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Validation of a Multidimensional E-Learning Quality Model for Clinical Military Medical Training

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Abstract

Introduction: The present study was conducted to design a quality management model for e-learning in the clinical groups of military medical universities.

Methods: This research is an exploratory mixed-methods design in terms of data type. The statistical population in the qualitative section consisted of experts and university professors experienced in the field of clinical e-learning, selected using purposive sampling of the theoretical type until theoretical saturation was achieved, resulting in 19 individuals being selected. In the quantitative part, there were 381 individuals, of whom 191 were selected using stratified random sampling. The data collection tool in the quantitative phase was a researcher-made questionnaire, which was developed by weighting the indicators derived from the qualitative section.

Results: The validated model comprises five key dimensions: Standards (prioritizing instructor competence), Planning (emphasizing resource management), Information Technology (focusing on system design), Continuous Quality Improvement (centered on quality control), and Evaluation (stressing internal assessment). All dimensions demonstrated strong reliability (α=0.784-0.983) and validity (AVE>0.50), with excellent model fit (SRMR=0.065, NFI=0.954). The Standard dimension ranked highest in importance, followed by Planning, IT, CQI, and Evaluation. Structural analysis confirmed significant factor loadings (0.755-0.963, $p<0.001$) across all components. This comprehensive framework effectively addresses the unique e-learning quality needs of military medical education.

Conclusion: This model offers a customized framework for managing e-learning quality in clinical groups at military medical universities. Structural equation modeling confirmed the model's fit, with each indicator playing a significant role in the overall model. This framework not only supports quality improvement in military clinical e-learning but also presents innovative quality management strategies tailored for medical and combat medicine training.

Keywords: Quality Management, E-Learning, Clinical Groups, Military Medical Universities.

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Introduction

Clinical education environments are considered the primary source of learning and professional identity formation for medical students and are therefore of significant importance. These environments are characterized by their dynamic and unpredictable nature, which inevitably affects the students' learning experience [1-3]. The integration of electronic technologies into clinical education in medical universities offers both opportunities and challenges. While these technologies can facilitate access to a wealth of educational resources, promote interactive learning environments, and enhance learner-instructor communication, they are not without issues [4-5]. One major issue involves technical difficulties that can disrupt access to course materials and hinder the learning process. Furthermore, assessing the quality of clinical education becomes problematic, as online settings may lack the depth and interaction of real classroom and clinical environments. The absence of real-world contact and experience in virtual environments can prevent learners from fully understanding and applying medical concepts and procedures [6-8].

A persistent concern in clinical education at medical universities is maintaining educational quality and minimizing harm to patients in teaching hospitals. Improving the quantity and quality of medical sciences education has always been a concern for medical education authorities, yet educational programs have often lacked the reforms necessary to address shortcomings—contributing to ongoing issues in healthcare delivery being linked to medical education shortcomings [5-9].

As warfare has become more destructive, so too have medical and nursing care systems evolved. Medical personnel, including medical and nursing students, often face potential exposure to chemical injuries or radiation in modern warfare environments. Since it is not feasible to recreate these conditions in clinical settings and chemical casualties are not admitted to military hospitals for training purposes, and because it would be unsafe to simulate these training scenarios on other patients, education in such cases carries considerable risk to healthcare personnel and can deplete medical resources [10-12]. Therefore, there is a critical need for careful educational planning and the use of advanced technologies to deliver high-quality clinical education. Training military medical personnel and improving the knowledge, skills, and readiness of clinical groups through military medical academies requires specialized, often costly environments and mannequins. These enable learners to perform essential life-saving interventions in out-of-hospital and resource-limited settings [5-9]. To this end, high-quality simulated e-learning environments using VR and AR headsets**,** animal and human simulation**,** artificial intelligence**,** machine learning**,** e-learning modules, virtual clinics, and more have helped mitigate these challenges. They enable learners to train for crisis and field conditions that are otherwise impossible to replicate in traditional educational settings [10-15].

Over recent years, many studies have focused on modern digital education methods in medical universities, aimed at enriching and ensuring the quality of medical education. However, despite the variety of studies evaluating the performance of e-learning in medical education, there seems to be a lack of significant research in Iran, especially considering the mission of military medical universities, which is to train human resources committed to religious values, military discipline, and professional competence. These individuals are expected to provide specialized educational and healthcare services in response to military occupational hazards and national crises [6-8]. Medical education is inherently complex and not as easily adapted to e-learning as some other fields. Therefore, this study—through access to existing literature, analysis of current models, and consultation with clinical education experts in military medical universities—aims to assess the quality performance of e-learning in medical education. It seeks to identify key dimensions and components, evaluate the use of innovative strategies, especially in teaching clinical skills, and provide a new conceptual model to help military medical universities assess and manage the quality of e-learning. This model can bridge current gaps and aid in strategic planning to enhance and manage the quality of this learning approach, considering the specific missions and constraints of military medical universities. It will also inform policy-making and strategic initiatives aimed at raising the level of clinical e-learning in these institutions.

