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Factors Influencing E-Learning Quality from the Perspective of Medical Sciences Students at Alborz University of Medical Sciences

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Abstract

Introduction: Given the widespread use of e-learning during the COVID-19 pandemic and the post-pandemic period—particularly in the critical field of medical sciences—examining students' perspectives on factors influencing e-learning quality is essential. The present study was conducted to investigate medical sciences students' perspectives on the factors affecting e-learning quality.

Methods: In this descriptive cross-sectional study, 854 medical sciences students at Alborz University of Medical Sciences, Karaj, Iran, were selected using convenience sampling between January and May 2022. The data collection instrument was a researcher-developed questionnaire comprising two sections: demographic information and factors influencing e-learning quality. After data collection, the data were analyzed using SPSS version 20, employing descriptive and inferential statistics at the $P \leq 0.05$ significance level.

Results: The mean score for instructor-related factors was 141.64 ± 19.41 (range: 35–175); for factors related to the educational content delivered, it was 55.32 ± 7.84 (range: 13–65); and for factors related to facilities, equipment, and infrastructure, it was 26.52 ± 3.63 (range: 6–30). Based on the results of the Friedman test, the highest-ranked domain was "factors related to facilities, equipment, and infrastructure". Among all dimensions, the items with the highest mean scores were as follows: teaching skills, mastery of the subject matter, ability to integrate theoretical and clinical content during instruction to facilitate better understanding, clear presentation of key and practical points in the instructional content, alignment between the amount of educational content and the learning objectives, scientific accuracy of the content, and inclusion of up-to-date material, the functioning microphone and uninterrupted audio, adequate internet speed, and availability of online class recording.

Conclusions: The development of adequate technical infrastructure, targeted investment, and the establishment of clear standards for evaluating learners' performance are essential for the effective utilization of e-learning. It is recommended that educational authorities and policymakers focus their efforts on enhancing the infrastructure of educational platforms and improving internet speed and quality. Additionally, organizing training workshops for faculty members on the principles of designing and conducting online classes, as well as producing standard electronic content, can contribute to improving instructors' teaching competencies and better addressing students' learning needs.

INTRODUCTION

With the global outbreak of the coronavirus, educational systems around the world faced unprecedented challenges. Schools and universities were closed due to concerns over the spread of the disease, and medical education—one of the most critical fields—was suddenly disrupted [1]. This crisis turned the planning for continuity in education and the completion of the academic year into a vital priority for educational systems. In response, leveraging technological capacities and adopting e-learning approaches emerged as an intelligent and flexible solution to the situation [2].

Learning is defined as a relatively permanent change in behavior that results from experience or practice and involves the acquisition of knowledge [3]. E-learning is defined as the use of digital technologies and the internet to deliver educational content, facilitate learner interaction, and assess their performance. This mode of education can take various forms, such as synchronous, asynchronous, blended, mobile-based, or game-based learning, with its main advantage being the provision of learning opportunities regardless of time and place. In this context, concepts such as distance learning, online education, and virtual learning fall under the broader umbrella of e-learning, each emphasizing a specific aspect of the learning process. For instance, distance learning primarily refers to the spatial separation between instructors and learners, whereas online and virtual education place particular emphasis on the use of internet platforms and interactive environments [4].

E-learning is a structured educational system that, through the use of modern technologies, redefines the teaching-learning process and enables instruction in online or offline environments—even when instructors and students are separated by time or space [4, 5]. Iran, with more than 40 million internet users, has also played a significant role in the development of this educational approach and holds the top rank in the Middle East in terms of the number of users [6]. E-learning in Iran was initiated in 2001 at the University of Tehran through the collaboration of several universities, and since 2020, with the onset and continuation of the COVID-19 crisis, its importance and necessity have received increased attention in educational institutions [7].

Experiences with e-learning in various countries—particularly in the field of medical sciences—vary significantly and are largely dependent on the level of infrastructure development and the extent of institutional support. While in developed countries such as the United States, the United Kingdom, and Italy, virtual education is widely recognized as an effective and commendable approach [8, 9], developing nations like Iran, Brazil, and Nepal face numerous challenges—including limited funding, inadequate infrastructure, and lack of equipment—that have undermined the effectiveness of this educational method [10-12].

The advantages of e-learning—such as easy access, temporal and spatial flexibility, and cost-effectiveness—have led to its increasing adoption [13, 14]. Furthermore, the use of multimedia content such as videos and podcasts can enhance the effectiveness of teaching and learning [15]. Research has also shown that webinars facilitate real-time interaction between instructors and students, making them a viable alternative to traditional face-to-face education [16, 17].

