Journal of Information Systems Engineering and Management
2025, 10(60s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Artificial Intelligence in Undergraduate Medical Education: Enhancing Teaching and Learning in Medical Colleges

Bassam Alhamad[1], Kajal Hayat[2]
[1]*University of Bahrain*
[2]*Khyber Medical University*

ARTICLE INFO

Received: 30 Dec 2024

Revised: 19 Feb 2025

Accepted: 27 Feb 2025

ABSTRACT

Artificial intelligence is changing medical education by providing innovative tools that improve teaching and learning. The paper presents AI applications in medical colleges that have specific focuses on personalized learning, clinical simulation, assessment, and faculty development. A mixed-method study of the Pakistani context highlights some opportunities and challenges for the adoption of AI: financial and infrastructural constraints and cultural resistance. The data was collected from one hundred undergraduate medical students and twenty faculty members engaged in medical teaching at Khyber Medical University medical colleges by an online survey and interviews by an expert-validated questionnaire (both structured and open-ended) following the pilot study. The findings from the study showed that the AI tools, personalized learning platforms, and assessment systems had high feasibility with great potential for improvement in quality. This includes leveraging open-source tools, building local expertise, and fostering partnerships as ways of ensuring sustainable integration of AI.

Keywords: Personalized Learning, Clinical Simulation, AI-Based Assessment.

INTRODUCTION

Medical education is developing to meet the modern challenges of health care systems. Now, AI has emerged as a transformative force that offers customized learning, interactive simulations, and automated assessment. The application of AI in medical education is extensive in developed countries, though integration into developing regions like Pakistan remains limited due to resource constraints. The present study intends to explore the feasibility, current applications, and challenges of AI in enhancing teaching and learning in medical colleges within Pakistan. This paper will highlight and discuss global trends and local research that could provide functional information to medical institutions.

This paper tackles the current levels of awareness and the preparedness for implementing AI in medical education among the undergraduate medical students in Pakistan. AI tools vary in terms of being expensive, user-friendly, effective, etc. Based on that, the possibilities of implementation of such AI tools will also be considered in the studies. This will include the financial or infrastructure barriers that the institution could face while adopting AI and implementing it in its education system. The paper would also evaluate the possibility level of integrating AI in curriculum. The objectives of this paper would hence be to 1) assess the levels of awareness, interest, and readiness of medical students and faculty regarding AI applications in education, 2) identify the suitable tools and its feasible implementation in the areas of personalized learning, virtual patient simulations, etc., and 3) to study the barriers that face medical colleges in Pakistan.

LITERATURE REVIEW

Artificial Intelligence in healthcare and medical education

AI is revolutionizing medical education for good with novel interventions in improving teaching-learning and feedback mechanisms. Students could be provided with immediate and actionable feedback that enhances both the theoretical understanding and practical competencies of learners (Chan & Zary, 2019).

Journal of Information Systems Engineering and Management
2025, 10(60s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

A study showcased the role of an AI system in constructing assessment tasks fully combined with the defined educational objectives while presenting personalized feedback to the students. These AI-powered assessments facilitate formative evaluation to a greater extent, highlighting the learning gaps among individual students and enabling personalized adjustments in teaching (Rasouli et al., 2024). Chheang et al., 2023, introduced the generative AI-based virtual assistant embedded in immersive VR environments (Chheang et al., 2023). Their work evidence that AI provides real-time interactive feedback to enable students to explore complex structures and improve their understanding of human physiology. Similarly, adaptive VR systems facilitate repeated, low-risk practice opportunities, providing a robust learning platform for anatomy training.

Chu and Goodell (2024) present a multimodal generative AI tool that simulates challenging conversations with synthetic patients. Their work highlights how this tool can provide feedback on clinical communication to enhance the medical students' empathy and adaptability. These simulations mimic real-life scenarios and provide students with a safe space to practice different scenarios, counseling, and other interpersonal skills that are essential in clinical practice (Chu & Goodell, 2024). Adaptive learning platforms like Coursera and Moodle use AI algorithms to assess a learner's strengths and weaknesses, dynamically adjusting the difficulty of tasks and recommending targeted resources (Krittanawong et al., 2017).

