiences of students and faculty members about using virtual social networks in education: a qualitative content analysis. J Adv Med Educ Prof. 2019;7(2):86–92. https://doi.org/10.30476/JAMP.2019.44712.

32. Pyörälä E, Mäenpää S, Heinonen L, Folger D, Masalin T, Hervonen H. The art of note taking with mobile devices in medical education. BMC Health Serv Res. 2019;19(96):1–10.

33. Alkhowailed MS, Rasheed Z, Shariq A, Elzainy A, El A. Digitalization plan in medical education during COVID-19 lockdown. Informatics Med. 2020;20(January):1–6.

34. Snekalatha S, Marzuk SM, Meshram SA, Maheswari KU, Sugapriya G, Sivasharan K. Medical students' perception of the reliability, usefulness and feasibility of unproctored online formative assessment tests. Adv Physiol Educ. 2021;45:84–8. https://doi.org/10.1152/advan.00178.2020.

35. Green BL, et al. A semi-quantitative and thematic analysis of medical student attitudes towards M-learning. J Educ Clin Pract. 2015;21:925–30. https://doi.org/10.1111/jep.12400.

36. Varga-Atkins T. A study of the role of a technology-enhanced learning implementation group in mediating an institutional VLE minimum standards policy. Res Learn Technol. 2016;24(32815):1–19.

37. Niebuhr V, Niebuhr B, Trumble J, Urbani MJ. Online faculty development for creating E-learning materials. Educ Heal. 2014;27(3):255–61. https://doi.org/10.4103/1357-6283.152186.

38. Hartnup B, Dong L, Hons BA, Eisingerich AB. How an environment of stress and social risk shapes student engagement with social media as potential digital learning platforms: qualitative study corresponding author. JMIR Med Educ. 2018;4(2):e10069. https://doi.org/10.2196/10069.

39. Saqr M, Alamro A. The role of social network analysis as a learning analytics tool in online problem based learning. BMC Med Educ. 2019;19:1–11.

40. Tekin PŞ, Ilgaz H, Adanır GA, Yıldırım D, Gülbahar Y. Flipping e-learning for teaching medical terminology: a study of learners' online experiences and perceptions. Online Learn J. 2020;24(2):76–93. https://doi.org/10.24059/olj.v24i2.2030.

41. Alpert JB, Young MG, Lala SV, Mcguinness G. Medical student engagement and clinical radiology learning environment: creation of virtual read-out sessions in response to the COVID-19 pandemic. Acad Radiol. 2020;28(1):112–8. https://doi.org/10.1016/j.acra.2020.09.011.

42. Liaw S, Huang H. Computers & education perceived satisfaction, perceived usefulness and interactive learning environments as predictors to self-regulation in e-learning environments. Comput Educ. 2013;60(1):14–24. https://doi.org/10.1016/j.compedu.2012.07.015.

43. Testers L, Gegenfurtner A, Brand-gruwel S. Taking affective learning in digital education one step further: trainees' affective characteristics predicting multicontextual pre-training transfer intention. Front Psychol. 2020;11:2189. https://doi.org/10.3389/fpsyg.2020.02189.

44. Toprak E, Aydin S. Ethics in e-learning 1. TOJET Turkish Online J Educ Technol. 2010;9(2):78–86.

45. Buckley P, Doyle E. Gamification and student motivation. Interact Learn Environ. 2016;24(6):1162–75. https://doi.org/10.1080/10494820.2014.964263.

46. Vinson CA. Using concept mapping to develop a conceptual framework for creating virtual communities of practice to translate cancer research into practice. Prev Chronic Dis. 2014;11(4):1–8.

47. Smith NR. Right-makers and the targets of virtue. J Value Inq. 2017;51(2):311–26. https://doi.org/10.1007/s10790-016-9571-8.

48. Chu A, Sullivan R, Sheng AY. Usability of learning moment: features of an E-learning tool that maximize adoption by students. West J Emerg Med. 2020;21(1):78–84. https://doi.org/10.5811/westjem.2019.6.42657.

49. Venkatesh S, Rao YK, Nagaraja H, Woolley T, Alele FO. Factors influencing medical students' experiences and satisfaction with blended integrated E-learning. Med Princ Pr. 2020;29:396–402. https://doi.org/10.1159/000505210.

50. Ding C, Li S, Chen B. Effectiveness of flipped classroom combined with team-, case-, lecture- and evidence-based learning on ophthalmology teaching for eight-year program students. BMC Med Educ. 2019;19(1):419. https://doi.org/10.1186/s12909-019-1861-y.