The skill-based and clinical nature of medical sciences disciplines, compared with other fields, makes theoretical learning alone insufficient; students require hands-on practice, clinical observation, and direct feedback [18, 19]. Consequently, the use of e-learning in medical sciences is accompanied by challenges such as the need for advanced simulation technologies to facilitate the transfer of practical skills [20]. A study by Mukhtar et al. (2020) in Pakistan also demonstrated that online education in the context of medical sciences is not effective for teaching and transferring practical and clinical skills, and is primarily useful for delivering theoretical knowledge. Additionally, due to the lack of immediate feedback in virtual instruction, instructors are unable to assess students' comprehension and progress during the teaching process [21].

According to existing evidence, e-learning generally enhances the knowledge of medical sciences students [22], and technology-based simulations also have a significant impact on improving their skills [23]. Nonetheless, e-learning is not without its challenges. Research conducted on the quality of virtual clinical education—particularly regarding mastery learning, its effects on patient outcomes, and the retention of learning—remains limited, heterogeneous, and methodologically diverse [24, 25]. Although the use of animations and three-dimensional models in technology-based simulations, especially in courses such as anatomy, substantially strengthens medical students' spatial understanding and knowledge retention [26], e-learning is accompanied by challenges such as reduced group interaction with peers [27]; the need for personal motivation, time management, and self-discipline on the part of students; limited social interaction; and negative impacts on the development of interpersonal skills and peer-support networks [28]. Moreover, additional challenges also confront e-learning, including issues such as technical difficulties, unreliable internet connectivity, lack of equipment, eye strain from prolonged screen exposure, and insufficient familiarity with educational software [29-31]. Such obstacles can lead to frustration and educational inequity among students [32].

In addition to infrastructure, the quality of educational content and instructors' proficiency in using technology play a pivotal role in the success of e-learning.

Instructors who possess the necessary digital competencies and hold a positive attitude toward the efficacy of online education tend to have a greater impact on student engagement and learning outcomes [33-35]. Therefore, empowering faculty members in the domain of e-learning and promoting the use of innovative teaching models are essential for improving the quality of virtual education and e-learning.

According to studies conducted in Iran, including the study by Feili et al. (2021), electronic knowledge and skills, organizational support, and system infrastructure and quality were identified as the most influential factors affecting the quality of virtual education at Hormozgan University of Medical Sciences [36]. Additionally, in the study by Kazemi Malek Mahmoudi et al. (2015), students at Golestan University of Medical Sciences reported that factors such as hardware and software infrastructure, social communication and collaborative techniques, instructional content and educational materials, learner assessment methods, academic disciplines, and finally student admission procedures played a role in the effectiveness of e-learning [37]. Similarly, the study by Golband et al. (2014) found that, from the perspective of virtual graduate students at Tehran University of Medical Sciences, instructor-related components, content, the virtual system, and student-related factors ranked from highest to lowest in their impact on e-learning [38].

Given the widespread use of e-learning during the COVID-19 pandemic and in the post-pandemic era—particularly in the critical field of medical sciences—examining students' perspectives on factors influencing e-learning quality is essential. As the primary stakeholders in this process, identifying students' needs, expectations, and experiences can serve as a foundation for developing strategies to enhance the teaching-learning process in virtual education. Accordingly, the present study was conducted to investigate the perspectives of students at Alborz University of Medical Sciences regarding the factors influencing e-learning quality during the COVID-19 pandemic to answer the question of which factors, from the perspective of the university's students, had the greatest impact on the quality of e-learning.

METHODS

Study Design, Setting, and Participants

This descriptive cross-sectional study was conducted between January and May 2022 at Alborz University of Medical Sciences. The study population included all medical sciences students (n = 3,500) across various disciplines, including nursing, midwifery, anesthesia, surgical technology, laboratory sciences, public health, emergency medicine, medicine, dentistry, and pharmacy. Based on Cochran's formula ($\alpha = 0.05$; $p = 0.5$, $q = 0.5$), the minimum required sample size was 350. To mitigate potential non-response and incomplete questionnaires, the sample size was increased to 900 to ensure adequate data reliability.

Inclusion criteria consisted of access to the internet, possession of a smartphone and/or laptop/desktop computer for participation in online and offline classes, and use of electronic educational content. Students who were willing to participate were recruited through convenience sampling. The exclusion criterion was incomplete responses to more than 5% of the questionnaire. In light of the COVID-19 pandemic and the requirement to conduct all classes electronically, students had between one and five semesters of experience with e-learning courses.

Instruments

In this study, a researcher-developed questionnaire consisting of two sections was used in accordance with the study objectives:

Section 1: Demographic Information

This section included seven items related to age, gender, marital status, academic major, academic level, and semester of study.

Section 2: Factors Influencing E-Learning Quality

This section consisted of 54 items across three domains: factors related to facilities, equipment, and infrastructure, factors related to the educational content delivered, and instructor-related factors. The influence of each item was assessed using a five-point Likert scale, ranging from 1 (very low) to 5 (very high).