Methods

The present study is of an exploratory mixed-method type (qualitative–quantitative).

Population and Sampling

The statistical population of this study consisted of two parts:

Qualitative Phase: Participants included experts, specialists, and academic faculty members in the fields of clinical education and military medicine. These participants were faculty members from military medical universities with at least 5 years of experience in teaching electronic learning and the army medicine. Additionally, participants included PhD-level experts in virtual education, medical education, higher education, and educational management, as well as IT engineers with a master's degree or higher and a minimum of 5 years of work experience. In the qualitative phase, theoretical saturation was achieved after conducting 19 interviews.

Quantitative Phase: The population consisted of clinical faculty members, educational specialists, and IT engineers from military medical universities. To determine the sample size for the quantitative phase, Krejcie and Morgan's table (1970) was used. Based on this table, a population of 381 individuals was used, and 191 participants were selected through stratified random sampling.

This group included: 72 medical faculty members, 76 nursing faculty members, 35 educational specialists (5 in higher education, 3 in virtual education, 12 in medical education, and 15 in educational management), and 8 IT engineers.

Data Collection Tools

The study employed two main tools:

Qualitative Phase: Semi-structured interviews conducted by the researcher were used to collect data.

Quantitative Phase: A researcher-developed questionnaire was created based on a review of the theoretical literature and findings from the qualitative analysis and model development. Each item in the questionnaire corresponded to an indicator identified in the conceptual model. The questionnaire was scored using a seven-point Likert scale.

Validity and Reliability

Face Validity: The questionnaire was reviewed by several university experts in clinical e-learning and military medicine education to assess grammar, word choice, question placement, and scoring appropriateness. Revisions were made based on their feedback.

Content Validity: Evaluated using Content Validity Ratio (CVR) and Content Validity Index (CVI).

CVR: Assessed by nine experts using a 3-point scale ("essential", "useful but not essential", "not essential"). Based on Lawshe's formula and table, CVR values ranged from 0.78 to 1.0, with an overall mean CVR of 0.96, which meets the required critical value (0.78 for nine experts).

CVI: Evaluated for simplicity, clarity, and relevance, with a mean of 0.97, indicating acceptable quality.

Construct Validity: Assessed using convergent and discriminant validity with SmartPLS version 3 software. Results confirmed both types of construct validity.

Reliability: The reliability of the questionnaire was confirmed using Cronbach's alpha, with an overall mean of 0.983, indicating excellent internal consistency (Table 1).

Table 1. Summary of Validity and Reliability Indices for the Questionnaire

Component	Subcomponents	Items	AVE	CR	Cronbach's Alpha
E-learning Quality	Standards	1–29	0.671	0.924	0.901
	Planning	30–54	0.789	0.937	0.911
	IT	55–77	0.803	0.924	0.877
	Quality	78–96	0.832	0.937	0.899
	Evaluation	97–104	0.887	0.940	0.872

Data Analysis

Qualitative Analysis: Included open coding, axial coding, and selective coding. To identify the components and indicators of the quality management variable in e-learning, a qualitative method was used, involving interviews analyzed with MAXQDA 2020 software.

Quantitative Analysis: For descriptive statistical reporting, frequency and percentage indices were used for categorical variables, while mean, standard deviation, minimum, and maximum were reported for quantitative variables. To assess the normal distribution of each questionnaire component, skewness and kurtosis indices, as well as the Kolmogorov–Smirnov (K–S) test, were employed. To rank the components of the questionnaire and determine their prioritization, the Friedman ranking test was employed. The ranking values reported in this test were used as the rank of each component. For validity assessment, two types were considered: discriminant validity, as assessed using the Fornell–Larcker table, and convergent validity, as assessed using the Average Variance Extracted (AVE) and Composite Reliability (CR) indices. To determine reliability, Cronbach’s Alpha was used. Finally, the conceptual model was evaluated as a whole using model fit indices, including SRMR (Standardized Root Mean Square Residual) and NFI (Normed Fit Index), along with the significance of factor loadings. All descriptive and prioritization analyses were performed using SPSS version 24. Due to the relatively small sample size, all validity, reliability, and model fit analyses for the conceptual model were executed using SmartPLS version 3. Furthermore, to generate confidence intervals, bootstrapping with 1000 samples was applied. The level of statistical significance in this study was set at 5%.

Ethical Considerations

A written ethics approval was obtained from Islamic Azad University, Central Tehran Branch, under ethics code IR.IAU.CTB.REC.1403.250.

Results

The emerging model of E-Learning Quality Management in Clinical Groups of Military Medical Universities, developed using the exploratory mixed-method approach, is described as follows:

This model was validated qualitatively by experts and quantitatively by users. It consists of 5 dimensions and 18 Components. This comprehensive model serves as a structured and validated framework for assessing and improving the quality of e-learning within clinical education settings specific to military medical universities (Fig. 1).