AI-driven virtual reality or virtual patients simulate real-life clinical scenarios, enabling students to practice history-taking, diagnosis, and treatment planning (Chheang et al., 2023; Lai & Zou, 2018; Shaw et al., 2025; Usmani et al., 2022). These tools improve clinical reasoning and communication skills in a controlled environment (Ellaway et al., 2019). However, high development costs and limited technical infrastructure pose challenges in implementing such systems in developing countries, (Jiang et al., 2017; Krittanawong et al., 2017; Wartman & Combs, 2018).

AI tools enhance evaluation processes by automating tasks like generating MCQs and providing instant feedback, as demonstrated in radiology training in Germany (Pesapane et al., 2018). AI automates formative assessments and provides instant feedback, which is critical for medical education. Tools like ChatGPT can generate multiple-choice questions and deliver customized feedback, enabling students to identify knowledge gaps (Reddy et al., 2018).

In Germany, AI is used in radiology training to interpret medical images, providing students with feedback on diagnostic accuracy (Pesapane et al., 2018). This application has potential in Pakistan, where AI can assist faculty in developing assessments aligned with local curricula, (Jiang et al., 2017). AI enhances specialized training like anatomy and surgical skills. In addition, virtual reality with AI offers an interactive 3D model of human anatomy, bringing greater improvement in the students' comprehension (Chheang et al., 2023; Lai & Zou, 2018; Usmani et al., 2022). **Table 1** shows the summary of the key AI applications in medical education.

Table 1. Summary of Key AI Applications in Medical Education

AI Application	Primary Benefit	Reference
Real-time feedback in simulations	Enhances practical skills and decision-making	BMC Medical Education (2024)
Adaptive MCQs and assessments	Personalizes evaluation and learning	BMC Medical Education (2024)
Virtual anatomy with AI and VR	Interactive learning of complex structures	(Chheang et al., 2023)
AI-powered synthetic patients	Improves clinical communication skills	(Chu & Goodell, 2024)
Personalized learning	Tailored content improves engagement and retention.	(Krittanawong et al., 2017)
Virtual patients and simulated learning	Enhances diagnostic skills in risk-free environments	(Ellaway et al., 2019)
AI in Assessment and Feedback	Automates evaluations and provides actionable feedback	(Pesapane et al., 2018)
Specialized AI Applications in Medical Training	Improves surgical and technical skills	(Wartman & Combs, 2018)

Journal of Information Systems Engineering and Management
2025, 10(60s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Reflections on Artificial Intelligence in medical education in Pakistan

There are many initiatives promoting and implementing Artificial intelligence in healthcare and medical education in Pakistan.

The Postgraduate Diploma in Artificial Intelligence Healthcare is one of the initiatives that shall help health professionals acquire AI competencies. The courses to be included are Machine Learning in Healthcare, Electronic Health Records, and AI Principles and Techniques (Health Services Academy, 2024). Besides, a study emphasized that training on AI should be included as part of medical education to enable future healthcare professionals to adapt to the technological change (Noor Ul-Sabah et al., 2023). An additional study had suggested the formulation of specific guidelines and investment in resources to support integration into medical curricula (Khan et al., 2023).

One qualitative study explored challenges and solutions for AI adoption in medical education in institutions in Pakistan (Fujimori et al., 2022; Mungaray-Lagarda, 2002; Nilsson & Ellström, 2012; Zarei et al., 2024). The results were barriers, including lack of technical skills, resource constraints, and ethical issues.

An initiative named "Darcheeni," an AI-driven healthcare framework, was designed to assist physicians and streamline healthcare processes within Pakistan. This framework also tends to develop patient-oriented care by integrating AI to improve healthcare delivery, thereby illustrating the practical application of AI in a medical setup (Zahoor et al., 2024). One article assessed the knowledge, attitudes, and perceptions of health care students and professionals in Pakistan concerning AI in health care. The findings indicated rising awareness and interest in AI applications, which involves a clarion call for educational activities to enhance the comprehension of AI and its integration into medical practice (Muhammad Mustafa Habib et al., 2024).