The questionnaire was initially developed with 68 items based on a literature review [39-41]. Face and content validity were subsequently evaluated by ten faculty members at Alborz University of Medical Sciences, including experts in instrument development (n = 4), nursing education (n = 5), and medical education (n = 1). Content validity was assessed using the Content Validity Ratio (CVR) to determine the "necessity" of each item, categorizing them as "essential," "useful but not essential," or "not essential," with a minimum acceptable CVR of 0.62 for ten experts, according to Lawshe's table [42]. Ten items scoring below this threshold were removed, leaving 58 items for further assessment using the Content Validity Index (CVI). In this stage, 54 items achieved CVI values above 0.79, while four items scoring below 0.7 were excluded. Construct validity was evaluated through Confirmatory Factor Analysis (CFA) using Smart PLS version 3. Reliability was assessed with Cronbach's alpha based on responses from 30 students, yielding coefficients of 0.95 for instructor-related factors, 0.84 for factors related to facilities, equipment, and infrastructure, 0.92 for educational content, and 0.96 for the overall questionnaire.

Data Collection

Data collection commenced following the approval of the Ethics Committee at Alborz University of Medical Sciences. Given the COVID-19 pandemic and the lack of in-person access to students, the electronic version of the questionnaire was administered via the Persian online survey platform "Porsline". Initially, the electronic questionnaire was designed to include explanations regarding the study title, objectives, and methodology. Subsequently, one student from each academic major was designated as a representative to facilitate communication with fellow students. These representatives were responsible for distributing the questionnaire link to eligible student groups via social media platforms such as Telegram and WhatsApp. Students who were willing to participate in the study completed the questionnaire. Data were collected over four months from January to May 2022. The questionnaire link was distributed to 900 students, of whom 854 completed the survey, yielding a response rate of 94.8%. This sample size (n = 854) exceeded the minimum required size of 350 originally calculated using Cochran's formula.

Statistical Analysis

Data analysis was performed using SPSS software version 20, employing both descriptive statistics (frequency, percentage, mean, and standard deviation) and inferential statistics (Friedman rank test). A significance level of $p \leq 0.05$ was considered for all statistical tests. To assess the distribution of the data (normality), skewness and kurtosis indices were used. Since the skewness and kurtosis values for all variables fell within the acceptable range of -2 to +2, the distribution of all variables was considered normal.

RESULTS

Of the 854 students who completed the questionnaire, 56.9% were male, and the majority of participants were single (92.7%). Most participants were undergraduate (53.4%) and professional doctoral students (42.5%). Students from the fields of nursing (27.2%), medicine (19.1%), pharmacy (12.8%), and dentistry (10.8%) had the highest participation rates, respectively. Most students (66.7%) were in semesters 1 to 5. The majority (70.4%) were 22 years old or younger, with a mean age of 22.04 ± 4.19 years and an age range of 17 to 50 years (Table 1).

As shown in Table 2, the mean score for instructor-related factors was 141.64 ± 19.41 (range: 35–175); for factors related to the educational content delivered, it was 55.32 ± 7.84 (range: 13–65); and for factors related to facilities, equipment, and infrastructure, it was 26.52 ± 3.63 (range: 6–30).

Table 1. Demographic characteristics of medical sciences students participating in the study (n=854)

	No. (%)
Gender	
Male	486 (56.9%)
Female	368 (43.1%)
Marital Status	
Single	792 (92.7%)
Married	62 (7.3%)
Academic Major	
Nursing	232 (27.2%)
Medicine	163 (19.1%)
Pharmacy	109 (12.8%)
Dentistry	92 (10.8%)
Health Science	81 (9.5%)
Pre-Hospital Emergency	53 (6.2%)
Laboratory Sciences	48 (5.6%)
Operating Room Technology	39 (4.6%)
Anesthesia	31 (3.6%)
Midwifery	6 (0.7%)
Education Level	
Bachelor	456 (53.4%)
Professional doctoral students	363 (42.5%)
Associate degree	25 (2.9%)
Master	10 (1.2%)
Semester	
1–5	570 (66.7%)
6–10	246 (28.8%)
11–13	38 (4.4%)
Age	
≤ 22	601 (70.4%)
> 22	253 (29.6%)

Using a one-sample t-test, the mean scores were compared with the expected mean values for each dimension (105 for instructor-related factors, 39 for factors related to the educational content delivered, and 18 for factors related to facilities, equipment, and infrastructure). The results indicated that the mean scores for all dimensions were significantly higher than the expected values for each dimension of the questionnaire ($p < 0.001$) (Table 2).

Based on the results of the Friedman test, conducted to rank the factors influencing e-learning quality, the highest-ranked domain was "factors related to facilities, equipment, and infrastructure" with a mean score of 4.42 ± 0.60. This was followed by "factors related to the educational content delivered" (4.25 ± 0.60), and "instructor-related factors" (4.05 ± 0.55) (Table 3).