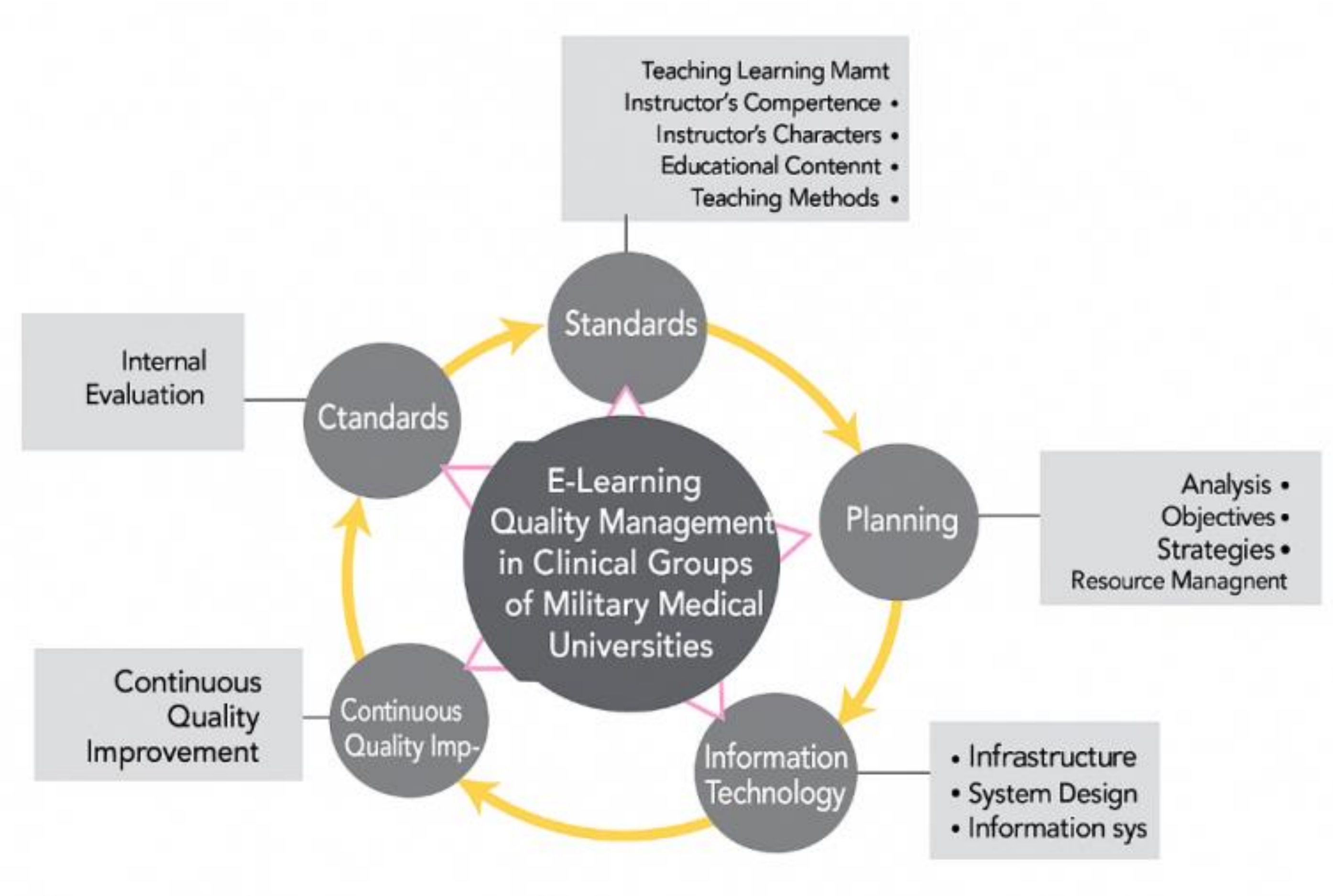

Fig 1. The Emerging Model of E-Learning Quality Management in Clinical Groups of Military Medical Universities

The study included 191 participants from clinical and educational fields at military medical universities. In terms of gender, 55.5% (106 individuals) were male and 44.5% (85 individuals) were female. Regarding educational background, the most prominent group comprised nursing faculty members (39.8%), followed by medical faculty (37.7%). Participants from medical education made up 6.3%, educational management 7.9%, higher education 2.6%, virtual education 1.6%, and information technology 4.2% of the total sample. In terms of work experience, 38.7% of the participants had less than 15 years of experience. 15.7% had 15 to 20 years, 19.9% had 20 to 25 years, 15.7% had 25 to 30 years, and 9.9% had more than 30 years of professional experience (Table 2).

Table 2. Descriptive data of participants

Variable	Category	Frequency	Percentage (%)
Gender	Female	85	44.5%
	Male	106	55.5%
Education Field	Medicine	72	37.7%
	Nursing	76	39.8%
	Medical Education	12	6.3%
	Higher Education	5	2.6%
	Virtual Education	3	1.6%
	Educational Management	15	7.9%
	Information Technology	8	4.2%
Work Experience	Less than 15 years	74	38.7%
	15 to 20 years	30	15.7%
	20 to 25 years	38	19.9%
	25 to 30 years	30	15.7%
	More than 30 years	19	9.9%

Table 3 presents the descriptive statistics and normality of distribution of various components across the five principal dimensions of the proposed e-learning quality management model in clinical groups at military medical universities. In the Standards dimension, elements such as teaching–learning management, instructor competence, and learner assessment showed mean scores ranging from 22.38 to 35.65. The skewness and kurtosis values suggest moderate normality, as all Kolmogorov–Smirnov test p-values are greater than 0.05, indicating no significant deviation from normality.

