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Review Article

Exploring applications of artificial intelligence in enhancing the quality of medical education: a mixed methods research synthesis

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Abstract

Background & Objective: Academic systems are among the many spheres of human life highly influenced by artificial intelligence (AI). The idea of quality in medical education is changing as a result of AI-driven developments, creating both opportunities and difficulties. The purpose of this study is to investigate how AI might be used to improve the quality of medical education.

Materials & Methods: Mixed methods research synthesis was the approach taken. Relevant studies published in Science Direct, Springer, ERIC, Emerald, Sage Journals, Wiley Online Library, PubMed, and Google Scholar between 2015 and 2025 were found using targeted search terms. Quality was assessed through the Mixed Methods Appraisal Tool (MMAT) and selection process followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The final review included 49 studies that met the criteria. A model with eight dimensions of the quality of medical education was employed to analyze the data.

Results: The results were grouped into eight categories: mission and goals, organizational structure and governance, faculty members, students, teaching and learning processes, curricula, facilities, and research activities. AI was found to have a positive effect on all areas, with the most focus on faculty members (38 citations) and teaching-learning processes (36 citations). It was found that these themes were very important for making education better. By comparison, mission and objectives, and research activities received little reference (8 references each), indicating strategic and research-focused AI integration lacunae.

Conclusion: AI has the most potential to change how medical education is taught by using new teaching tools, better lesson plans, and personalized learning. But the fact that research and planning dimensions don't cover everything shows how important it is to do research and make policies with clear, well-defined goals. Balanced implementation of AI in all dimensions of quality is needed to bring sustainable and comprehensive transformations in medical education. The current study offers significant implications to educators, policymakers, and researchers for guiding AI-supported education reforms in the future.

Keywords: artificial intelligence (AI), medical education, educational technology, quality improvement, mixed methods synthesis

Introduction

Medical education is a key part of higher education because it has a direct impact on the quality of care and patient outcomes. Unlike generic areas of education, medical education necessitates training of competent health professionals that combine extensive theoretical knowledge with practical as well as clinical competencies needed to contribute meaningfully to society [1]. So, the quality of medical education has a direct effect on the efficiency of the healthcare delivery system and public health [2]. There are many challenges to providing high-quality medical education, such as constantly updating the curriculum, training faculty, coming up with new ways to teach, and coming up with strong ways to test students. These efforts are meant to make sure that graduates have not only a lot of knowledge but also the important clinical and interpersonal skills they need.

Improving the quality of medical education has therefore become a priority for different stakeholders such as learners, teachers, patients, healthcare workers, regulatory agencies, and financiers [3]. To address this priority, quality in medical education has drawn significant scholarly attention as researchers seek to understand and maximize it amidst evolving health needs [4]. The quality of medical education is important beyond the academe since it is irrevocably entwined with the ability of health systems to deliver safe, effective, and equitable care. All stakeholders agree that without earnest dedication to the quality of medical education, quality improvements in healthcare delivery are not feasible [5]. High-quality medical education is characterized by well-structured educational systems, comprehensive curricula, qualified faculty, and enhanced teaching practices. Furthermore, medicine graduates need to attain a blend of soft skills, practical skills, and theory-based medical understanding [6]. However, "quality" is an aggregate and comparative term and is still challenging to define as there are multiple interpretations based on stakeholders' perceptions and standards [7]. Amidst rapidly evolving international trends shaping higher education today, quality has become increasingly critical. Universities are faced with complex issues with technological advancement accelerating, calling for adaptive interventions and revolutionary changes in their function as educators [8]. Artificial Intelligence (AI), a revolutionary technological innovation, also promises to enhance the quality of education in every discipline, including medical education. The application of AI—including intelligent tutoring systems, chatbots, adaptive learning platforms, automated grading, and learning analytics—enables individualized learning experiences, enhances teaching effectiveness, and streamlines academic administration [9-13]. In addition to its well-known applications in medical training, artificial intelligence is driving a wide range of innovations across the broader field of medicine. For instance, personalized medicine has been developed with the aim of providing drugs based on the individual characteristics of patients [14]. In addition to its well-known applications in medical training, artificial intelligence is driving a wide range of innovations across the broader field of medicine [15]. Yet another key focus area is the early diagnosis of various diseases, which results in improved prevention and reduced costs of treatment [16]. Also, advances in medical imaging have provided improved analysis of radiological data, thereby improving diagnostic efficiency [17]. In medical care, AI has proven to be an effective tool for patient monitoring and surveillance [18], while clinical decision-support systems have enhanced diagnostic and therapeutic processes [19].

Medical data management has also been streamlined through advanced algorithms, enabling the analysis of large-scale health datasets [20]. In addition, genome analysis and genetic medicine have opened new pathways for treatments based on patients' genetic profiles [21]. Virtual medical consultations and AI-driven assistants have also played a substantial role in improving patient engagement and expanding access to healthcare services [22]. Finally, AI has contributed to optimizing therapeutic processes and improving the overall efficiency of healthcare systems [23]. Despite this potential, the integration of AI into education presents several challenges. Some of these are the danger of relying too much on AI tools, which could hurt academic standards, worries about student data privacy, and the possibility of biases being built into AI platforms through algorithms that reflect human biases [24, 25]. Therefore, AI should not be regarded as a universal remedy, but rather as a supportive instrument whose efficacy is contingent upon the establishment of suitable safeguards. Current studies underscore these dual facets of AI in education. Kabudi [26] identifies critical areas such as educator roles, support for special-needs students, racial and data bias in AI-based learning systems, and commercialization challenges. Flores-Viva and García-Peñalvo [27] emphasize ethical considerations in AI's educational applications. Nkechi et al. [28] show how AI can help close the digital divide and overcome language barriers to make education more equal. Ajani et al. [29] talk about how AI can help with personalized learning, better teaching methods, and more efficient administration. They also talk about privacy and ethical issues. AlSagri and Sohail [30] argue that deeper understanding of AI capabilities can inform policies fostering equitable and sustainable education systems. This study employs a mixed methods research synthesis approach to address international research gaps regarding AI's role in improving education quality, with a novel focus on medical education. The results give a broad, worldwide view of how AI could improve the quality of medical education. This study helps close the knowledge gap by giving educators, policymakers, and researchers who want to use AI to improve the quality of medical education useful information. This study adheres to the most prevalent framework for evaluating the intrinsic quality of university teaching [31–35]. There are eight principal dimensions in the conceptual model: Mission and Objectives, Organizational Structure and Management, Faculty Members and Students, Teaching-Learning Processes, Educational Programs and Curricula, Educational and Research Facilities, and Research Activities.