The Pakistani government has called for international investment and cooperation to overcome the challenges that the world faces today. Institutions such as the Pakistan Kidney and Liver Institute & Research Centre are committed to offering state-of-the-art medical services, thus contributing toward a healthier and more resilient society (Pakistan Today, 2024). These examples demonstrate the commitment of Pakistan toward the incorporation of AI into their medical education and healthcare systems. Besides, there is no widespread use of personalized learning platforms in medical schools across Pakistan. However, in higher education, there is a growing tendency toward the use of tools like Moodle, which supports AI plugins for adaptive learning. AI-powered platforms can tailor learning to individual students' styles and thus provide customized suggestions for study resources, quizzes, and practice exercises.

METHODOLOGY

Study Design

The present research is done through a mixed-methods approach to investigate how practical it would be to implement artificial intelligence in the field of undergraduate medical education at Pakistan. By using both qualitative and quantitative approaches, it examines awareness, preparedness, and barriers toward AI adoption among medical students and faculty. A criteria-based model was also created to assist universities in systematically assessing the feasibility of implementing AI technologies. The study duration was a total of three months (10 November 2024 to 10 February 2025).

Data Collection

1.1.1 Surveys

Participants to the survey involved 100 medical students (Bachelor in Medicine and Bachelor in Surgery, MBBS) and 20 faculty members from the anatomy, clinical medicine, surgery, and pharmacology departments from four Khyber Medical University's affiliated medical colleges of Pakistan. The instrument used was a semi-structured questionnaire including Likert-type items and open questions designed to assess the 1) awareness and understanding of AI tools, 2) perceptions towards the advantages of AI in educational settings, and 3) challenges encountered in adopting AI technologies in their institutions.

Journal of Information Systems Engineering and Management
2025, 10(60s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

1.1.2 Interviews

Participants to the interviews involved twenty faculty (both academic and administrative) participated in semi-structured interviews. The focus areas of discussion will include 1) institutional preparedness for the AI integration, 2) what faculty tell us about how AI might change teaching and learning, and 3) issues like financial limitations, infrastructure insufficiencies, and reluctance to progress. To contextualize the survey and interview results, a review of institutional documents, IT infrastructure capacity, and budget allocations was completed.

Criteria for Feasibility Assessment

A criteria-based framework was created to determine whether AI applications could feasibly be implemented in medical education. Each AI application was evaluated according to six key criteria, scored from 1 (low feasibility) to 3 (high feasibility), see **Table 2**.

Table 2. Criteria for Feasibility Assessment

Criterion	Description
Cost	Affordability of AI tools and infrastructure relative to institutional budgets.
Technical Infrastructure	Availability of necessary hardware, software, and internet connectivity.
Ease of Implementation	Complexity of integrating AI tools into existing teaching workflows.
Scalability	Ability to scale the AI application to accommodate large student cohorts.
Local Expertise	Availability of skilled personnel to manage and maintain AI systems.
Relevance to Needs	Alignment of the AI application with specific educational goals and challenges in medical education.

The scoring system to identify the level of feasibility is based on the following:

- **1 Point:** Low feasibility—There are substantial barriers to implementation.
- **Points:** Moderate feasibility—Barriers exist but can be overcome.
- **Points:** High feasibility—Few barriers to implementation.

For the quantitative data using the survey responses, the total feasibility scores for each AI technology application (ranging from 6 to 18 points) are calculated by summing the scores across the six criteria, High Feasibility: 15–18 points, Moderate Feasibility: 10–14 points, Low Feasibility: 6–9 points. For the qualitative data, thematic content analysis will be conducted identifying common perceptions, barriers, and readiness levels among faculty members. Findings from both quantitative and qualitative data were integrated to provide a comprehensive analysis of the potential for AI implementation in medical schools.