Table 2. Mean and standard deviation of factors influencing the quality of e-learning, and comparison mean with the average value of each dimension

	Mean ± SD	Min	Max	Mean diff	t	P-value*	Effect Size
Instructor-related factors	141.64 ± 19.41	35	175	36.64	55.17	< 0.001	19.41
Factors related to the educational content	55.32 ± 7.84	13	65	16.32	60.85	< 0.001	3.63
Factors related to facilities, equipment, and infrastructure	26.52 ± 3.63	6	30	8.52	68.57	< 0.001	7.84

*One Sample T-Test, df = 853

Table 3. Mean and standard deviation of factors influencing the quality of e-learning and their ranking based on the Friedman test

Rank	Factors	Mean ± SD
1	Factors related to facilities, equipment, and infrastructure	4.42 ± 0.60
2	Factors related to the educational content	4.25 ± 0.60
3	Instructor-related factors	4.05 ± 0.55

Chi Square = 429.11, df = 2, P < 0.001

Table 4. Mean and standard deviation of the questionnaire items and their ranking using the Friedman test

	Mean ± SD	Rank	Test
Factors related to facilities, equipment, and infrastructure (6 items)			Chi-square = 87.39; df = 5; P-value < 0.001
The functioning microphone and uninterrupted audio	4.55 ± 0.75	1	
Adequate internet speed	4.47 ± 0.77	2	
Availability of online class recording	4.42 ± 0.84	3	
Background noise during the instructor's lecture	4.41 ± 0.83	4	
The instructor's skill and proficiency in using online and offline educational platforms	4.36 ± 0.79	5	
Adherence to the designated duration and exact start and end times of the online class	4.32 ± 0.87	6	
Factors related to the educational content (13 items)			Chi-square =5902.79; df = 34; P-value < 0.001
Clear presentation of key and practical points in the instructional content	4.50 ± 0.71	1	
Alignment between the amount of educational content and the learning objectives	4.46 ± 0.74	2	
Scientific accuracy of the content and inclusion of up-to-date material	4.45 ± 0.72	3	
Use of images and educational videos relevant to the subject matter	4.38 ± 0.79	4	
Logical and well-organized presentation of the content during the session	4.35 ± 0.76	5	
Consistency between the lecture slides and the instructor's verbal explanations	4.26 ± 0.90	6	
Preparation of slides and educational content by the instructor themselves	4.26 ± 0.87	7	
Clear identification of the sources used by the instructor	4.20 ± 0.94	8	
Use of PowerPoint and slides for teaching	4.16 ± 0.91	9	
Presentation of practical and attainable learning objectives	4.13 ± 0.88	10	
Correct spelling and punctuation in the presented content	4.08 ± 3.63	11	
Appropriate layout and font in the presented materials	4.07 ± 0.91	12	
Providing links to educational videos to reinforce the taught content	4.02 ± 0.99	13	
Instructor-related factors (35 items)			Chi-square =5902.79; df = 34; P-value < 0.001
Teaching skills	4.73 ± 0.59	1	
Instructor's mastery of the subject matter	4.56 ± 0.72	2	
Ability to integrate theoretical and clinical content during instruction to facilitate better understanding	4.51 ± 0.75	3	
Instructor's enthusiasm for the subject being taught	4.50 ± 0.72	4	
Proficiency in applying appropriate teaching methods and techniques based on the content	4.49 ± 0.72	5	
Communication skills and the ability to engage with students in online classes	4.41 ± 0.83	6	
Time management skills during teaching	4.37 ± 0.80	7	
Organization and coherence in the instructor's speech	4.35 ± 0.79	8	
Fair and equitable treatment of students by the instructor	4.33 ± 0.85	9	
Instructor's speaking pace during lectures	4.31 ± 0.81	10	
Ability to inspire interest and motivation in students for learning	4.28 ± 0.83	11	
Instructor's flexibility	4.27 ± 0.85	12	
Receptiveness to feedback and constructive criticism	4.22 ± 0.91	13	
Instructor's tone of voice during teaching	4.19 ± 0.91	14	
Recognizing and accommodating individual differences among students in teaching	4.16 ± 0.89	15	
Providing sufficient and appropriate time for feedback and addressing students' questions and difficulties	4.15 ± 0.88	16	
Instructor's self-confidence	4.14 ± 0.90	17	
Incorporating short breaks during online teaching sessions	4.12 ± 0.94	18	
Skill in guiding and advising students to appreciate the importance of the subject	4.10 ± 0.87	19	
Instructor's ability to use teaching methods that promote critical and creative thinking	4.09 ± 0.85	20	
Providing feedback and motivation to encourage students' attendance in online classes	4.03 ± 0.94	21	
Use of innovative and modern teaching methods by the instructor	4.03 ± 0.93	22	
Encouraging and stimulating students for independent learning	4.02 ± 0.99	23	
Instructor's accessibility outside of scheduled virtual class hours	4.01 ± 0.96	24	
Observance of social and ethical norms by the instructor during teaching	3.99 ± 0.99	25	
Guiding and supporting students in completing academic tasks	3.86 ± 1.00	26	
Creating opportunities for student participation in online class discussions	3.80 ± 1.02	27	
Continuous assessment of student learning by the instructor	3.73 ± 1.02	28	
Attention to the presence and engagement of active students	3.70 ± 1.08	29	
Instructor's assertiveness and appropriate level of strictness	3.64 ± 1.07	30	
Assigning short tasks at the end of each session to reinforce learning	3.58 ± 1.14	31	
Instructor's extensive teaching experience	3.45 ± 1.05	32	
Providing feedback to inactive students	3.39 ± 1.15	33	
Instructor's academic rank	3.15 ± 1.15	34	
Assigning students the responsibility of presenting parts of the course content	3.03 ± 1.29	35	