Materials & Methods

Design and setting(s)

Since both quantitative and qualitative studies, as well as those employing mixed-method research designs, are available for examining the applications of artificial intelligence in quality of medical education, we chose an integrated Mixed-Methods Research Synthesis (MMRS) design as the methodological framework for our review. A mixed-methods research synthesis is a form of systematic review that applies the principles of mixed-methods inquiry. In essence, such a study is expected not only to include two distinct strands—one qualitative and one quantitative—each with its own questions, data, analyses, and conclusions—but also to integrate, link, or connect these strands in a meaningful way [36]. Specifically, we adopted the MMRS framework developed by Heyvaert and colleagues [37]. A diagrammatic overview of this framework can be found in **Figure 1**. Considering the multidimensional complexity of artificial intelligence applications quality of medical education, it seems essential to employ a mixed-methods approach in the synthesis of the studies (**Figure 1)**. Quantitative studies primarily seek to investigate the effectiveness of AI tools by measuring the performance improvement of learners, or system accuracy, while qualitative studies evaluate attitudes, experiences, and ethical and educational dilemmas with the implementation of this technology. A synthesis of these two types of data provides a richer understanding of the phenomenon. On one hand, quantitative data provide empirical and objective evidence about efficiency and outcomes; on the other hand, qualitative data primarily offer enhanced insights into the contexts, meanings, and processes associated with the use of AI in quality of medical education. In a methodological sense, a mixed synthesis approach is especially relevant for publishing the synthesis or results of qualitative and quantitative studies, as it allows for interpretation of these diverse findings within a unifying framework. In this manuscript, and as shown in **Figure 1**, data from the base qualitative and quantitative studies were first synthesized in their separate studies. In the last stage, through an integrative synthesis, similarities, differences, and complementarity across the two strands were assessed. The framework provides a six-stage process [37], and subsequent sections of this report describe the process we undertook for each of the particular six stages of this study.

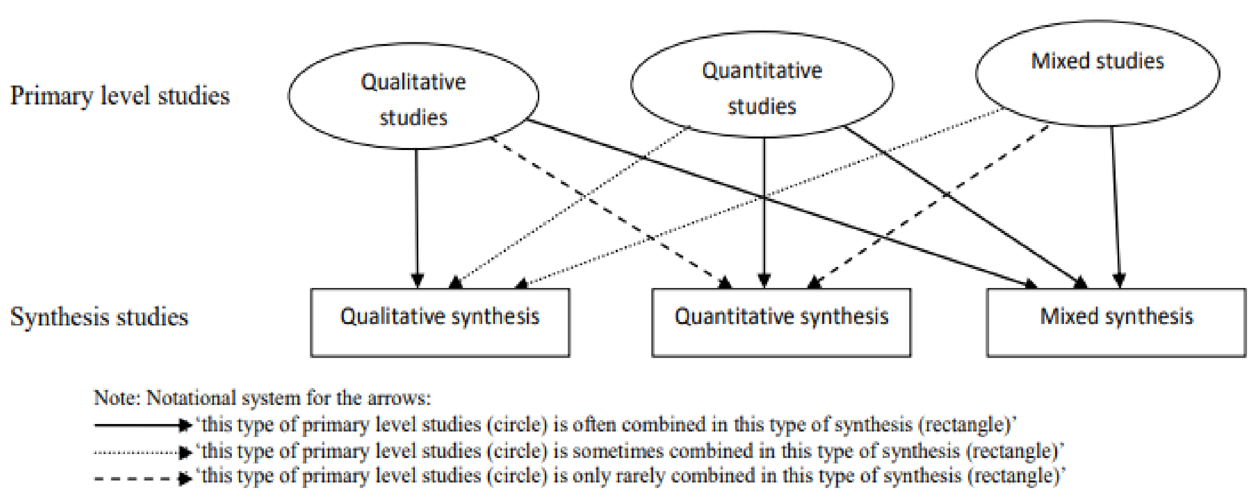

Figure 1. Qualitative, quantitative, and mixed methods research synthesis

The problem identification and question formulation stage

The research question was designed using the standard PICo/PICO framework, which helps researchers define the scope and objectives of their study with precision and clarity. In this study, Population (P) refers to students, faculty members, administrators, and other stakeholders in both medical and non-medical education systems, who are considered the primary users or beneficiaries of AI applications. Interest/Intervention (I) represents the phenomenon under study, namely the application of Artificial Intelligence in improving the quality of medical education. Context (C) refers to the academic settings, including higher education institutions and medical training centers where AI technologies have been integrated into educational processes. To ensure methodological rigor, the search strategy was explicitly derived from this framework. The Population (P) was operationalized into keywords such as "medical students," "residents," "faculty," and "medical education stakeholders." The Intervention (I) generated terms including "artificial intelligence," "AI," "machine learning," "deep learning," "chatbots," and "educational technology." The Comparison (C) dimension was not uniformly applicable across studies due to the heterogeneity of their designs. However, where relevant, comparative terms such as "traditional education," "non-AI learning," or "conventional teaching" were included. Finally, the Outcomes (O) were framed in terms of "quality improvement," "learning outcomes," "teaching effectiveness," and "educational quality," which were translated into keywords such as "quality of medical education," "teaching quality," and "educational improvement." By systematically mapping these PICo/PICO elements into database search strings, we ensured comprehensive coverage of the literature relevant to AI applications in enhancing the quality of medical education. Grounded on such considerations, this research question was formulated: What are the applications of AI in enhancing the quality of medical education? To ensure accuracy in answering this question, key constructs were operationally defined to provide consistency and clarity in study selection and data analysis. AI applications were classified as any digital or computational systems that utilize machine learning, natural language processing, deep learning, expert systems, or other associated intelligent technologies that are applied within educational environments. These included, but were not limited to, intelligent tutoring systems, adaptive learning systems, chatbots, automated grading systems, virtual or augmented reality made easier by AI, predictive analytics, and AI-driven academic management systems. We looked at the following categories when it came to levels of medical education: Undergraduate Medical Education (UME): Basic programs that lead to the first medical degrees (like MBBS or MD); Postgraduate Medical Education (Residency and Fellowship): Structured training programs for specialists after undergraduate medical education; Continuing Medical Education (CME): Formal and informal learning activities that help practicing doctors and other healthcare professionals keep their skills up to date and improve them; Interprofessional Education (IPE): Learning spaces where medical students and allied health professionals learn together using AI-enabled tools. Only research that specifically addressed the application of AI at one or more of these levels of medical education, with a clear connection to quality improvement, was considered eligible for analysis.

The development of a review protocol and the literature search

The study protocol was crafted to facilitate mixed methods research synthesis MMRS framework regarding the utilization of AI in the enhancement of medical education quality. The creation of the protocol needed multiple steps: crafting the research question and study objectives; choosing a conceptual framework; setting up inclusion and exclusion criteria; devising the search strategy and resource retrieval techniques; delineating the screening and selection process for studies; choosing tools to evaluate study quality; deciding on the data analysis method; and validating and confirming the results. We did a systematic search of the literature for peer-reviewed articles that were published in English between 2015 and 2025. This decade was chosen to include the era of large progress in machine learning, deep learning, and natural language processing, which have become essential in revolutionizing educational assessment and improving quality. The electronic databases Science Direct, Springer, ERIC, Emerald, Sage Journals, Wiley Online Library, PubMed, and Google Scholar were all searched. With an emphasis on (O) Quality Improvement, the search strategy combined keywords associated with (I) Artificial Intelligence and (P) Medical Education in a Boolean query based on the PICO framework. For every database, the search string was modified. Below is a representative example: An example of a search query is: ("artificial intelligence" OR AI OR "machine learning" OR chatbot*). AND ("clinical training" OR "medical student*" OR "medical education") AND ("learning outcome*" OR "educational quality" OR "quality improvement")

The following standards served as a guide for choosing the study: Criteria for inclusion: publications from 2015–2025 that are peer-reviewed in English, specifically address AI applications in medical education, and use either mixed-methods, quantitative, or qualitative research.

