RESEARCH ARTICLE	Open Access

Empowering Future Physicians: Design, Implementation, and Evaluation of an Artificial Intelligence Course for Undergraduate Medical Students.

Asmaa Alaa [1], Nahla Hassan[1], Sally Fouad[1] , Nourhan F. Wasfy[1]

[1] Department of Medical Education, Faculty of Medicine, Suez Canal University, Ismailia, Egypt.

Abstract

Background:

In recent decades, the rapid growth of medical information has made it increasingly challenging for students and physicians to keep up with the vast amount of data they need to learn. The advent of artificial intelligence (AI) has further accelerated this expansion. Educating the next generation of physicians with the right techniques and adaptations to AI will enable them to become part of this emerging data science revolution. Accordingly, this study aimed to design, implement and evaluate an AI course at the Faculty of Medicine at Suez Canal University (FOM-SCU) to enhance undergraduate medical students' knowledge, skills, and attitude toward AI.

Methods:

A Quasi-experimental (pre-test/post-test) study design was conducted to evaluate the effect of the implemented AI course on the knowledge acquisition of undergraduate medical students, at FOM-SCU using MCQs followed by the assessment of students' satisfaction regarding the AI course and their attitude towards AI in healthcare and medical education using two questionnaires.

Results:

There was a significant increase in the mean post-test scores compared to the pre-test scores across AI-related subthemes, with a significance level of $p < 0.001$. Also, the undergraduate medical students demonstrated overall satisfaction with the implemented AI course. The undergraduate medical students concurrently expressed optimism and concerns toward AI in healthcare and medical education.

Conclusion:

The implemented AI course achieved promising outcomes and offered a beneficial framework for educating medical students about AI in healthcare and medical education to cope with forthcoming challenges.

Keywords:

Artificial intelligence, Course, Healthcare, Medical education.

Address for Correspondence
Asmaa Alaa,
Instructor of Medical Education,
Faculty of Medicine, Suez Canal University,
E-mail:asmaaalaaibrahim32@gmail.com,
Phone: 01203168658

Introduction:

Over the past decade, Artificial intelligence (AI) has advanced rapidly due to an ever-increasing amount of data and computing power [1]. It has increasingly become an integral part of our lives, having an undeniable impact on today's society. Also, AI has positioned itself as a supportive technology in many domains, ranging from industry to business and education [2].

Artificial Intelligence, as a new era in medical education and health care, has begun to be incorporated into medicine to improve patient care by speeding up processes and achieving greater accuracy, opening the path to providing overall better healthcare [3]. Medical practitioners need to understand the implications of AI to improve their efficiency and provide better patient-care, as the goal of AI integration in healthcare is not to replace doctors but to support and enhance their role [4].

The medical field is shifting from being solely information-driven to being both information- and AI-driven, leading to enhanced patient-care interactions. [5]. Healthcare delivery will rely heavily on vast datasets and AI applications, managed by multidisciplinary healthcare teams. Medical education needs to equip the workforce with a thorough understanding of AI applications to integrate big data into patient-care [6].

Moreover, AI integration into medical education has the potential to transform students' learning experiences and elevate their knowledge, skills, and competencies [7].

As AI becomes a standard part of healthcare, there is a risk of a growing gap between those who are proficient in AI and those who are not. Integrating AI education into medical curricula helps bridge this gap, ensuring that all future healthcare professionals have the necessary competencies and become part of this emerging data science revolution [8]. As physicians without AI knowledge may find themselves at a disadvantage compared to peers who are well-versed in these technologies. This could affect their career opportunities, progress and development [9].

As AI isn't included in the undergraduate medical curriculum at FOM-SCU, to address this gap, this study aimed to design, implement and evaluate an AI course at FOM-SCU to enhance undergraduate medical students' knowledge, skills, and attitude toward AI. The research questions in this study were: what is the effect of the implemented AI course on the undergraduate students' knowledge of AI in healthcare and medical education at FOM-SCU? What is the attitude of undergraduate students towards AI in healthcare and medical education at FOM-SCU?