The Planning dimension, which includes analysis, objectives, strategies, and resource management, showed higher mean values, particularly in resource management (M = 47.36). The data distribution was again found to be acceptably normal based on skewness and kurtosis indices. For the Information Technology dimension, the highest mean score was for system design (M = 57.97), and the lowest for information systems (M = 28.71). Skewness ranged from -0.83 to -0.98, and all p-values remained above the 0.05 threshold.

In the Continuous Quality Improvement dimension, quality control and assurance components reported moderate to high average scores (M = 46.57 and M = 35.27, respectively). Normality assumptions were upheld across all components. The Evaluation dimension had the lowest overall means, with internal evaluation at 29.52 and external evaluation at 17.57. These variables also exhibited slightly higher skewness, but remained within acceptable ranges, and their distributions did not significantly deviate from normality. Overall, the data across all dimensions demonstrated normal distribution characteristics, validating the appropriateness of parametric statistical analyses in the subsequent stages of model testing.

Table 3. Descriptive Statistics and Normality Indices of E-Learning Quality Management Dimensions

Dimension	Component	Mean	SD	Min	Max	Skewness	Kurtosis	P-value
Standards	Teaching–Learning Management	22.38	3.46	11.00	28.00	-0.81	0.50	0.129
	Instructor’s Competence	35.65	4.40	16.00	42.00	-1.10	0.91	0.093
	Learner Characteristics	23.10	3.05	10.00	28.00	-0.74	1.48	0.144
	Educational Content	23.94	3.05	11.00	28.00	-0.92	1.30	0.112
	Teaching Methods	35.20	4.55	18.00	42.00	-0.85	1.08	0.121
	Learner Assessment Methods	28.90	3.83	13.00	35.00	-0.86	1.10	0.119
Planning	Analysis	34.59	4.43	17.00	42.00	-0.78	0.82	0.139
	Objectives	28.52	3.88	14.00	35.00	-0.50	0.26	0.169
	Strategies	33.95	4.93	15.00	42.00	-0.71	0.88	0.147
	Resource Management	47.36	6.05	22.00	56.00	-0.94	1.38	0.109
Information Technology	Infrastructure	47.30	5.61	27.00	56.00	-0.98	1.56	0.103
	System Design	57.97	7.11	33.00	70.00	-0.88	1.10	0.115
	Information Systems	28.71	4.23	14.00	35.00	-0.83	1.00	0.124
Continuous Quality Improvement	Quality Control	46.57	5.64	21.00	56.00	-0.91	1.03	0.113
	Quality Assurance	35.27	4.74	15.00	42.00	-1.21	1.55	0.089
	Quality Enhancement	29.50	3.88	13.00	35.00	-0.94	1.39	0.109
Evaluation	Internal Evaluation	29.52	4.00	13.00	35.00	-1.47	0.49	0.076
	External Evaluation	17.57	2.58	6.00	21.00	-1.24	0.79	0.084

The Friedman test, a non-parametric method, was used to prioritize the components of the questionnaire. Each component received a mean rank, where higher ranks indicate higher priority. Standard dimension: The highest priority was given to the teacher's ability and competence, followed by the teaching method. Teaching-learning management was ranked lowest. Planning dimension: Resource management ranked highest, and objectives were the lowest priority. Information Technology: System design was the top priority, with information systems ranked last. Continuous Quality Improvement: Quality control was the most important, and quality enhancement was ranked lowest. Evaluation: Internal evaluation was prioritized over external evaluation. E-learning Quality Management: Among the dimensions, the standard was the highest priority, followed by planning, IT, continuous quality improvement, and evaluation (Table 4).

The overall prioritization of the questionnaire dimensions, ranked from highest to lowest priority, was standard, planning, information technology, continuous quality improvement, and evaluation.

Table 4. Friedman Tests Priority Ranking of Questionnaire Components

Dimension	Component	Friedman Mean Rank	Priority
Standard	Teacher's ability & competence	49.5	1
	Teaching method	42.5	2
	Learner evaluation method	3.96	3
	Educational content	3.72	4
	Learner characteristics	2.01	5
	Teaching-learning management	1.75	6
Planning	Resource management	3.98	1
	Analysis	2.62	2
	Strategies	2.33	3
	Objectives	1.07	4
Information Technology (IT)	System design	2.98	1
	Infrastructure	2.02	2
	Information systems	1.00	3
Continuous Quality Improvement	Quality control	2.99	1
	Quality assurance	1.97	2
	Quality enhancement	1.04	3
Evaluation	Internal evaluation	2.00	1
	External evaluation	1.00	2
E-learning Quality Management	Standard	4.97	1
	Planning	3.87	2
	Information technology	3.13	3
	Continuous quality improvement	2.03	4
	Evaluation	1.00	5