51. Rennie LJ. Blurring the boundary between the classroom and the community: challenges for teachers' professional knowledge. In: The professional knowledge base of science teaching. Springer Netherlands; 2011. p. 13–29. https://doi.org/10.1007/978-90-481-3927-9_2.

52. Hesrcu-Kluska R, Hesrcu-Kluska R. The interaction between learners and learner-facilitator in an online learning environment. Creat Educ. 2019;10(7):1713–30. https://doi.org/10.4236/CE.2019.107122.

53. Keaton W, Gilbert A. Successful online learning: what does learner interaction with peers, instructors and parents look like? J Online Learn Res. 2020;6(2):129–54.

54. Fabian K, Smith S, Taylor-Smith E, Meharg D. Identifying factors influencing study skills engagement and participation for online learners in higher education during COVID-19. Br J Educ Technol. 2022. https://doi.org/10.1111/BJET.13221.

55. Harnett M, George S, Dron J. Examining motivation in online distance learning environments: complex, multifaceted, and situation-dependent. Int Rev Res open distance Learn. 2011;12(6):20–38.

56. Saiyad S, Virk A, Mahajan R, Singh T. Online teaching in medical training: establishing good online teaching practices from cumulative experience. Int J Appl Basic Med Res. 2020;10(3):149. https://doi.org/10.4103/IJABMR.IJABMR_358_20.

57. Cook DA. The value of online learning and MRI: finding a niche for expensive technologies. Med Teach. 2014;36(11):965–72. https://doi.org/10.3109/0142159X.2014.917284.

58. Falloon G. From digital literacy to digital competence: the teacher digital competency (TDC) framework. Educ Technol Res Dev. 2020;68(5):2449–72. https://doi.org/10.1007/S11423-020-09767-4/FIGURES/4.

59. Donkin R, Askew E, Stevenson H. Video feedback and e-learning enhances laboratory skills and engagement in medical laboratory science students. BMC Med Educ. 2019;19(310):1–12.

60. Aguilar-Peña JD, Rus-Casas C, Eliche-Quesada D, Muñoz-Rodríguez FJ, Dolores La Rubia M. Content curation in e-learning: a case of study with Spanish engineering students. Appl Sci. 2022;12(6):3188. https://doi.org/10.3390/APP12063188.

61. Pedro NS, Kumar S. Institutional support for online teaching in quality assurance frameworks. Online Learn. 2020;24(3):50–66. https://eric.ed.gov/?id=EJ1272052. Accessed 29 Jul 2022.

62. Khin S, Ho TCF. Digital technology, digital capability and organizational performance: a mediating role of digital innovation. Int J Innov Sci. 2019;11(2):177–95. https://doi.org/10.1108/IJIS-08-2018-0083/FULL/PDF.

63. Masiero S, Arvidsson V. Degenerative outcomes of digital identity platforms for development. Inf Syst J. 2021;31(6):903–28. https://doi.org/10.1111/ISJ.12351.

64. Guraya SS, Guraya SY, Yusoff MSB. Preserving professional identities, behaviors, and values in digital professionalism using social networking sites; a systematic review. BMC Med Educ. 2021;21(1):1–12. https://doi.org/10.1186/S12909-021-02802-9/TABLES/3.

65. Durmuş SÇ, Gülnar E, Özveren H. Determining digital burnout in nursing students: a descriptive research study. Nurse Educ Today. 2022;111:105300. https://doi.org/10.1016/J.NEDT.2022.105300.

66. Braem S, Egner T. Getting a grip on cognitive flexibility. Curr Dir Psychol Sci. 2018;27(6):470–6. https://doi.org/10.1177/0963721418787475.

67. Vedechkina M, Borgonovi F. A review of evidence on the role of digital technology in shaping attention and cognitive control in children. Front Psychol. 2021;12:487. https://doi.org/10.3389/FPSYG.2021.611155/BIBTEX.

68. Danesh A, Bailey A, Whisenand T. Technology and instructor-interface interaction in distance education. Int J Bus Soc Sci. 2015;6(2). www.ijbssnet.com. Accessed 29 Jul 2022.

69. Alkis Y, Kadirhan Z, Sat M. Development and validation of social anxiety scale for social media users. Comput Hum Behav. 2017;72:296–303. https://doi.org/10.1016/j.chb.2017.03.011.