Application of the Feasibility Criteria

Six AI applications identified in the literature review were assessed using the feasibility framework:

1. Platforms for personalized learning.
2. Virtual patient simulations.
3. Automated assessments and feedback.
4. AI-powered anatomy and physiology education tools.
5. Clinical communication simulators.
6. Predictive analytics for academic success.

Each application was scored against the six criteria to find the most feasible solutions for implementation in Pakistani medical schools. The workflow summary of the study design for the feasibility assessment is shown in **Figure 1**.

Journal of Information Systems Engineering and Management
2025, 10(60s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

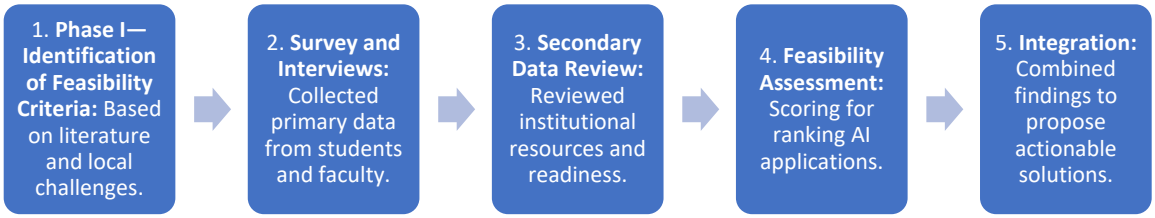

Figure 1. Workflow of Study Design

RESULTS AND DISCUSSIONS

The results and discussions section accounts for findings based on surveys, interviews, and the feasibility assessment according to established criteria. This quantitative and qualitative analysis evaluates whether it is feasible to integrate AI into medical education in Pakistan and its alignment with institutional goals. There had been 51 respondents to the survey, where 35% were faculty members and 65% were students. The average experience of students is 3.1 years.

The surveys filled out by students showed that 69% of students reported being unfamiliar with AI applications in education. In addition, 85% expressed a strong interest in learning about AI tools, especially those enhancing clinical skills and assessments. Regarding faculty members, they reported that 50% of faculty members had a moderate understanding of AI tools, largely due to international exposure. Only 20% of the faculty members stated that they had prior experience using AI in their teaching practices.

Regarding personalized learning, 70% of students believed AI could address individual learning challenges effectively. Faculty emphasized the potential of AI to enhance engagement in theoretical subjects. Regarding clinical skills development, 65% of students identified AI-powered virtual patients as crucial for practicing clinical decision-making in safe, controlled settings. Regarding Assessment and Feedback, 75% of faculty recognized AI's ability to expedite assessments and provide rich, individualized feedback. A group of constraints had been stated based on the survey and interview results. They mainly mentioned the financial constraints. 70% of faculty cited high initial costs as a significant barrier.

Technical infrastructure was another barrier, where 60% of students and faculty reported insufficient IT resources in their institutions. There are barriers around training and expertise, where 80% of faculty felt unprepared to adopt AI tools, citing limited access to training and professional development opportunities. The feasibility scores for each AI application are summarized in **Table 3**.

Referring to **Table 3**, AI automation and personalized learning platforms, received the highest scores of 18 and 17 respectively, indicating that this application can be most easily integrated into medical schools. These tools require very minimal infrastructure and greatly reduce faculty workload while improving student outcomes through instant feedback. It is seen that adaptive learning systems such as Moodle, when adapted to AI plugins, can emerge as viable methods of meeting individual learning needs at low costs.

Table 3. Summary of the feasibility assessment of AI applications

AI Application	Cost	Technical Infrastructure	Ease of Implementation	Scalability	Local Expertise	Relevance	Total Score	Feasibility

Journal of Information Systems Engineering and Management
2025, 10(60s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Personalized Learning Platforms	3	3	3	3	2	3	17	High Feasibility
Virtual Patient Simulations	2	2	2	2	2	3	13	Moderate
Automated Assessments and Feedback	3	3	3	3	3	3	18	High Feasibility
AI-Powered Anatomy Education Tools	1	1	2	2	1	3	10	Moderate
Clinical Communication Simulators	2	2	2	2	2	3	13	Moderate
Predictive Analytics for Success	2	2	3	3	2	3	15	High Feasibility