Table 5. Factors influencing the quality of e-learning by demographic characteristics

	Instructor-related factors	Factors related to facilities, equipment, and infrastructure	Factors related to the educational content	Total Factors
Gender				
Male	143.95 ± 17.23	27.20 ± 2.88	56.59 ± 6.94	227.75 ± 24.73
Female	138.59 ± 21.61	25.61 ± 4.27	53.64 ± 8.16	217.85 ± 32.12
t	4.03	6.50	5.54	5.09
p-value	< 0.001*	< 0.001*	< 0.001*	< 0.001*
Effect Size	19.24	3.55	7.70	28.15
Marital Status				
Single	141.21 ± 19.51	26.46 ± 3.68	55.18 ± 7.89	222.86 ± 28.73
Married	147.15 ± 17.28	27.21 ± 2.90	57.08 ± 6.96	231.44 ± 25.12
t	2.32	1.56	1.84	2.28
p-value	0.02*	0.12	0.06	0.02*
Effect Size	19.36	3.63	7.83	28.49
Age				
≤ 22	140.65 ± 19.45	26.52 ± 3.70	55.27 ± 7.85	222.45 ± 28.66
> 22	143.99 ± 19.16	26.51 ± 3.46	55.43 ± 7.83	225.93 ± 28.23
t	2.30	0.06	0.27	1.63
p-value	0.02*	0.02*	0.79	0.11
Effect Size	19.36	3.63	7.84	28.53
Academic Major				
Medicine	137.72 ± 18.03	26.82 ± 3.02	55.43 ± 6.54	219.96 ± 24.55
Dentistry	142.60 ± 17.77	26.30 ± 3.57	54.98 ± 7.62	223.88 ± 26.98
Pharmacy	143.06 ± 19.01	26.73 ± 3.19	55.83 ± 7.17	225.62 ± 26.60
Nursing	142.62 ± 18.70	26.27 ± 3.62	55.22 ± 7.57	224.11 ± 27.82
Midwifery	142.33 ± 20.80	26.67 ± 3.72	55.33 ± 8.12	224.33 ± 29.96
Medical emergencies	132.98 ± 31.33	24.38 ± 6.16	50.77 ± 12.50	208.13 ± 48.39
Health Science	143.95 ± 15.58	26.93 ± 3.03	55.62 ± 6.91	226.49 ± 23.57
Operating Room Technology	144.97 ± 19.22	27.28 ± 3.97	55.72±9.34	227.97 ± 30.08
Anesthesia	142.68 ± 18.29	27.13 ± 3.12	57.16 ± 7.76	226.97 ± 27.06
Laboratory Sciences	147.42 ± 17.23	27.25 ± 3.11	57.92 ± 7.15	232.58 ± 24.65
F	2.86	3.05	2.92	2.92
p-value	0.003*	0.001*	0.002*	0.002*
Effect Size	0.030	0.032	0.030	0.030
Level of education				
Associate degree	130.72 ± 37.08	23.76 ± 7.07	49.56 ± 14.57	204.04 ± 57.09
Bachelor	143.05 ± 18.63	26.57 ± 3.63	55.56 ± 7.87	225.18 ± 28.03
Master	144.70 ± 19.06	26.00 ± 3.56	54.60 ± 7.11	225.30 ± 26.54
Medical Practitioner Students	140.55 ± 18.42	26.66 ± 3.22	55.43 ± 7.01	222.64 ± 25.89
F	3.94	5.16	4.76	4.57
p-value	0.008*	0.002*	0.003*	0.003*
Effect Size	0.014	0.018	0.017	0.016
Semester				
1-5	142.48 ± 19.71	26.53 ± 3.78	55.70 ± 8.05	224.72 ± 29.31
6-10	139.09 ± 19.01	26.43 ± 3.53	54.20 ± 7.36	219.71 ± 27.12
10-14	145.58 ± 15.74	26.87 ± 3.09	56.84 ± 6.93	229.29 ± 23.80
F	3.47	0.26	3.96	3.49
P-value	0.03*	0.77	0.02*	0.03*
Effect Size	0.008	0.001	0.009	0.008

t = Independent sample T test, F = ANOVA, statistically significant at p ≤ 0.05*

According to the findings, within the dimension of Instructor-related factors, the highest mean score was attributed to the item "teaching skills (clear and explicit presentation of content and logical sequencing)" (4.73 ± 0.59). This was followed by the items "mastery of the subject matter" (4.56 ± 0.72) and "ability to integrate theoretical and clinical content during instruction to facilitate better understanding" (4.51 ± 0.75). The Friedman test indicated a significant difference among item rankings within this dimension (χ^2 = 5902.79, df = 34, P < 0.001).