Exclusion criteria include: studies done outside of the designated time frame; editorials, opinion pieces, and non-peer-reviewed literature; and articles that do not focus on improving educational quality.

Look at the selection procedure: As shown in **Figure 2**, the PRISMA guidelines were followed during the study selection process. 187 records were found in the first database search. 77 studies were excluded after the titles and abstracts of these records were screened and duplicates were removed. After abstract review, 43 of the 110 remaining studies were eliminated. Following a full-text evaluation of the 67 studies that were found, 18 articles that did not fit the inclusion criteria were eliminated.

The MMAT (Mixed Methods Appraisal Tool, 2018 version) was adopted to assess the quality of the methodological approach of all the studies included in this synthesis. Each study was reviewed based on five criteria followed by a score of between zero to five. The criteria cut-off was defined to be any study that scored three or above, which is demonstrative of a compromise between quality and feasibility. Lower scores indicate methodological concerns with confidence and an increased risk of bias which may affect confidence in the findings from this synthesis.

As such a score of three or above is the minimum standard of quality and validity to avoid studies that demonstrate methodological concerns from being included in the synthesis. The MMAT scores for studies included in this synthesis are shown in **Table 1**.

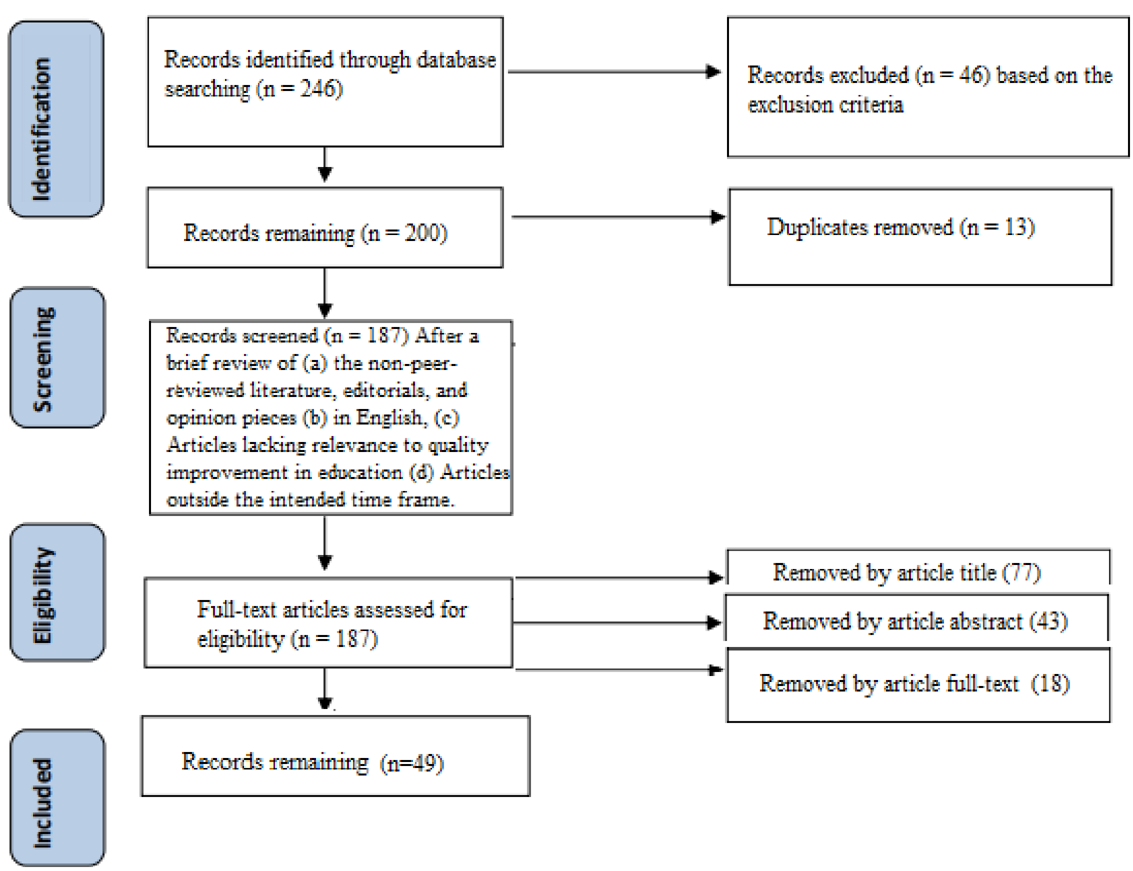

Figure 2. PRISMA flowchart for screening the articles

Table 1. Bibliography of the selected articles

Reference	Authors	Year	Article title	Country	Study designs	MMAT
38	Merliana & Tantri	2022	Improving the quality of Hindu education in the era of Society 5.0 through digital culture	Indonesia	Literature review with descriptive qualitative approach	3.5
39	Somasundaram et al.	2020	Artificial intelligence (AI) enabled intelligent quality management system (IQMS) for personalized learning path	India	Conceptual-descriptive	3.5
40	Ibrahim	2024	The effects of implementing artificial intelligence systems on enhancing educational services' quality from the perspective of employees at Alzaiem Alazhari University-Sudan	Sudan	Descriptive-analytical	4
41	Sahari	2024	Exploring the role of AI in advancing quality education in higher institutions for sustainable development	India	Qualitative	4
42	Muminov	2024	Development of artificial intelligence and its impact on educational quality in public schools	Uzbekistan	Mixed-methods	3.5
43	Arruda & Arruda	2024	Artificial intelligence for SDG 4 of the 2030 agenda: transforming education to achieve quality, equality, and inclusion	Brazil	Qualitative	3.5
44	Buaton et al.	2022	Optimization of higher education internal quality audits based on artificial intelligence	Indonesia	Applied-developmental	3.5
45	Judijanto et al.	2023	Student sentiment analysis: implementation of artificial intelligence in improving teaching quality	Indonesia	Quantitative	3.5
46	Sayfullayeva	2024	The role of artificial intelligence in improving the quality of student learning process	Indonesia	Qualitative	3.5
47	Abdullayev	2023	Harnessing technologies for enhancing the quality of higher education	Uzbekistan	Literature review	4
48	Nugroho & Anwar	2023	Implementation of artificial intelligence in increasing the quality of learning	Indonesia	Qualitative	3.5
49	Shikokoti & Mutegi	2024	Influence of artificial intelligence on the quality of education in higher learning: a case study of Faculty of Education, University of Nairobi, Kenya	Kenya	Mixed-methods	4.5
50	Lei	2017	Modern educational technology theory and university quality education	China	Literature review	3
51	Chemlal & Azouazi	2023	Implementing quality assurance practices in teaching machine learning in higher education	Morocco	Literature review	3
52	Wang	2023	The high-quality development path of education from the perspective of digitization	China	Literature review	3
53	Chekirine & Zoubida	2024	Artificial intelligence's impact on higher education quality	Algeria	Literature review	3
54	Hafiiak et al.	2019	Information technology as a component of improving the training quality future specialists in higher education institutions	Ukraine	Literature review	3
55	Peñalvo et al.	2024	Safe, transparent, and ethical artificial intelligence: keys to quality sustainable education (SDG4)	Spain	Qualitative	4.5
56	Li & Su	2020	Evaluation of online teaching quality of basic education based on artificial intelligence	China	Mixed-methods	3
57	Yang	2022	Digital transformation to advance the high-quality development of higher education	China	Qualitative	3.5
58	Hussain et al.	2022	The effect of the artificial intelligence on learning quality & practices in higher education	India	Qualitative	3.5
59	Flores-Viva & García-Peñalvo	2023	Reflections on the ethics, potential, and challenges of artificial intelligence in the framework of quality education (SDG4)	Spain	Qualitative	4.5
60	Perminova et al.	2023	The role of artificial intelligence in improving the quality of education and research	Ukraine	Qualitative	4
61	Yuan et al.	2020	Evaluation model of art internal auxiliary teaching quality based on artificial intelligence under the influence of COVID-19	China	Quantitative	3
62	Patil	2024	The potential of AI in enhancing education access and quality	India	Qualitative	4
63	Ajani et al.	2024	Leveraging artificial intelligence to enhance teaching and learning in higher education: promoting quality education and critical engagement	South Africa	Literature review	4.5
64	Lv	2021	Research on evaluation of teaching quality of Marxist theory in massive open online course based on artificial intelligence	China	Quantitative	4
65	Yugandhar & Rao	2024	Artificial intelligence in classroom management: improving instructional quality of English class with AI tools	India	Qualitative	3.5
66	Li & Wang	2023	Artificial intelligence and edge computing for teaching quality evaluation based on 5G-enabled wireless communication technology	China	Quantitative	4
67	Altinay et al.	2024	Capacity building for student teachers in learning, teaching artificial intelligence for quality of education	Turkey	Qualitative	4
68	Rane	2023	Enhancing the quality of teaching and learning through ChatGPT and similar large language models: challenges, future prospects, and ethical considerations in education	India	Qualitative	3.5
69	Utkirov	2024	Artificial intelligence impact on higher education quality and efficiency	Uzbekistan	Mixed-methods	4
70	Verma et al.	2021	Study of AI techniques in quality educations: challenges and recent progress	India	Literature review	4
71	Rodríguez-Abitia et al.	2020	Digital gap in universities and challenges for quality education: a diagnostic study in Mexico and Spain	Mexico and Spain	Qualitative	3