In the Standard dimension, all components—including teaching-learning management, teachers' professional competence, learner characteristics, educational content, teaching method, and learner evaluation method—showed acceptable levels of convergent validity, with AVE values ranging from 0.558 to 0.669. These AVE values were all higher than 0.50 and lower than their corresponding CR values (ranging from 0.861 to 0.911), indicating acceptable convergent validity. Cronbach's Alpha values for this dimension ranged from 0.784 to 0.883, reflecting good reliability. The Planning dimension also demonstrated solid validity and reliability. The AVE values for components such as analysis, objectives, strategies, and resource management ranged from 0.548 to 0.623, with CR values between 0.879 and 0.921. Cronbach's Alpha ranged from 0.834 to 0.902, confirming strong internal consistency. For the Information Technology dimension, components such as infrastructure, system design, and information systems had AVE values between 0.512 and 0.645, with CR values ranging from 0.901 to 0.912. Reliability was confirmed through Cronbach's alpha values, which ranged from 0.861 to 0.892, indicating a high degree of internal consistency. The Continuous Quality Improvement dimension also met all validation criteria. Its components—quality control, quality assurance, and quality enhancement—showed AVE values ranging from 0.571 to 0.608 and CR values between 0.873 and 0.914. The Cronbach's Alpha scores ranged from 0.818 to 0.892, reflecting consistent and reliable responses.

In the Evaluation dimension, internal and external evaluation components had AVE scores of 0.648 and 0.728, respectively. CR values were 0.902 and 0.889, while Cronbach's Alpha values were 0.863 and 0.814. These results indicate that both components have satisfactory convergent validity and reliability. Finally, for the overall questionnaire, the AVE values for the five principal dimensions ranged from 0.671 to 0.887, all exceeding the threshold of 0.50 and remaining below their respective CR values, which ranged from 0.924 to 0.940. Cronbach's Alpha values for each dimension ranged between 0.872 and 0.911. Notably, the overall Cronbach's Alpha for the questionnaire was 0.983, which indicates excellent overall reliability (Table 5).

Table 5. Summary of Convergent Validity (AVE), Composite Reliability (CR), and Cronbach's Alpha

Dimension	Component	Questions	AVE	CR	Cronbach's Alpha
Standard	Teaching-Learning Management	1–4	0.668	0.889	0.834
	Teacher's Competence	5–10	0.558	0.883	0.841
	Learner Characteristics	11–14	0.609	0.861	0.784
	Educational Content	15–18	0.669	0.890	0.835
	Teaching Method	19–24	0.630	0.911	0.883
	Learner Evaluation Method	25–29	0.573	0.870	0.812
Planning	Analysis	30–35	0.548	0.879	0.834
	Objectives	36–40	0.623	0.892	0.849
	Strategies	41–46	0.585	0.894	0.856
	Resource Management	47–54	0.594	0.921	0.902
Information Tech.	Infrastructure	55–62	0.533	0.901	0.873
	System Design	63–72	0.512	0.912	0.892
	Information Systems	73–77	0.645	0.901	0.861
Quality Improvement	Quality Control	78–85	0.571	0.914	0.892
	Quality Assurance	86–91	0.608	0.903	0.871
	Quality Enhancement	92–96	0.581	0.873	0.818
Evaluation	Internal Evaluation	97–101	0.648	0.902	0.863
	External Evaluation	102–104	0.728	0.889	0.814
Overall Questionnaire	Standard	1–29	0.671	0.924	0.901
	Planning	30–54	0.789	0.937	0.911
	Information Technology	55–77	0.803	0.924	0.877
	Quality Improvement	78–96	0.832	0.937	0.899
	Evaluation	97–104	0.887	0.940	0.872

To evaluate the goodness-of-fit of the conceptual model, each dimension was first analyzed separately through its components, and then the final model structure was assessed collectively. Structural model fit was determined using factor loadings, t-values, and two key indices: SRMR (Standardized Root Mean Square Residual) and NFI (Normed Fit Index). An SRMR value below 0.08 indicates a good model fit, and an NFI value greater than 0.90 indicates a desirable model (Table 6). For the Standard dimension, all components showed significant positive effects, with factor loadings ranging from 0.755 to 0.896 and all t-values well above the threshold of significance ($p < 0.001$). The SRMR value of 0.070 and NFI of 0.939 indicate a good model fit for this dimension.

In the Planning dimension, all components (Analysis, Objectives, Strategies, and Resource Management) also showed significant loadings, ranging from 0.866 to 0.916. With SRMR at 0.074 and NFI at 0.918, this model demonstrates acceptable fit and strong structural integrity.

The Information Technology dimension showed substantial and statistically significant loadings for its components (Infrastructure, System Design, and Information Systems), with values ranging from 0.863 to 0.943. Fit indices (SRMR = 0.071, NFI = 0.932) also confirmed the model's suitability for this domain.