Methods:

a) Study Design:

A quasi-experimental (Pre-test/Post-test) study design was utilized to evaluate the AI course designed and implemented for undergraduate students at FOM-SCU.

b) Sample and Context:

A convenient sample of the undergraduate students from 1st year to 5th year during the academic year 2023-2024 at FOM-SCU.

c) Sample size

The sample size was calculated using the following formula:

$$n = \left[\frac{Z_{\alpha/2}}{E}\right]^2 * P(1 - P)$$

Where

n= sample size

Z $\alpha/2$ = 1.96 (The critical value that divides the central 95% of the Z distribution from the 5% in the tail)

P = Proportion of medical students who supported AI's inclusion in the curriculum= 76.7% [10].

E = the margin of error (=width of confidence interval)

So, the sample size is 272 students, and with a 10% drop-out rate, the total sample size equals 300 students.

d) Study Procedure:

The study procedure was divided into 3 stages:

1. Course Design

The course was developed following the six-steps approach for curriculum development described by Kern et al. [11]. Table 1 below summarizes the six steps for the artificial intelligence course.

Table 1: The six steps for designing the AI course

Step	Description
Problem identification and general needs assessment	AI is a new era in medical education and health care. Medical education needs to prepare the workforce to be knowledgeable about AI applications that process big data and integrate the results into patient care. Early exposure to AI is crucial for aligning medical education with the evolving needs of the healthcare system and planning for future integration of AI into medical curricula.
Needs assessment for the learners targeted	A meeting with the administration was convened to assess the extent to which AI is incorporated within undergraduate medical curricula. Our findings revealed a notable absence of AI integration within the undergraduate medical curricula at FOM-SCU, resulting in ambiguous levels of knowledge, skills and attitude towards AI among medical students. Consequently, we propose designing and implementing an AI course for undergraduate medical students to enhance AI competence in the field of education and healthcare. This can improve their readiness to learn, adopt, and deal with AI tools.
Goals and objectives	The goal of the course was to enhance the medical student's knowledge, skills, and attitude toward AI to improve patient care. Our objectives in this course were: • Define Artificial Intelligence. • Illustrate how AI works • Demonstrate AI levels. • Identify the history of AI • Explain AI applications in medical education • Suggest some prompts on the ChatGPT application • Formulate a video with an AI application • Design Presentation slides with an AI application • Describe AI applications in healthcare List the ethical considerations in using AI tools.
Educational strategies	The course was designed as an extracurricular online (voluntary) format. Content: the covered topics in our course were basics of AI (definition, history and levels and how AI works), AI applications in medical education (personalized learning, automated grading system, personalized feedback, virtual reality and generating learning content "text, presentation and video"), AI applications in healthcare (digitalization of medical records, medication management, treatment plan design, virtual assistant, precision medicine, AI in radiology and AI in histopathology) and ethical considerations when using AI tools. Instructional methods: The course was conducted in two consecutive sessions, each lasting three hours and consisting of lectures and group discussions.
Implementation	The material and tasks included in the course were prepared and revised. The venue is planned to be a user-friendly online platform, ensuring easy access for all students and facilitating their interaction, so we used the Microsoft Teams application. The course time was arranged with the Vice Dean for Education and Student Affairs according to the student's schedules and commitments to allow them to participate in the course. The course was presented by the first author.
Evaluation	The course was evaluated using Kirkpatrick's evaluation model, which has two levels: the 1st level (reaction) and the 2nd level (learning).

After reviewing relevant literature in multiple databases and attending several webinars and online courses on the fundamentals of artificial intelligence, AI in healthcare, and AI in medical education. Then, the course material was revised by 9 medical education experts to ensure the relevance and appropriateness of the course content for the undergraduate medical students.   All experts replied that the course was relevant and appropriate and added some comments like adding more visual aids, adding AI applications of medical education to the course, and deleting some more details related to AI history.

2. Implementation of the course

An online invitation was sent via social media two weeks before its start to the students from 1st to 5th year at the FOM-SCU. Before the course implementation, an online registration form, including a pre-test, was disseminated via social media. After the course, the post-test and the satisfaction and attitude questionnaire were distributed using the same Google Form link through the Microsoft Teams chat. Out of the 370 medical students who attended the course, 354 completed both the pre-and post-tests, along with the satisfaction and attitude questionnaires.