For virtual patient simulations, the score was 13; virtual patients are considered useful for clinical training but were limited by cost and infrastructure challenges. While such tools as Body Interact are game-changing, the initial investment remains unaffordable for many institutions. Similarly, anatomy education VR-based tools scored 10, reflecting their potential but also their high costs and demanding infrastructure. It is recommended that institutions begin with affordable 3D anatomy applications before gradually transitioning to advanced VR systems. Stage-wise implementation would leverage the feasibility level. These include financial constraints and high costs initially required for advanced applications of virtual patients and VR systems, and these do represent a main barrier.

AI Applications to Medical Education Across Disciplines

The feasibility and significance of AI applications in medical education vary across disciplines. This analysis evaluates AI tools in key areas such as anatomy, clinical medicine, radiology, and surgery, using the previously defined six criteria. The level of significance is identified to relate the AI application and its high influence on the teaching and learning experience. The results are shown in **Table 4**.

The total score for AI tools like 3D anatomy platforms and VR systems is “10”, based on which the feasibility level was identified as “Moderate Feasibility”. The “high” significance score implies improving comprehension and reducing reliance on cadavers, particularly in foundational medical training.

The assessment of AI application on “Clinical Medicine” show that the total score is “14”, based on which the feasibility level was identified as “Moderate Feasibility”. The “high” significance score implies preparing students for real-world patient interactions and enhancing decision-making.

The assessment of AI application on “Radiology” show that the total score is “14”, based on which the feasibility level is identified as “Moderate Feasibility”. The “high” significance score implies the importance of consistent feedback, where accurate image interpretation is critical.

Journal of Information Systems Engineering and Management
2025, 10(60s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

The assessment of AI application on “Surgery” show that the total score is “8”, based on which the feasibility level is identified as “Low Feasibility”. The “high” significance score implies preparing students for real-world patient interactions and enhancing decision-making, as it is critical for procedural training but has limited feasibility in resource-constrained environments.

The above analysis shows that the areas of higher feasibility are non-invasive fields. Clinical medicine and radiology scored a little higher since these depend on purely software-based AI tools, which are affordable and scalable. Virtual patients and radiology imaging systems could be implemented at a moderately resourced setup and thus within the means of Pakistani institutions. It is also noted that there is limited feasibility for resource-intensive fields. Anatomy and surgery depend on VR and hardware-intensive simulators; these are more expensive and require greater infrastructure, hence are less feasible in resource-poor settings.

Regarding the field-specific significance related to "anatomy," AI tools in the form of 3D models and VR facilitate interactive learning, reducing reliance on cadavers. Related to "Clinical Medicine," virtual patients enhance diagnostic reasoning and communication skills, aligning with real-world practice. Regarding "Radiology," AI-driven imaging analysis develops proficiency in interpreting diagnostic images. In relation to "Surgery," AI simulators are transformational for surgical training but face major feasibility challenges regarding cost and infrastructure limitations.

Based on the discussions above, a focus on high-impact, software-based applications is recommended. It would be done by emphasizing virtual patients and AI tools for radiology and clinical medicine, showing high feasibility with substantial educational benefits. Secondly, scaling up faculty training programs in readiness for AI adoption, is recommended in fields such as clinical medicine and radiology.

Thematic Analysis and Other Qualitative Analysis for AI in Medical Education

To analyze the responses using qualitative research techniques, a thematic analysis was employed alongside other relevant analysis methods like content analysis and frequency analysis (Braun & Clarke, 2006). Next, a general sentiment was implemented behind each response being positive, neutral, or negative. Based on that, the main themes and content analysis were identified. The thematic analysis for all the questions within interviews and comparison with the survey questions are summarized in **Table 5**.