In the Continuous Quality Improvement dimension, component loadings were high and statistically significant (ranging from 0.881 to 0.933). The model fit was supported by an SRMR of 0.068 and an NFI of 0.947, confirming a strong and desirable model structure.

For the Evaluation dimension, the components of internal and external evaluation had very high and statistically significant factor loadings (0.917 and 0.963). The SRMR was 0.075 and the NFI was 0.910, indicating an acceptable model fit.

Finally, the overall conceptual model for e-learning quality management in clinical groups was tested. All five main dimensions—Standard, Planning, Information Technology, Quality Improvement, and Evaluation—had high, statistically significant factor loadings ranging from 0.813 to 0.925. The overall model demonstrated a desirable fit with SRMR = 0.065 and NFI = 0.954, supporting the conclusion that the conceptual structure is statistically valid and well-fitting. These results confirm that the designed components make a significant and reliable contribution to the understanding and management of e-learning quality.

Table 6. Structural Model Fit Summary (Loadings, Significance, SRMR, NFI)

Dimension	Component	Loading	SE	95% CI (Low - Up)	T-value	P-value	SRMR	NFI
Standard	Teaching-Learning Mgmt	0.755	0.03	0.69 – 0.81	23.14	< 0.001	0.070	0.939
	Teacher Competence	0.818	0.03	0.75 – 0.87	25.60	< 0.001		
	Learner Characteristics	0.794	0.04	0.72 – 0.85	22.46	< 0.001		
	Educational Content	0.854	0.03	0.80 – 0.89	33.71	< 0.001		
	Teaching Method	0.896	0.02	0.86 – 0.92	58.91	< 0.001		
	Learner Evaluation Method	0.813	0.03	0.74 – 0.87	23.25	< 0.001		
Planning	Analysis	0.901	0.02	0.86 – 0.93	51.41	< 0.001	0.074	0.918
	Objectives	0.868	0.02	0.83 – 0.91	43.48	< 0.001		
	Strategies	0.916	0.01	0.89 – 0.94	79.33	< 0.001		
	Resource Management	0.866	0.03	0.80 – 0.91	29.39	< 0.001		
Information Technology	Infrastructure	0.877	0.03	0.81 – 0.92	32.30	< 0.001	0.071	0.932
	System Design	0.943	0.01	0.92 – 0.96	91.27	< 0.001		
	Information Systems	0.863	0.02	0.81 – 0.91	36.32	< 0.001		
Quality Improvement	Quality Control	0.919	0.02	0.88 – 0.94	55.74	< 0.001	0.068	0.947
	Quality Assurance	0.933	0.01	0.90 – 0.95	68.21	< 0.001		
	Quality Enhancement	0.881	0.02	0.83 – 0.91	39.70	< 0.001		
Evaluation	Internal Evaluation	0.963	0.01	0.94 – 0.98	117.48	< 0.001	0.075	0.910
	External Evaluation	0.917	0.02	0.88 – 0.94	52.64	< 0.001		
Overall Model (Clinical)	Standard	0.910	0.02	0.87 – 0.94	46.37	< 0.001	0.065	0.954
	Planning	0.925	0.01	0.89 – 0.95	62.71	< 0.001		
	Information Technology	0.888	0.02	0.85 – 0.92	47.55	< 0.001		
	Quality Improvement	0.894	0.02	0.85 – 0.93	43.18	< 0.001		
	Evaluation	0.813	0.04	0.74 – 0.87	23.09	< 0.001		

Discussion

The emerging model of E-learning Quality Management in Clinical Groups of the Armed Forces Medical Universities is a five-dimensional framework developed through an exploratory mixed-method approach and validated by both expert and user perspectives. The finalized model includes 5 dimensions, 18 components, and 104 indicators. Below is a detailed discussion of each dimension, its theoretical alignment, practical relevance, and innovation grounded in literature and empirical data.

Standard Dimension

This dimension goes beyond formal rule-making; it includes critical foundations to ensure quality in clinical e-learning environments. In military medical universities, where both educational excellence and mission-readiness are vital, these standards play a fundamental role. It comprises six components: teaching-learning management, instructor capabilities, learner characteristics, educational content, teaching methods and learner assessment. These align with findings from Sadeghi et al. (2022) and Alqahtani et al. (2020) on digital skills and standard formulation, and Johnsson et al. (2024) on method-objective alignment[6-8]. Research by Gan et al. (2023) and Alhabeeb et al. (2018) reinforce the emphasis on instructor behavior and student-centered evaluation in virtual settings [9-10]. Recent innovations in AI and diagnostic support, such as the 3D AI model proposed by Chen et al. (2024), suggest that adaptive standards can further streamline clinical training and diagnosis, enabling more precise preoperative decision-making[11].

Planning Dimension

Planning is the backbone of effective e-learning implementation. The four components are analysis, objectives, strategies and resource management. Findings are consistent with Tobin (2024) and Singh et al. (2023), emphasizing that strategy formulation and planning should not only address pedagogical outcomes but also meet the unique operational and clinical demands of military environments[12-13]. Research by Gruter et al. (2023) supports the role of planning in system integration and resource incentives[14]. The model's innovation lies in localizing these processes to meet both academic and mission-specific goals.