72	Nedungadi et al.	2024	The transformative power of generative artificial intelligence for achieving the sustainable development goal of quality education	India and Taiwan	Literature review	4
73	Rahayu	2023	Analyzing of using educational technology to improve the quality and equity of learning outcomes at Politeknik Maritim Negeri	Indonesia	Qualitative	3.5
74	Ahmed	2024	The role of artificial intelligence applications in enhancing the quality of online higher education	Saudi Arabia	Qualitative	4
75	Ahmad et al.	2024	Transforming teaching learning with chatbots in higher education: quest, opportunities and challenges for quality enhancement	Pakistan	Qualitative	4
76	Nie	2023	Research on improving education quality and efficiency through artificial intelligence and big data analysis	China	Mixed-methods	3

The selection of an appropriate design and method

The third phase of this investigation selected the mixed content analysis approach as the primary analytical lens in order to determine the appropriate synthesis design and method.

The goal of the research is to achieve an in-depth understanding of the uses of artificial intelligence in medical education through the integration of quantitative and qualitative evidence, and as such, content analysis offers a mechanism by which to provide shared meaning units to represent the diverse findings of primary studies, and identify categories and themes from the units.

Further, within this methodological approach, data from quantitative studies have also been transformed into classizable units of meaning via content-based extraction and description—for example, by identifying indicators, variables, statistical findings or evidence statements—that can also be analyzed alongside qualitative findings. This methodological approach design has constituted a synthesis that is grounded in meaning and content as opposed to data type, thus generating a coherent and multi-faceted account of applications of artificial intelligence in the quality of medical education.

The data extraction and evaluation stage

The articles' texts were read several times to help readers become fully immersed in the content before the data was extracted.

Key sections of the articles were documented in a structured format using Microsoft Word. For identifying key concepts—those conveying the most significant meanings—the paragraph was utilized as the unit of analysis, from which the most critical concepts were extracted.

Throughout the analysis process, memos were employed extensively.

During the initial reading of the texts, researchers made notes on key points, trends, or potential connections.

The notes included preliminary impressions of the focal issues of the articles, key ideas related to the research issue, and emerging ideas or issues worth investigating.

During coding, memos aided the recording of the rationale for why the codes were chosen, meaning-making, and interconnection, thus promoting conversation among the researchers.

In later data organization and extraction, memos proved helpful to aid the research team to compile suitable codes to create categories and overall themes. Examples of how to extract codes are shown in **Table 2**.

Table 2. Examples of how to extract codes

Extracted code sample	Example sentence
Curriculum personalization	"In curriculum design and planning, each student's preferences for the career path and his/her aptitude will be tested; based on the aptitude, his/her curriculum will be designed" [39, p. 441].
Personalize learning, personalized feedback, track student academic performance	"AI can personalize learning. AI-powered systems can track student progress and provide individualized feedback, helping students learn at their own pace and tailored to their individual needs" [41, p. 2].

The data analysis and interpretation stage

We followed Elo and Kyngas [77] This framework for examining information is built upon three foundational pillars. The initial stage focuses on establishing a foundation, where information is gathered and a structure for categorization is defined.

The subsequent stage, concerned with systematic arrangement, involves a meticulous review and sorting of the data based on its alignment with pre-established classifications.

The final and culminating stage is dedicated to presenting the outcomes, which articulates the findings to enable a deeper understanding of the identified patterns.

Furthermore, the insights derived from this process can be significantly augmented by integrating a mixed-methods approach that incorporates both statistical and interpretive techniques.

To ensure consistency, the concepts derived from each classification session were compared to measure the degree of agreement between the two coding processes. The process involved labeling similar codes across the two-time intervals as "agreement" and dissimilar codes as "disagreement."

The frequency of agreements and disagreements was then used in a formula to calculate the reliability of the coding process over time. This study conducted coding and classification twice, with a 14-day interval between sessions. A total of 403 concepts were extracted, with agreement reached on 175 of them between the two coding sessions. The calculated reliability for this retest was 86%, which, since it exceeds the 60% threshold, confirms the reliability of the coding process [78].

$$\text{test-retest reliability} = \frac{175 * 2}{403} * 100$$

The reporting and discussing of research findings

Finally, the findings were systematically documented and shared, ensuring a comprehensive and rigorous analysis process.

Results

As stated earlier, we used a standardized framework for quality assessment, which has been widely accepted in many studies, as a standard by which to measure the caliber of medical education.

To ensure alignment with this framework, key concepts were extracted and then categorized according to their similarities and differences.

Mission and objectives, organizational structure and management, faculty, students, teaching-learning processes, educational programs and curricula, academic and research facilities, and research activities are the eight primary dimensions that make up the framework. Within this framework, the integrated key concepts were taken into consideration as criteria. The departmental goals and missions are covered by the Mission and Objectives dimension. Academic departments' organizational setup, including policies, staffing levels, and services, is covered by the Organizational Structure and Management dimension. Academic counseling, consultation accessibility, and faculty-student interactions are all included in the Faculty Members dimension. The Students dimension covers student activities like participation in departmental planning, awareness of departmental goals, and knowledge of their rights and responsibilities.