IMPLICATIONS TO RESEARCH AND PRACTICE

Across all questions, faculty and student training emerged as a consistent theme. A strong positive perception was noted where most participants believe AI can significantly enhance medical education, particularly in personalized learning and simulation-based training. Students need access to affordable AI tools and personalized training sessions. Workshops, certifications, and AI-focused professional development initiatives are necessary. The need for institutional investment in AI labs, software, and internet access was emphasized in all questions. Government support is crucial for addressing financial barriers, especially in developing regions. Resistance to AI adoption stems from misconceptions about AI replacing human roles. Awareness programs and open discussions can help overcome cultural and institutional resistance. Responses highlighted the importance of integrating AI into the existing curriculum. Electives, workshops, and interdisciplinary collaborations should be promoted. Ethical considerations, including data privacy and bias in AI systems, need to be addressed with clear institutional policies.

Table 4. AI Feasibility by Medical Field

Medical Field	Cost	Technical Infrastructure	Ease of Implementation	Scalability	Local Expertise	Relevance	Total Score	Feasibility	Significance
Anatomy	*1 – VR-based systems are	1 – Advanced computing	2 – Requires faculty training and	2 – Limited scalabili	1 – Few local experts in	3 – Highly relevant for	10	Moderate	High for foundational

Journal of Information Systems Engineering and Management
2025, 10(60s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

	expensive, requiring significant investment in hardware/software.	and VR equipment often unavailable in resource-limited settings.	integration with existing curricula.	ty due to the cost of equipment for large cohorts.	VR and AI implementation.	understanding spatial relationships in anatomy.		Feasibility	medical training.
Clinical Medicine	2 – Moderately expensive; can use cloud solutions to reduce costs.	2 – Requires reliable internet and computing resources.	2 – Faculty/students need training to use virtual patient systems.	3 – Cloud-based virtual patients can scale easily for large student groups.	2 – Moderate expertise available, but advanced customization is limited.	3 – Critical for diagnostic reasoning and communication.	14	Moderate Feasibility	High for diagnostic and communication skills.
Radiology	2 – Licensing required but can be shared across institutions.	2 – Requires advanced imaging systems not available in all medical schools.	2 – Radiology faculty need training to integrate AI tools into workflows.	3 – Scalable with centralized AI systems and datasets.	2 – Growing expertise, but limited to specialized centers.	3 – Essential for developing diagnostic imaging skills.	14	Moderate Feasibility	High for diagnostic imaging skills.
Surgery	1 – Surgical simulators are among the most expensive AI tools.	1 – Requires high-performance hardware and specialized labs.	1 – Complex setup and ongoing maintenance make implementation difficult.	1 – Limited scalability due to high costs and equipment constraints.	1 – Very few local experts are trained in using or maintaining these systems.	3 – Extremely relevant for technical and procedural training.	8	Low Feasibility	High for procedural skill development.

* Score - Reasoning

Table 5. AI Application Feasibility by Medical Field (Scores + Reasoning)

Theme	Q1: How Can AI Enhance Medical Education?	Q2: What Steps Are Needed to	Q3: What Steps Are Needed for Effective AI Implementation?	Total Mentions (Q1–Q3)	Key Survey Insight

Journal of Information Systems Engineering and Management
2025, 10(60s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

		Overcome Barriers?			
Personalized Learning	35	0	0	35	High feasibility (17/18) in personalized learning
Simulation-Based Learning	28	0	0	28	Virtual simulations seen as high impact
Assessment and Feedback Enhancement	22	0	0	22	Automation benefits recognized in assessments
Faculty and Student Training	18	35	38	91	80% of faculty feel unprepared
Infrastructure Development & Cost	12	40	42	94	70% cited high cost as a barrier
Awareness and Resistance to Change	10	28	30	68	69% of students unfamiliar with AI tools
Ethical and Administrative Oversight	8	18	20	46	Ethics concerns aligned with interviews
Curriculum Integration & Policies	0	22	24	46	High feasibility for elective courses
Technical Support & Skilled Personnel	0	16	18	34	Lack of local technical expertise
Monitoring and Evaluation	0	10	12	22	Implied importance in scalability and feedback

The key findings could be summarized as: training, cost and infrastructure, resistance and awareness, curriculum integration, and ethical oversight, policies and guidelines for AI use. The following points are summarized as following:

Journal of Information Systems Engineering and Management
2025, 10(60s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

- AI enhances medical education through personalized learning, automated assessments, and simulation-based training.
- High-feasibility tools like adaptive learning platforms and MCQ generators can improve quality at low cost.
- Faculty and student readiness remains a barrier, highlighting the need for structured training.
- Infrastructure and cultural resistance hinder widespread adoption in Pakistan.
- Strategic, phased integration ensures sustainable and ethical AI implementation.