Information Technology Dimension

IT enables content delivery, system integration, and adaptive learning. Its three components are infrastructure, system design and information systems. This study affirms the findings of Sadeghi et al. (2022) and Baber et al. (2020) regarding access and user support[6, 15]. Cutting-edge integrations like VR (Birrenbach et al., 2024) and AI (Kim et al., 2023) demonstrate its capacity to transform not just delivery but diagnosis, triage, and decision-making in military emergency settings[16-17]. Moreover, Groves et al. (2023) showed that VR-based trauma simulations were equally effective as cadaver-based training, supporting IT as a scalable, cost-efficient alternative in military environments[18].

Continuous Quality Improvement Dimension

This dimension ensures ongoing adaptation and optimization. It comprises quality control, quality assurance and quality enhancement. Findings by Stander (2019) affirm that QA processes—especially in high-stakes environments like military medicine—must be symbolic and systemic[19]. The inclusion of emerging indicators for feedback loops, real-time assessment, and integration of AI-based monitoring (Johnsson et al., 2024) highlights this model's strength in maintaining relevance and effectiveness[8].

Evaluation Dimension

Evaluation is bifurcated into internal evaluation, providing self-assessment by learners and faculty and external evaluation, ensuring alignment with institutional and professional standards. As noted in Sadeghi et al. (2022), multi-source feedback loops are critical[6]. New insights from Groves et al. (2023) and Traba et al. (2021) validate video-based and TeleOSCE-based evaluations as credible substitutes or supplements to traditional assessments[18, 20].

Emerging Indicators and Innovation

Several novel components and indicators—especially those related to external evaluation and analytical planning—were identified through qualitative coding. These were absent in previous general education models and reflect the unique military context, such as combat readiness, confidentiality, and situational adaptability. Comparison with previous literature (e.g., Singh et al., 2023, Masengu et al., 2023) revealed 12 new indicators in areas like infrastructure, system design, and evaluation that directly address clinical-military integration[13, 21]. These additions strengthen the model's localization and relevance in Armed Forces universities.

Validation Process

A researcher-developed questionnaire, validated by 9 domain experts, led to a refined, evidence-based framework: Standard dimension scored highest for teaching-learning management, Planning ranked highest for analysis, IT scored best on infrastructure, quality improvement was strongest in quality control, evaluation favored internal mechanisms. Consequently, the model evolved from an initial 5-dimensional, 19-component, 129-indicator structure to a validated framework with 5 dimensions, 18 components, and 104 indicators. This process exemplifies a scientifically rigorous, context-sensitive, and forward-looking approach to managing e-learning quality in military clinical education.

Conclusion

This emerging model, validated both qualitatively and quantitatively, offers a customized framework for managing e-learning quality in clinical groups at military medical universities. Structural equation modeling confirmed the model's fit, with each indicator playing a significant role. This framework not only supports quality improvement in military clinical e-learning but also introduces innovative quality management strategies tailored for medical and combat medicine training.

Highlights

What Is Already Known?

Clinical education environments are recognized as the primary source of learning and the formation of professional identity for medical students, making them significantly important.

What Does This Study Add?

This model enhances quality improvement in military clinical e-learning and introduces innovative quality management strategies tailored for medical and combat medicine training.

Authors' Contributions

Concepts and design: Leila Vosoug BeneKohl, Baharak Shirzad Kebria; **Data gathering:** Leila Vosoug BeneKohl, Baharak Shirzad Kebria; **Writing of paper:** Leila Vosoug BeneKohl,Baharak Shirzad Kebria, Fatemeh. Hamidifar, Abbas Khorshidi; **Editing and final approving:** Leila Vosoug BeneKohl, Baharak Shirzad Kebria, Fatemeh. Hamidifar, Abbas Khorshidi.

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Conflicts of Interest Disclosures

We declare that there is no any conflict of interest.

Consent For Publication

The authors agree with the publication.

Ethics approval

The Ethical Committee of Islamic Azad University, Tehran, Iran, approved the protocol of this study. (Ethical code: IR.IAU.CTB.REC.1403.250)

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The extent of AI use

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References

1. Almarzouqi A, Aburayya A, Salloum SA. Prediction of user’s intention to use metaverse system in medical education: A hybrid SEM-ML learning approach. IEEE access. 2022 Apr 21;10:43421-34. Doi:10.1109/ACCESS.2022.3169285.

2. Chugh, M., Upadhyay, R., & Chugh, N. (2023). An empirical investigation of critical factors affecting acceptance of e-learning platforms: A learner’s perspective. SN Computer Science, 4(3), Article 240. https://doi.org/10.1007/s42979-023-01839-0.

3. Bhatia, N., Trivedi, H., Safdar, N., & Heilbrun, M. E. (2020). Artificial intelligence in quality improvement: Reviewing uses of artificial intelligence in noninterpretative processes from clinical decision support to education and feedback. Journal of the American College of Radiology, 17(11), 1382–1387. https://doi.org/10.1016/j.jacr.2020.04.002.