Additionally, teaching and learning strategies, technology integration, and student assessment procedures are all included in the Instruction-Learning Processes dimension. The academic programs themselves, including their alignment with departmental missions and their design in accordance with curriculum planning principles, are covered by the Educational Programs and Curricula dimension. The infrastructure and resources that are available, including libraries, information systems, and technological services, are covered by the Educational and Research Facilities dimension. Lastly, academic work done by both students and faculty is included in the Research Activities dimension. The analysis's specific results are shown in **Tables 3** and **4**.

The frequency of references to different aspects of quality assessment in medical education, as indicated by the data in the table, stresses the significance and precedence of each aspect in related research.

Teaching-learning processes (36 references) and faculty members (38 references) are given the highest priority, highlighting the critical roles that creative learning strategies, teaching approaches, and faculty engagement play in determining the quality of education.

These results highlight the value of AI tools and cutting-edge technologies in improving the teaching and learning processes. 32 of the included studies made reference to the students dimension, and 34 references to organizational structure and management show that they actively take part in creating and carrying out successful educational initiatives.

The development of data-driven strategies and effective resource management targeted at ongoing quality improvement in medical education are supported by highlighting these dimensions.

However, dimensions like Mission and Objectives and Research Activities—of which there are only eight—seem to be less closely looked at in the studies. The intricacy of assessing these aspects or a stronger emphasis on more realistic and concrete aspects could be the cause of this.

Additionally, educational programs and curricula (21 times) and educational and research facilities (14 times) show how infrastructure and curriculum design quality directly affect the quality of the learning experience.

In order to guarantee a more uniform improvement in the quality of education, this frequency distribution pattern emphasizes the necessity of giving different aspects equal attention, with a special emphasis on the development of infrastructure and research initiatives. The frequency of each dimension is shown in the bar chart that follows (**Figure 3**).

In **Table 4**, examples of AI applications in enhancing the quality of medical education are presented, categorized according to each dimension of the framework.

Table 3: Analysis of findings based on the standard framework for assessing the quality of medical education

Dimensions	Criteria	Sample references
Mission and objectives	The development of policies in goal setting, plays a crucial role in shaping educational missions and frameworks for strategic goal-setting, assists in determining the necessary performance criteria to achieve quality objectives, while analyzing the relationship between educational goals and the execution of performance evaluations, additionally, it supports the identification of new goals, helps track outcomes, and ensures alignment with educational objectives, furthermore, it clarifies goals and values, aids in aligning objectives, and supports digital strategic planning for defining missions.	[42, 45, 49, 51, 53, 55, 57, 69]
Organizational structure and management	Data-driven decision making; culture of innovation; transformation in design and strategy in organizational architecture; transformation in policy-making approaches; timely delivery of educational services; responsible response to complaints and challenges; committed leadership; digital leadership; development of quality culture with a digital approach; development of management information systems and dashboards; increasing transparency in administrative systems; digitalization of administrative processes; sentiment and emotion analysis of educational service recipients; prediction and provision of solutions for administrative system issues; enhancing organizational employee performance; increasing organizational commitment to quality; optimization of financial resource management; reducing administrative costs; time management in administrative processes; assisting in the delivery of standardized educational services; helping university managers in providing efficient strategies; supporting informed decision-making based on performance; reviewing existing regulations; formulating laws on the use of AI; optimizing monitoring mechanisms for educational processes; organizing, integrating, registering, and developing intelligent systems for data mining; assisting in the formulation of management strategies; supporting optimal allocation of financial resources; weighting and optimizing internal evaluation standards; comparing standards in internal evaluation; developing Blockchain approaches in certification issuance; streamlining university management systems; identifying organizational needs; developing program evaluation mechanisms; identifying gaps in internal evaluation processes; developing financial mechanisms; reorganizing and optimally allocating financial resources; reducing managers' time in problem-solving; eliminating manual administrative tasks and improving administrative processes; optimizing and automating information processes; developing information modeling methods; information-based management; developing an information culture; adapting to various organizational needs; IT-based university governance; more flexible organizational structure; organizational information management; reducing organizational levels and hierarchies; expanding the scope of management; financial resource management; intelligent human resource management; helping design applicable and practical evaluation indicators; facilitating data collection for evaluation processes; quality management; developing reporting and feedback systems in evaluation.	[38, 40–44, 47, 49, 50, 53–57, 59, 61–63, 66, 69–71, 76]
Faculty members	Helping predict student performance accurately; helping identify strengths, weaknesses, and knowledge gaps of students; receiving personalized advice for faculty members; designing lesson plans; designing timetables for each course; ability to infer new knowledge from existing knowledge; assisting in aligning teaching strategies with students' learning styles, abilities, and needs; supporting and enhancing teaching methods; automating tasks and reducing workload; assisting in comparative evaluation; helping provide innovative teaching methods; helping identify areas where students at risk need further attention and improvement; analyzing factors and identifying patterns in student data; providing timely interventions for students in need of support; developing analytical and evaluation skills; providing student-centered education; evaluating student progress over time; helping with professional development; automated grading systems in assessments; improving evaluation accuracy; helping in continuous knowledge updating; analyzing data from various sources for evaluation; analyzing attendance and behavioral data; smart pedagogy; educational robots as assistants; helping evaluate teaching effectiveness; assisting in self-teaching planning; automatic assessment; innovation in teaching methods; assisting in designing collaborative projects; innovative teaching methods; helping set materials and difficulty levels based on individual student abilities; predictive analysis to identify complex learning behavior patterns; identifying potential future learning problems; supporting educational activities; assisting in real-time monitoring of learning progress; helping design assignments; helping design exam questions; automatic grading of exams; boosting confidence; real-time evaluation; helping provide insights into student learning patterns; customized evaluations; providing critical insights for revising teaching methods; generating new educational ideas; online assessments; theoretical innovation in education; adopting modern teaching practices; helping identify learning needs; designing learning activities; improving and optimizing teaching design; new teaching forms; developing exploratory teaching methods; collaborative teaching methods; sharing educational resources; assisting in time management; computer-based education; personalized teaching methods; helping provide relevant explanations and examples; identifying the shortest paths to deliver course content; identifying innovations in education; adjusting educational tasks; assisting in lectures; innovation in evaluation; data-driven evaluation; diversifying evaluation methods; teaching supported by big data; evaluating students' online behaviors; enriching educational resources; web-based education; helping assess student competencies; designing extracurricular activities; helping	[39–50, 52–68, 72–76]
Students	Developing career paths for each student; AI tools as student mentors; receiving personalized advice for students; receiving real-time feedback; creating a deeper understanding of course content; encouraging students to engage with educational material; helping increase participation; boosting motivation for learning; assisting in better understanding of course content; receiving smart feedback; supporting self-development; chatbots as private tutors; voice assistants; helping students with special needs; increasing problem-solving abilities; improving virtual interactions among students; improving academic outcomes; increasing academic satisfaction; helping cultivate creativity; assisting with assignments; helping develop soft and hard skills; acting as an academic guide; helping with time management; simulating exam questions; self-learning; assisting with translation into different languages; developing personalized learning paths; helping acquire new skills; assisting with adapting to the changing job market needs; reducing cognitive load; helping absorb and digest key points and complex materials; assisting with academic planning; helping with team building and teamwork; developing digital competencies; preparing students for future industry trends; helping students achieve learning goals; simplifying assessment processes; providing additional practice opportunities and resources; strengthening self-efficacy; meaningful learning; familiarizing with new study methods; increasing adaptability and empathy skills; enhancing writing skills; boosting employability skills.	[39, 41, 45–51, 53–67]