In the dimension of Factors related to the educational content delivered, the highest mean score corresponded to the item "clear presentation of key and practical points in the instructional content" (4.50 ± 0.71). This was followed by "alignment between the amount of educational content and the learning objectives" (4.46 ± 0.74) and "scientific accuracy of the content and inclusion of up-to-date material" (4.45 ± 0.72). The Friedman test also revealed significant differences in item rankings within this dimension (χ^2 = 5902.79, df = 34, P < 0.001).

For the dimension of Factors related to facilities, equipment, and infrastructure for online and offline education, the highest mean score was observed for the item "the functioning microphone and uninterrupted audio" (4.55 ± 0.75). The items "adequate internet speed" (4.47 ± 0.77) and "availability of online class recording" (4.42 ± 0.84) were ranked next. The Friedman test indicated significant differences among

item rankings in this dimension as well ($\chi^2 = 87.39$, df = 5, $P < 0.001$) (Table 4).

Analysis of factors influencing e-learning quality based on demographic characteristics showed that, across all three dimensions, male students had significantly higher scores than female students ($p < 0.001$). Married participants also had higher scores than single participants in the dimension of instructor-related factors and overall questionnaire score ($p = 0.02$). Age was significantly associated with the scores of the instructor-related factors dimension and the factors related to facilities, equipment, and infrastructure; students older than 22 years had higher scores ($p = 0.02$). By academic major, laboratory sciences students had higher overall scores ($p = 0.02$), and operating room technology students had higher scores in the dimension of factors related to facilities, equipment, and infrastructure ($p = 0.02$). Regarding educational level, master's students had higher scores in the instructor-related factors dimension ($p = 0.008$) and overall questionnaire score ($p = 0.003$); professional doctoral students had higher scores in the dimension related to facilities, equipment, and infrastructure ($p = 0.002$); undergraduate students had higher scores in the dimension of factors related to the educational content delivered ($p = 0.003$). The academic term (semester) was also significantly associated with the scores of the instructor-related factors dimension ($p = 0.03$), the factors related to the educational content delivered ($p = 0.02$), and overall questionnaire score ($p = 0.03$), such that students in terms 10–14 had higher scores (Table 5).

DISCUSSION

The present study was conducted to investigate the factors influencing e-learning quality during the COVID-19 pandemic. Based on the findings, the most significant factors during this period were, in order of importance: factors related to facilities, equipment, and infrastructure for online and offline education; factors related to the educational content delivered; and instructor-related factors.

In contrast to the findings of the present study, in the study by Moslehi and Alidoust Ghahfarrokhi (2022), instructor characteristics were identified as the most influential factor affecting the quality of e-learning in both theoretical and practical courses from the perspective of undergraduate physical education students at Tehran University. This was followed by the technical features of the educational platform, and then by the educational content [43]. This discrepancy in results may be attributed to the inherent characteristics of the disciplines and the differing learning needs of medical sciences students compared with those of physical education students.

Among the factors related to online/offline educational infrastructure—which ranked first in importance—four items received the highest mean ranks: functioning microphones and uninterrupted audio; adequate internet speed; ability to record online classes; and background noise during instruction. In this regard, various studies have emphasized the critical role of technical issues in the effectiveness of online education. For instance, technical problems such as audio and video disruptions [31, 44, 45], internet speed and quality [46, 47], unstable connections and spontaneous disconnection during online classes [14, 48, 49], and extraneous noises during class recordings [45] were identified as major challenges by participants—highlighting their importance in the effectiveness of e-learning [50].

Additionally, in the study by Mortazavi et al. (2021), students expressed dissatisfaction with non-downloadable files. Some also reported a lack of access to a computer or laptop at home and difficulty adapting to studying via mobile phones [6]. Similarly, Sahu (2020) noted that the lack of laptops and internet access at home was a major issue many students faced in the context of e-learning [51].

Moreover, nursing students in the study by Watson et al. (2023) stated that recorded virtual classes allowed them to study at their own pace and at times convenient to them. This flexibility supported their understanding of the course content [52]. Of course, for this flexibility to yield positive outcomes, students must demonstrate personal motivation, time management skills, and self-discipline [28].