CONCLUSION

In conclusion, institutions must adopt a phased approach, starting with affordable, high-feasibility solutions while progressively working toward more advanced AI applications as resources become available. Without proper training, even the most advanced AI tools will fail to deliver meaningful educational outcomes. Investing in comprehensive faculty and student development programs is non-negotiable for AI's successful integration. In addition, shifting the mindset of faculty, students, and administrators is essential for fostering a collaborative environment where AI is seen as a partner in enhancing education, not as a threat.

On the other hand, sustainable implementation requires a collaborative effort between educational institutions, government bodies, and industry partners to ensure that financial constraints do not hinder the adoption of transformative AI technologies. Ethical considerations should guide AI integration to protect student data, promote fairness, and ensure that the technology is used for its intended educational benefits. Embedding AI within the curriculum ensures that future medical professionals are well-versed in both clinical and technological competencies, fostering a generation of AI-literate healthcare providers. AI integration should not be a one-time event but a dynamic, evolving process guided by ongoing assessment, feedback, and technological advancements.

Finally, AI has the potential to revolutionize undergraduate medical education in Pakistan by enhancing personalized learning, streamlining assessments, and providing immersive simulation experiences. However, successful implementation requires a multifaceted approach that addresses infrastructure challenges, trains faculty and students, and fosters institutional and governmental collaboration.

By adopting a phased strategy that prioritizes high-feasibility applications, builds capacity, and promotes ethical usage, medical institutions can bridge the gap between technology and education. This will ensure that AI becomes a transformative force in developing competent, future-ready healthcare professionals in Pakistan and beyond.

FUTURE RESEARCH

Building on the current findings, future research could focus on evaluating the implementation of the adopted tools in medical education colleges. Across Pakistan, future research through longitudinal studies would evaluate the long-term impact of AI tools on enhancing medical students' academic performance, clinical decision-making, and diagnostic accuracy.

Research could involves designing and assessing faculty development preparedness programs. One important aspect is to compare urban and rural institutions and measure the barriers and enablers to AI adoption. Moreover, there should be studies that undergoes cost-benefit analysis of AI tools, especially in resource-constrained environments due to financially sustainable implementations. Future studies should also investigate student-led innovation and co-creation of localized AI tools, enhancing engagement and contextual relevance. Finally, research could evaluate different frameworks to assess and evaluate AI, something like an AI readiness index that could support the possible scalable integration of AI in medical education both in Pakistan and other developing contexts.

CONFLICT OF INTEREST

There are no conflicts of interest.

REFERENCES

[1] Chheang, V., Sharmin, S., Marquez-Hernandez, R., Patel, M., Rajasekaran, D., Caulfield, G., Kiafar, B., Li, J., & Barmaki, R. L. (2023). Towards Anatomy Education with Generative AI-based Virtual Assistants in Immersive Virtual Reality Environments. https://doi.org/10.48550/arXiv.2306.17278