Dimensions	Criteria	Sample references
Teaching-learning processes	Lifelong learning; enhancing online learning capacity; utilizing social media in learning; making the learning process more exciting; customizing learning; personalizing learning; knowing how to learn; developing a quality management system in learning; additional learning in each course; visualizing learning processes; improving the quality of learning experiences; adaptive learning; maximizing learning outcomes; providing flexible learning opportunities; developing online learning platforms; learning anytime and anywhere; gamifying learning; simulation-based learning; interactive learning; active learning; designing digital learning experiences; creating an innovative learning environment; creating more inclusive learning experiences; supporting diversity in learning environments; developing more creative approaches to learning; collaborative learning; student-centered learning; strengthening deeper understanding of concepts in learning; dynamiting learning processes; making learning more effective; open learning; offering valuable insights on learning trends; augmented reality in learning; virtual reality in learning; learning analytics; optimizing learning methods; supportive learning environment; increasing enthusiasm for learning; inclusive learning; sharing learning experiences; independence in learning; changing learning habits; situational learning; expanding learning channels; innovative learning methods; acquiring new learning experiences; evidence-based learning; metaverse-based learning; collective learning; hybrid online and offline learning model; developing student learning profiles; inventing appropriate learning strategies; developing learning networks; developing new learning theories; changing learning experiences; multitasking learning; problem-based learning; collaborative learning; increasing learning speed; practical learning; project-based learning; self-regulated learning; metacognitive scaffolding in learning; being a learning partner; mobile learning; identifying learning patterns, trends, and gaps; graphical learning environments; access to global learning opportunities; step-by-step learning; self-directed learning; fast food learning; sentiment	[38, 39, 41–52, 54, 55, 57–61]
Educational programs and curricula	Customized educational programs; innovation-based curriculum; curriculum with a sustainable development approach; curriculum personalization; adopting advanced and innovative methods in educational programs; assisting in curriculum content development; smartening curriculum content; assisting in curriculum evaluation; designing customized content; optimizing the curriculum; restructuring the curriculum; multimedia content production; assisting in organizing the curriculum; analyzing curriculum content; assisting in summarizing curriculum content; visualizing curriculum content; helping in developing a comprehensive curriculum; managing curriculum resources; redefining curriculum quality standards; interdisciplinary curricula; assisting in educational planning; reducing curriculum content production time; standardizing curriculum content.	[38–40, 43, 46, 48–51, 53, 55–57, 59, 62, 64, 65, 67, 68]
Educational and research facilities	Development of smart campuses; smart classroom implementation; development of Internet of Things technology; providing high-quality welfare services; development of technical infrastructure; high-speed internet connections; development of data storage capabilities; investment in the creation and development of AI infrastructure; infrastructure to ensure data security; digitization of libraries; development of virtual laboratories; AI-based research laboratories; development of AI infrastructure; smartening administrative tools; development of smart learning spaces; information infrastructure; development of hardware and software technology infrastructure; digitization of educational facilities; online virtual laboratories; development of broadband networks; development of public service centers; cloud computing infrastructure; big data infrastructure; smart building infrastructure; 5G network infrastructure; wireless technology infrastructure; development of renewable energy infrastructure.	[38, 41, 58–60, 63, 65, 68–73]
Research activities	Development of research standards; helping identify gaps in research areas; intelligent analysis of research data; development of research methods; increasing the publication rate of academic research; enhancing interdisciplinary collaborations in research; improving research productivity; more practical and efficient research; development of research protocols; facilitating teamwork and research communication; faster and more practical execution of research tasks; rapid big data analysis in research; reducing research costs; simplifying tools for researchers across disciplines; innovation in research; assistance in coding and data analysis; help in article preparation; research data repositories; sharing research results; summarising research content; aiding systematic literature review; increasing creativity in research; simplifying research processes; smart recommendation systems for topic selection; article editing.	[44, 49, 55, 60, 65, 69, 70]

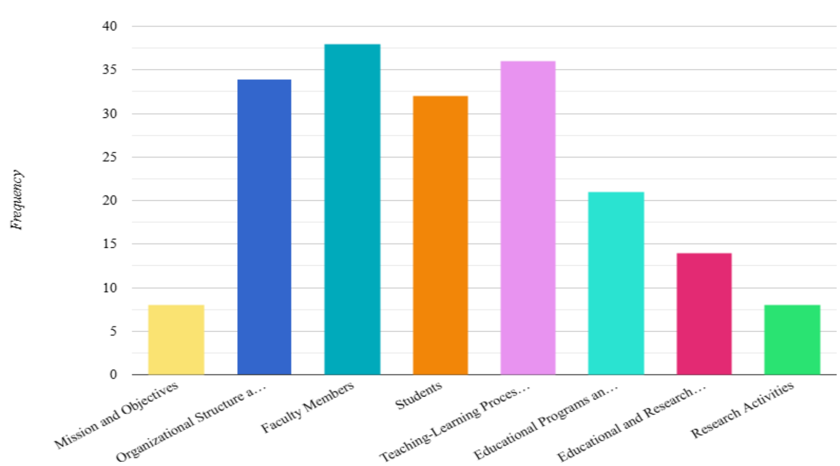

Figure 3. Column chart of the dimensions of the framework used

Table 4: Applications of Artificial Intelligence (AI) for enhancing quality in medical education