In the study by Chamasemani and Ehtesham (2021), key infrastructure-related factors influencing the quality of virtual education included high-speed, free internet; the provision of appropriate virtual infrastructure for all three stakeholders (universities, faculty, and students); upgrading necessary infrastructure; and allocating sufficient bandwidth [53].

Based on the findings of these studies, it can be concluded that the provision of technological facilities and equipment is a foundational and critical factor in e-learning. Providers of online courses need to offer high-quality support services for learners, who are the primary stakeholders in the educational process [39]. In other words, improving the e-learning process requires the enhancement of reliable and affordable internet access, the development of appropriate infrastructure, and the provision of accessible technical support. Advancing these areas can facilitate more effective use of virtual education, improve the learning process, and promote innovative learning methods [12].

Among the factors related to the educational content delivered—which ranked second in importance—four items received the highest mean rankings: clear presentation of key and practical points in the course content; alignment between the amount/quantity of

content and the learning objectives; scientific accuracy and inclusion of up-to-date material; and use of images and educational videos appropriate to the topic. The findings of the study by Veisi et al. (2021) similarly emphasized the use of instructional content that is clear, understandable, simple, and straightforward; appropriately scoped to learning goals; and scientifically accurate, efficient, and useful [39].

According to a study conducted by Bao at Peking University, dividing instructional content into smaller segments (each approximately 20 to 25 minutes long) can help improve students' concentration during the learning process [54]. Likewise, the study by Atashinsadaf et al. (2024) found that most students favored concise lectures, educational videos, interactive sessions, group discussions, role-playing, and teaching methods that combined both verbal and visual delivery [14]. In the study by Cheraghbeigi et al. (2023), students reported using audiovisual resources such as watching educational videos and listening to recorded PowerPoint slides to better understand the material [45].

In e-learning, the design and production of content is of paramount importance. When grounded in a set of established principles and scientific theories, content can serve as an effective educational resource that meets learners' needs and helps them achieve their goals in the shortest possible time. One of the distinctive features of virtual education is its simultaneous use of visual, auditory, and written learning modalities [55]. Educational materials accompanied by videos or audio files promote better learning and support uninterrupted instruction, ultimately enhancing learning effectiveness [15]. Therefore, a key distinction between traditional and virtual education can be drawn: while traditional education is often one-dimensional, virtual learning offers a more dynamic and multifaceted approach [56].

Among the instructor-related factors—which ranked third in importance—four items received the highest mean ranks: instructor's teaching skills; instructor's mastery of the course content; ability to connect theoretical and clinical concepts to facilitate understanding; and instructor's enthusiasm for the subject matter. These findings are consistent with the results of Bashardoust et al. (2020) [41]. Similarly, Çakmakkaya et al. (2024) reported that the online teaching skills of faculty members, along with the use of teaching methods prioritizing interactive strategies, significantly enhanced student satisfaction [50]. Zareisaroukolaei et al. (2020) also recommended that instructors ensure mastery of the subject, present content with interest and enthusiasm, and possess strong subject-matter expertise to increase the effectiveness of e-learning [57].

According to the findings of the present study, two additional instructor-related items—proficiency in applying appropriate teaching methods and techniques based on the content, and communication skills and the ability to interact with students in online classes—were ranked fifth and sixth, respectively. Badeleh and Shamloo (2023) also identified proficiency in educational software, the application of modern teaching strategies, and the use of technology-based teaching models as key factors contributing to improved virtual education [35].

In asynchronous e-learning environments, students often lack a mental image of the instructor's face, teaching style, and personal attributes. In such contexts, the absence of direct interaction between students and instructors may hinder effective communication [44]. In other words, one of the primary barriers to effective virtual education is the reduced opportunity for face-to-face interaction and verbal communication [6], which can lead to feelings of isolation or concern among students regarding the inadequacy of their learning experience [55].

The classroom is a formal environment in which instructors—who believe they can positively influence students' learning—strive to enhance learning by interacting and building meaningful connections with them. Accordingly, one of the key strategies for the successful implementation of online education is faculty empowerment [39]. Instructors must be proficient in virtual education and able to flexibly integrate digital technologies into their teaching practices [33]. Teaching competency appears to significantly influence student engagement and learning outcomes in virtual education settings [33, 34]. Moreover, an instructor's positive attitude toward the effectiveness of e-learning can foster greater enthusiasm and willingness to use such technologies in teaching and learning processes [57].

In addition, motivation to adopt virtual education, proficiency with educational software, the use of modern and technology-based teaching strategies, mastery of diverse assessment methods, and the possession of strong ethical leadership are among the key components that contribute to improved quality in virtual education [35]. Therefore, educational system experts need to design and implement faculty development programs aimed at cultivating the knowledge, skills, and positive attitudes necessary for effective e-learning [39].