[2] Chu, S. N., & Goodell, A. J. (2024). Synthetic Patients: Simulating Difficult Conversations with Multimodal Generative AI for Medical Education. ArXiv.
[3] Ellaway, R. H., Masters, K., & Greene, P. (2019). Virtual patients for medical education: A review of developments and practices. Medical Teacher, 41(6), 640–647. https://doi.org/10.1080/0142159X.2018.1464655
[4] Fujimori, R., Liu, K., Soeno, S., Naraba, H., Ogura, K., Hara, K., & et al. (2022). Acceptance, Barriers, and Facilitators to Implementing Artificial Intelligence-Based Decision Support Systems in Emergency Departments: Quantitative and Qualitative Evaluation. JMIR Formative Research, 6(6), e36501. https://doi.org/10.2196/36501
[5] Health Services Academy. (2024). Postgraduate Diploma in Artificial Intelligence Healthcare. https://hsa.edu.pk/wp-content/uploads/2024/04/PGD-ALDIP-AL-HSA-Copy-final.pdf
[6] Khan, M. J., Lajber, M., Bilal, N., Khan, S., Siddiqi, Z., & Ahmad, A. (2023). The Barriers and Solution to Artificial Intelligence Adoption in Medical Education: A Qualitative Study. Journal of Saidu Medical College. https://orcid.org/0000-0002-3519-1914
[7] Krittanawong, C., Zhang, H., Wang, Z., Aydar, M., & Kitai, T. (2017). Artificial Intelligence in Precision Cardiovascular Medicine. Journal of the American College of Cardiology, 69(21), 2657–2664. https://doi.org/https://doi.org/10.1016/j.jacc.2017.03.571
[8] Muhammad Mustafa Habib, Zahra Hoodbhoy, & A. Rehman Siddiqui. (2024). Knowledge, attitudes, and perceptions of healthcare students and professionals on the use of artificial intelligence in healthcare in Pakistan. PLOS Digital Health, 3(5), 1–14. https://doi.org/10.1371/journal.pdig.0000443
[9] Mungaray-Lagarda, A. (2002). Re-engineering Mexican higher education toward economic development and quality. The XXI century challenge. Higher Education Policy, 15(4), 391–399. http://www.sciencedirect.com/science/article/pii/S0952873302000284
[10] Nilsson, S., & Ellström, P. (2012). Employability and talent management: challenges for HRD practices. European Journal of Training and Development, 36(1), 26–45. https://doi.org/10.1108/03090591211192610
[11] Noor Ul-Sabah, Faizan Fazal, Amina Khan, Hajira Arooj, Isha Rafiq, Muhammad Ahmed Dar, & Mansoor Ahmed. (2023). Artificial Intelligence in The Healthcare System; A Cross-Sectional Study Involving Medical Students. Pak J Med Dent, 12(3), 16–22. https://doi.org/10.36283/PJMD12-3/004
[12] OECD. (2023). Digital Innovation in Education: Challenges and Opportunities.
[13] Pakistan Today. (2024). PM Calls for Global Efforts in AI, Health, and Education to Overcome Contemporary Challenges. In Pakistan Today. https://www.pakistantoday.com.pk/2024/10/29/pm-calls-for-global-efforts-in-ai-health-and-education-to-overcome-contemporary-challenges/
[14] Pesapane, F., Codari, M., & Sardanelli, F. (2018). Artificial intelligence in medical imaging: threat or opportunity? Radiologists again at the forefront of innovation in medicine. European Radiology Experimental, 2. https://doi.org/10.1186/s41747-018-0061-6
[15] Usmani, A., Imran, M., & Javaid, Q. (2022). Usage of artificial intelligence and virtual reality in medical studies. Pakistan Journal of Medical Sciences, 38, 777–779. https://doi.org/10.12669/pjms.38.4.5910
[16] Wartman, S. A., & Combs, C. D. (2018). Medical education must move from the information age to the age of artificial intelligence. Academic Medicine, 93(8), 1107–1109. https://doi.org/10.1097/ACM.0000000000002044
[17] Zahoor, I., Ihtsham, S., Ramzan, M. U., Raza, A. A., & Ali, B. (2024). AI-Driven Healthcare Delivery in Pakistan: A Framework for Systemic Improvement. Proceedings of the 7th ACM SIGCAS/SIGCHI Conference on Computing and Sustainable Societies, 30–37. https://doi.org/10.1145/3674829.3675058
[18] Zarei, M., Eftekhari Mamaghani, H., Abbasi, A., & Hosseini, M. S. (2024). Application of artificial intelligence in medical education: A review of benefits, challenges, and solutions. Medicina Clínica Práctica, 7(2), 1004–1022. https://doi.org/10.1016/j.mcpsp.2023.1004-22