Dimension	Applications
Mission & objectives	**AI-powered strategic goal setting:** AI analyzes historical data, trends, and institutional needs to help define and refine educational missions, ensuring alignment with strategic quality objectives. **Data-driven policy development:** By processing large-scale datasets, AI identifies gaps in medical education, forecasts future demands, and informs the development of policies to enhance training programs. **Goal alignment and monitoring:** AI systems continuously track institutional goals against evolving healthcare needs, recommending adjustments to maintain compliance with industry standards and accreditation requirements.
Organizational structure & management	**AI-driven quality management:** AI enhances internal quality assurance by optimizing evaluation standards, automating data collection, and improving reporting and feedback mechanisms. **Digital Leadership and Decision Support:** AI aids department managers in strategic planning, streamlines administrative workflows, and facilitates data-driven decision-making for more effective governance.
Faculty members	**Personalized learning & performance prediction:** AI analyzes student data to forecast academic performance, identify individual learning needs, and facilitate customized educational pathways. **Automated assessment & evaluation:** AI-powered grading systems improve the accuracy and efficiency of evaluations, automate scoring, and provide real-time feedback on student progress. **Adaptive teaching & pedagogy:** AI supports educators in creating personalized lesson plans, refining teaching strategies based on learning analytics, and implementing innovative instructional methods.
Students	**AI-powered personalized mentorship:** Virtual mentors, such as AI-driven chatbots and assistants, offer students real-time feedback, tailored study plans, and ongoing academic guidance. **Skill development & career readiness:** AI helps students cultivate essential soft and hard skills, adapt to industry changes, and prepare for their professional careers through personalized learning experiences. **Enhanced learning engagement & comprehension:** AI-driven tools boost student motivation and participation while simplifying complex medical concepts to improve depth of understanding.
Teaching-learning Processes	**Adaptive & personalized learning:** AI customizes learning trajectories based on individual student progress, providing personalized content recommendations and optimizing study materials. **Simulation-based & immersive learning:** AI-powered immersive technologies (e.g., AR, VR, metaverse) provide realistic, hands-on simulations for practicing complex procedures and clinical scenarios. **Learning analytics & performance optimization:** AI tracks student progress, identifies knowledge gaps, and delivers real-time insights to help students and instructors improve learning strategies.
Educational programs & curricula	**Personalized & adaptive curriculum design:** AI tailors educational programs to individual student needs, dynamically adjusting learning paths and content based on their progress and proficiency. **Smart curriculum content development:** AI assists in generating, summarizing, and visualizing curricular content, using multimedia and interactive simulations to clarify complex subjects. **Curriculum evaluation & optimization:** AI analytics assess curriculum effectiveness, correlate programs with student outcomes, and suggest data-informed improvements.
Educational & research facilities	**AI-powered virtual laboratories:** AI-driven simulations and virtual labs allow students to practice surgical techniques, diagnostic methods, and lab procedures in a risk-free environment. **Smart classrooms & learning spaces:** AI-integrated classrooms use real-time analytics and adaptive learning tools to create responsive, personalized learning experiences. **AI-based research laboratories:** AI infrastructure in research settings facilitates big data analysis, assists in medical image interpretation, and supports predictive modeling for disease diagnosis and treatment.
Research activities	**AI-powered research data analysis:** AI enables researchers to analyze large, complex datasets, identify significant patterns, and accelerate data-driven discoveries. **Intelligent research topic identification:** AI-driven recommendation systems analyze existing literature and trends to suggest relevant and innovative research topics aligned with a researcher's expertise. **AI-assisted systematic literature review:** AI automates the screening and synthesis of vast medical literature, helping researchers identify gaps and conduct reviews more efficiently.

Discussion

Higher education is predicted to experience even more significant changes as a result of artificial intelligence's revolution in educational systems [79]. Quality, which has always been central to academic thinking, is still a crucial tenet. Using standardized criteria that are frequently used in the medical field for rigorous evaluation, this study methodically investigated how AI can improve the caliber of medical education. In the second dimension, organizational management and structure, AI demonstrates extensive applications in strengthening university governance. Bhaskar et al. [88] highlights blockchain's unique capacity to introduce efficiency and transparency, while Balayan et al. [89] shows AI's utility in monitoring student enrollment and graduation. These tools support administrators in data-driven decision-making, process organization, and workflow optimization, ultimately enabling better utilization of resources [90]. AI also enhances human resource management through automation and optimization, reengineering recruitment, training, performance appraisal, career planning, and employee mobility [91, 92]. Universities can also forecast revenues and expenditures, improving the precision of budgets and association of allocation of resources with educational quality. AI therefore significantly enhances management and organizational systems, resulting in improved academic performance. These results are congruent with research [42, 44–48, 51, 53, 57–61, 64, 67, 68, 71, 74–76]. Empirical evidence exists for these results: Zabol University of Medical Sciences in Iran reported an adequate status in organizational structure [93], as did the University of Qom in Iran, which scored a mean of 2.11 and reflected positive assessment of educational quality [94]. These results indicate that there is a strong influence of effective governance, stable institutions, and institutional leadership on quality improvement. Further, AI automates routine tasks like admissions, whereby chatbots offer continuous support, decrease workload for staff, and increase efficiency [95–98]. In the third aspect, faculty members, AI has extensive applications to improve the quality of scholarly and teaching work. A significant contribution is reducing labor in grading, increasing efficiency and accuracy [98]. Professors utilizing AI technologies gain immensely in terms of providing extra examples, individualizing instruction, and improving materials [99]. Chan and Tsi [100] mention that AI tools improve teaching practice and provide instant feedback, hence instructional design increases. By analyzing students' learning patterns, strengths, and weaknesses, AI enables individualized, data-driven instruction [101]. These findings are supported by extensive previous studies [39–70]. Empirical findings support these advantages: students of Yazd University of Medical Sciences indicated high levels of satisfaction with the punctuality of teachers and dedication of time [102], and Tehran University of Medical Sciences also reported positive results [103]. Conversely, in Tehran e-learning, the interaction between faculty and students was unsatisfactory (45% satisfaction) [104], and at Mashhad University, both interaction and feedback were unsatisfactory [105]. These conflicting results point towards variability in faculty communication and interaction, especially in online environments. AI allows faculty to save time for routine tasks such as attendance and grading, freeing time for course design [106]. Moreover, AI plans out lesson planning, syllabus creation, exams, tests, and rubrics [107]. Intensive technology such as image recognition and prediction systems increases assessment accuracy and effectiveness, decreasing test development, grading, and performance analysis [108].

In the fourth dimension—students—AI technologies are extensively used to significantly enhance the quality of learning. Chen et al. [109] summarize that chatbots are conversational interactive systems with the capacity to educate primary concepts and dispense instructional material. Similarly, Su et al. [110] demonstrate that AI allows one-on-one real-time support in e-learning, thereby enhancing the performance and participation of students. AI technologies simplify hard things, help students with disabilities, and promote inclusive learning [111]. According to Robert et al. [112], AI personalizes materials and feedback based on individual needs and learning styles, thereby creating adaptive learning environments. The collection of technologies as a whole improves learning through providing personalized experiences. There is proof that AI has very strong positive impact on quality and attainment of learning, in accordance with previous research studies [39, 41, 42, 45–72]. Empirical findings vary by institution: at Isfahan University of Medical Sciences, the student factor received a low score in comparison to other categories [113], while at Hamedan University, it received a high score [114]. These contradictory findings show how context-dependent student-related factors are, affected by learning environments, support services, and institution culture. Remarkably, student perceptions remain critical to complete assessments of education quality. AI systems provide tailored feedback, pinpoint weaknesses, and recommend targeted interventions for improvement [115]. In addition, algorithms for machine learning and neural networks promote autonomous learning by recognizing latent patterns in data and adapting continually from experience, facilitating dynamic and self-adjusting learning [116]. Apart from individuals, AI also assesses group performance, classroom relationships, and collective behavior, dealing with affective and social dimensions of learning. Through the promotion of teamwork, motivation, and communication, AI reinforces both individual and collective quality of learning [117].