On the other hand, in recent years, emerging educational technologies such as interactive simulators, virtual reality (VR), and artificial intelligence (AI) have created valuable opportunities to enhance medical sciences education, which can be effectively utilized [58-60]. Simulation-based and VR-based learning allow students to practice clinical skills in a safe and controlled environment before entering real clinical settings, and have demonstrated positive effects on clinical competence, critical thinking, reduced anxiety, and increased self-confidence [58, 59]. Moreover,

integrating artificial intelligence into medical education can provide personalized learning, immediate feedback, and improved learning outcomes [60].

According to the findings of the present study, male and married participants had significantly higher overall questionnaire scores compared to female and single participants. The researchers believe that male students in this study may have experienced greater self-efficacy and confidence in using technology and virtual environments. Additionally, the social and familial responsibilities of married individuals may have increased their sense of commitment when responding to the questionnaire, leading to more accurate identification of factors influencing e-learning quality. Age was significantly associated with instructor-related factors and facilities, equipment, and infrastructure for online and offline education. Students older than 22 years had higher scores in both dimensions. The researchers suggest that older students typically have more experience with the university environment and interactions with instructors; therefore, they may better understand and more fairly evaluate instructor performance-related criteria. Furthermore, over time, their skills in using virtual learning systems tend to improve, which may enhance their perceptions of the quality of the virtual environment and available facilities. Students in laboratory sciences scored significantly higher on the overall questionnaire, and operating room technology students scored higher in the dimension related to facilities, equipment, and infrastructure. This may be due to the inherently practical and technologically oriented nature of these disciplines. Students in these fields frequently use specialized tools and equipment (including laboratory software and operating room simulators), which may increase their readiness to engage with educational technologies and improve their ability to identify factors influencing e-learning. These differences across fields of study may also be attributable to students' individual attitudes. Moreover, master's students and those in semesters 10–14 obtained higher scores on the overall questionnaire. Similarly, in the study by Hung et al. (2010), senior students demonstrated considerably higher readiness for self-directed learning and online self-efficacy compared to junior students [61]. This may facilitate more accurate recognition of factors influencing electronic education among these groups.

Study Limitations

This was a cross-sectional study, with data collection conducted for four months. To gain a more comprehensive understanding of factors influencing e-learning quality, the design and implementation of interventional and longitudinal studies are recommended. Moreover, the target population in this study consisted solely of students from a single university; therefore, the findings cannot be readily generalized to students at other institutions. Accordingly, multicenter studies with larger sample sizes and the inclusion of university faculty are recommended.

Another limitation of this study is the use of convenience sampling, which may be associated with certain degrees of bias. However, given that all university instruction was conducted entirely online during the COVID-19 pandemic, all students were required to use virtual learning systems; therefore, the likelihood of over-representation of students already familiar with technology was reduced. Nevertheless, caution is still warranted when generalizing the findings, and it is recommended that future studies employ probability sampling methods to enhance generalizability.

Another one of the limitations is the omission of certain variables, such as peer interaction. Future research is advised to examine variables such as peer interactions, group collaboration, and social support within e-learning environments separately, to provide a more comprehensive understanding of factors affecting the quality of electronic education. Potential response biases related to the COVID-19 pandemic also represent a limitation of the present study. Students' perceptions and attitudes toward e-learning during the pandemic may have been influenced by sudden transitions and psychological pressures associated with this period, potentially shaping their views in temporary or biased ways. It is recommended that future studies assess this contextual factor separately and compare pre- and post-pandemic student groups to enable a more precise analysis of perceptions and attitudes.

CONCLUSIONS

The findings of this study indicated that factors related to online and offline educational infrastructure, the quality of educational content, and the role of instructors were, respectively, the most significant elements influencing the quality of e-learning from the students' perspectives. Accordingly, developing appropriate technical infrastructure, making targeted investments, and establishing clear standards for learner assessment are essential for the effective utilization of e-learning. It is recommended that educational policymakers and administrators focus their efforts on improving the infrastructure of learning platforms and enhancing internet speed and quality. Additionally, organizing training workshops for faculty members on the principles of conducting online classes and creating high-quality digital content can enhance their teaching skills and better address students' learning needs.

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AUTHORS' CONTRIBUTION

M.KZ. and M.A. were involved in the conception and organization of the study. M.KZ. was involved in data collection. M.A. and E.S. designed the statistical analysis. M.KZ., N.SH. and M.N. prepared the first draft of the manuscript. M.A. performed the critical review, and all authors approved the final manuscript.

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ETHICAL CONSIDERATIONS

This study was conducted in accordance with the principles outlined in the revised Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of Alborz University of Medical Sciences (Ethics Code: IR.ABZUMS.REC.1398.226). All ethical considerations were observed throughout the research process. Participation in the study was entirely voluntary. At the beginning of the online questionnaire, participants were provided with information regarding the purpose of the study and informed consent. Completion and submission of the questionnaire were considered as implied informed consent. The questionnaires were completed anonymously, and all participant information was kept strictly confidential.

CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

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