4. Bratkevich, V. (2020). E-learning education systems efficiency rating model. ScienceRise, (1)(66), 56–65. https://doi.org/10.15587/2313-8416.2020.193733.

5. Cole, R., & Wightman, J. M. (2023). Impact of a multiday, high-fidelity, immersive simulation on military medical students’ self-confidence. Military Medicine, 188(Suppl. 3), 21–27. https://doi.org/10.1093/milmed/usad167.

6. Sadeghi, F., Fazaeli, S., Kimiafar, K. H., Ameri, F., & Meraji, M. (2023). E-learning Quality Assessment Indicators: A Narrative Review. Journal of Medical Education and Development. Doi:10.18502/jmed.v18i4.15178.

7. Alqahtani, A. Y., & Rajkhan, A. A. (2020). E-learning critical success factors during the COVID-19 pandemic: A comprehensive analysis of e-learning managerial perspectives. Education Sciences, 10(9), 216. https://doi.org/10.3390/educsci10090216.

8. Johnsson, V., Søndergaard, M. B., Kulasegaram, K., Sundberg, K., Tiblad, E., Herling, L., ... & Tolsgaard, M. G. (2024). Validity evidence supporting clinical skills assessment by artificial intelligence compared with trained clinician raters. Medical Education, 58(1), 105–117. Doi: 10.1111/medu.15190.

9. Gan, W., Mok, T. N., Chen, J., She, G., Zha, Z., Wang, H., ... Zheng, X. (2023). Researching the application of virtual reality in medical education: One-year follow-up of a randomized trial. BMC Medical Education, 23(1),3. Doi: 10.1186/s12909-022-03992-6.

10. Alhabeeb, A., & Rowley, J. (2018). E-learning critical success factors: Comparing perspectives. Journal name missing.

11. Chen, W. S., & Yao, A. Y. T. (2016). An empirical evaluation of critical factors influencing learner satisfaction in blended learning: A pilot study. Universal Journal of Educational Research, 4(7), 1667–1671. https://doi.org/10.13189/ujer.2016.040719.

12. Tobin, R. (2024). Evaluation of a simulation-based, e-learning intervention to develop prelicensure nursing students' clinical competency to recognize tracheostomy airway complications (Doctoral dissertation).

13. Singh, P., Alhassan, I., Binsaif, N., Alhussain, T. (2023). Standard measuring of E-Learning to assess the quality level of E-Learning outcomes: Saudi electronic university case study. Sustainability, 15(1), 844. Doi:10.3390/su15010844.

14. Grüter AA, Van Lieshout AS, van Oostendorp SE, Henckens SP, Ket JC, Gisbertz SS, Toorenvliet BR, Tanis PJ, Bonjer HJ, Tuynman JB. Video-based tools for surgical quality assessment of technical skills in laparoscopic procedures: a systematic review. Surgical endoscopy. 2023 Jun;37(6):4279-97. Doi:10.1007/s00464-023-10076-z.

15. Baber, H. (2020). Determinants of students' perceived learning outcome and satisfaction in online learning during the pandemic of COVID-19. Education and Information Technologies, 26(6), 6701–6718. Doi:10.20448/journal.509.2020.73.285.292.

16. Birrenbach, T., Stuber, R., Müller, C. E., Sutter, P. M., Hautz, W. E., Exadaktylos, A. K., & Sauter, T. C. (2024). Virtual reality simulation to enhance advanced trauma life support trainings: A randomized controlled trial. BMC Medical Education, 24, Article 666. https://doi.org/10.1186/s12909-024-05094-z.

17. Kim, Y. S., Kim, M. W., Lee, J. S., Kang, H. S., Urtnasan, E., Lee, J. W., & Kim, J. H. (2023). Development of an artificial intelligence model for triage in a military emergency department: Focusing on abdominal pain in soldiers. Intelligence-Based Medicine, 8, 100112. Doi:10.1016/j.ibmed.2023.100112.

18. Groves, H., Fuller, K., Mahon, V., Butkus, S., Varshney, A., Brawn, B., ... Puche, A. C. (2023). Assessing the efficacy of virtual reality trauma surgery training as compared to cadaveric training. [Journal name missing—consider adding if known]. Doi:10.1186/s12909-025-06835-2.

19. Stander, E. (2019). Accreditation and managing quality assurance in private higher education institutions in South Africa (Doctoral dissertation, University of Pretoria).

20. Traba, C., Holland, B., Laboy, M. C., Lamba, S., Chen, S. (2021). A multi-modal remote clinical skills Mini-Course utilizing a teaching TeleOSCE. Medical science educator, 31, 503-509. Doi: 10.1007/s40670-020-01201-x.

21. Masengu, R., Muchenje, C., Ruzive, B., & Hadian, A. (2023). E-learning quality assurance is an act of symbolic control in higher education institutions (HEIs). In SHS Web of Conferences (Vol. 156, p. 06001). EDP Sciences. Doi:0.1051/shsconf/202315606001.