In the fifth dimension, teaching–learning procedures, AI really adds quality to education by identifying students' learning habits and making customized recommendations for academic improvement. These technologies make classroom learning settings more flexible, responsive, and effective [118]. Passaic et al. [119] emphasize that augmented and virtual reality, learning games, and other AI offerings provide students with new and engaging experiences. Zhai et al. [120] confirm that AI automates testing and delivers timely feedback, boosting student performance, while Crawford et al. [121] show that tools such as ChatGPT foster interactive learning environments. Mislevy et al. [122] highlight the necessity of adaptive instruction, a central advantage of AI, enabling education tailored to students' intellectual abilities. Collectively, these findings demonstrate AI's broad utility in advancing teaching–learning quality, consistent with prior studies [38–75]. These claims are backed by Iranian university empirical data: 76% of the medical students at Isfahan University of Medical Sciences expressed satisfaction with the teaching process [123], and Guilan University was also satisfied [124]. The teaching process, however, indicated the highest variance between desired and experienced quality at Urmia University [125] and reflected institutional variations in teaching procedures. While some universities have well-coordinated student strategies, others struggle to align targeted quality goals with insights gained from experience. For digital natives, new interactive technologies significantly enhance motivation [126]. Virtual reality offers experience-derived learning environment that replicates real-world conditions [127]. AI also supports adaptive learning using data mining, intelligent tutoring, learning analytics, and real-time individualization. Gamification, another AI-supported technology, increases engagement by enabling real-time adaptation of game mechanics to students' values, needs, and performance [128]. Augmented reality, particularly in anatomy and radiology, helps students better grasp complex concepts from the early years of study [129].

In the sixth dimension, curricula and training programs, AI-based personalization has arrived as a revolutionary method in medical education. Learning analytics determine students' areas of strength and weakness in order to create personalized learning paths that modify practice, study plans, content, and simulation-based evaluation to meet individual needs. The innovations improve professional preparedness for clinical settings, decrease burnout, and streamline efficiency. Curriculum visualization tools, such as diagrams, concept maps, and charts tracking progress, create unified perspectives on content, goals, and tests. These, along with AI, become dynamic, real-time updating relative to performance, alerting, and suggesting personalized routes of self-regulation. This is in line with previous studies [38–40, 43, 46, 48–50, 51, 53, 55–57, 59, 62, 64–68]. Besides, the convergence of AI and big data has also opened up new promises of large-scale learning analytics, promoting reform and enhancing curriculum quality [130]. AI-informed insights direct curriculum planning that aligns student needs with labor market and future health care demand requirements [131].

At the seventh dimension, research and education facilities, infrastructural development is one of the key drivers to the quality of education. Among the best applications of AI is the concept of smart campuses, which integrates intelligent systems such as ICT infrastructure, intelligent sensors, autonomous control, prophylactic care, and sustainability to deliver harmonized and efficient learning environments [132]. These campuses leverage high-performance cloud computing and Internet of Things (IoT) to facilitate collaboration, security, and adaptive services in higher education [133]. Upgrading software and hardware infrastructures enables innovation and uptake of modern learning technologies consistent with findings from earlier studies [38, 41, 48, 49, 52, 54, 56–58, 70–73]. Empirical evidence indicates differences, however: Behbahan University of Medical Sciences cited infrastructural shortages as a key factor in decreasing educational quality [134], as did Hamedan University, who also recorded poor performance here [135]. Yasouj University, however, assessed its equipment in the laboratory—an essential infrastructural component—very satisfactory [136]. Such variations are indicative of the difference in infrastructural provision, with direct consequence for perceived and actual educational quality. Artificial Intelligence-based Learning Management Systems (LMS) like Absorb LMS and Docebo enhance learning efficiency with intelligent content development, administrative automation, and personalized pathways [137]. The broader concept of smart campuses positions AI in the middle of creating adaptive, data-driven, and student-centered environments. AI delivers academic and administrative services more accurately and efficiently through predictive analytics and adaptive services [8]. In the eighth dimension—research activities—AI has significant potential to support and transform university research. Although still maturing, AI technologies, particularly no-code platforms, can transform research design and implementation [138]. AI software aids the researcher by rapidly reviewing and summarizing literature, generating short summaries, organizing references, and refining manuscript writing [139]. Tools such as ChatGPT provide personalized feedback, and thus scholars improve in writing, creating insights, and improving the quality of the work [140]. Specifically, ChatGPT helps clinical researchers in drafting literature reviews, abstracts, references, and even draft versions of the manuscript [141]. These benefits align in consistency with previous results [44, 49, 55, 60, 66, 69, 70, 72]. Evidence by Sabzevar University of Medical Sciences is also in support that research work was considered desirable in internal quality evaluations [142], calling for the integration of research productivity into instruction structures. By coming up with concepts, posing research questions, and identifying keywords, AI also aids in the development of research problems [143]. Furthermore, sophisticated language models enhance readability, fix grammatical mistakes, expand vocabulary, and fortify syntax, freeing up researchers to concentrate on analytical and experimental tasks. Additionally, these technologies facilitate more logical and fact-based communication by assisting non-native English speakers in overcoming language barriers [144]. Beyond writing, AI also enhances data gathering, examination, and inter-disciplinary coordination by acting as recommendation systems that suggest to researchers pertinent areas of research across a wide variety of subjects [145–147].

Conclusion

With the advent of AI, decision-makers and policymakers should maximize its potential to further enhance educational quality. These results need to be used continuously to develop interventions to improve educational quality with systems thinking and understanding. Quality is not a static state; it is an ever-changing and evolving entity. All organizational elements, from culture, a directional and so-called soft capability, through to governance and management frameworks, are involved and contributing to the quality movement. Without the involvement of all elements, significant improvements in educational quality are unrealistic. From a systems perspective, all components must work together—much like parts of a living entity—to enhance quality.

The purpose of this research was to gather, combine, and summarize the existing research in this subject using mixed methods research synthesis in order to obtain a general idea of the applications of AI to enhance educational quality.

Apart from methodological comprehensiveness and comprehensive coverage, this research is still exposed to some limitations.

The most important one is the use of only English-written peer-reviewed articles in the final selection. This language barrier may also lead to the exclusion of relevant studies that were published in other languages, particularly from non-English-speaking countries where AI application in medical education may be imminent but not well represented in international databases.

Furthermore, reliance on database-indexed literature may exclude thoughtful observations from grey literature, conference talks, or institutional reports not covered by mainstream systems. Though Google Scholar was consulted to respond to this in part, it will not compensate for such potential omissions. These constraints suggest that the findings, while informative, may be English-dominant or Western-centric perception of the contribution of AI to medical education. The delimitation to this research is the exclusion of grey literature, i.e., unofficial and non-academic sources such as organizational documents, theses, conference papers, government documents, etc. that are not typically formally published or are not widely accessible.

Another limitation is the problem of updates; meta-syntheses tend to capture the prevailing situation at the time of research. The study needs to be updated frequently because of the rapid advancements in fields like artificial intelligence. It is noteworthy that future research should pay more attention to the operational aspects (faculty roles, teaching-learning processes) than the strategic ones (research and mission).

Ethical considerations

This study did not use primary data from either human or animal participants; rather, it is a mixed methods research synthesis of previously published research. Therefore, no institutional review board (IRB) code or ethical approval was needed. To maintain academic integrity, all included studies were openly accessible and properly referenced.

Artificial intelligence utilization for article writing

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Conflict of interest statement
The authors declare that they have no conflict of interest.

Author contributions
AK led the conceptualization and had the primary role in developing the manuscript.
FD was responsible for the collection and organization of references.
RK contributed to the structural review and refinement of the manuscript. RM conducted the final review and provided critical revisions.

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Data availability statement
All data analyzed in this study are available in publicly accessible databases.

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