3. Evaluation of the course

The course was evaluated using the first two levels of Kirkpatrick's model.

e) Data Collection Tools:

• MCQs (Pre- and post-test)

The pre- and post-tests included 8 MCQs, as demonstrated in supplementary 1, about four subthemes: the basics of artificial intelligence (3 questions), artificial intelligence in healthcare (3 questions), artificial intelligence in medical education (1 question), and ethical considerations while using AI tools (1 question). The MCQs were developed based on the course content and then were validated (content validity) by 9 medical education experts (experts' opinions).

• Undergraduate medical student's attitude towards AI questionnaire

The questionnaire assessed the attitude toward artificial intelligence of the undergraduate medical students who attended the course (n=354). The questionnaire was adapted from Stewart et al. [12], Moldt et al. [13] and Grassini, S. [14]. The attitude questionnaire included 28 questions, as demonstrated in supplementary 2, about four subthemes: undergraduate medical students' optimistic perspectives towards AI in healthcare (6 questions), undergraduate medical students' concerns towards AI in healthcare (8 questions), undergraduate medical students' optimistic perspectives towards AI in medical education (8 questions), and undergraduate medical students' concerns towards AI in medical education (6 questions).

• Students' satisfaction with the AI course questionnaire

Another questionnaire was used to assess the satisfaction of the undergraduate medical students who attended the course (n=354) with the implemented course. The questionnaire was adapted from Sabet's study [15]. The undergraduate medical students' satisfaction with the course questionnaire included 14 questions, as demonstrated in supplementary 3, about three subthemes: the course structure (6 questions), the instructor's presentation and expertise (4 questions), and the course design (4 questions).

Both satisfaction and attitude questionnaires were validated (content validity) by 9 medical education experts (experts' opinions). Each question was evaluated using a 5-point Likert scale, with responses ranging from strongly agree to strongly disagree.

f) Data Analysis:

The questionnaires responses were analyzed using the Statistical Package for Social Sciences (SPSS) version 25.0. The data were then analyzed descriptively, and internal consistency reliability testing using Cronbach's Alpha statistics was conducted.

Results:

As demonstrated in Figure 1, the highest number of attendees was from the first-year students (50.3%), while the lowest number was from the third-year students (3.4%).
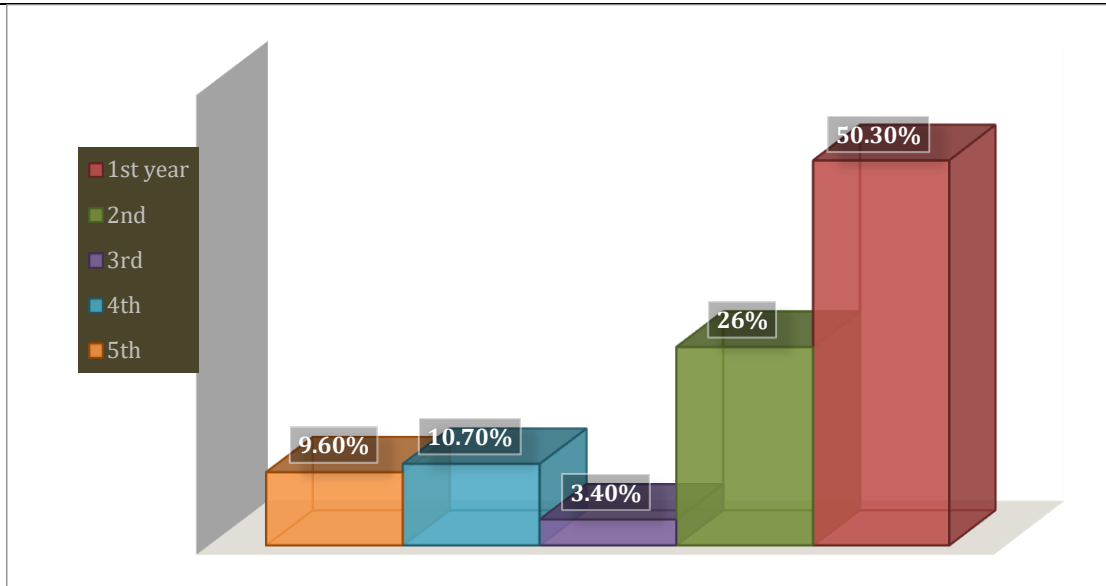
Fig. 1: The distribution of the undergraduate students who attended the course across the years of study (n= 354).

The majority of the attendees were males 209 (59%), while the female attendees were 154 (41%) as shown in figure 2.
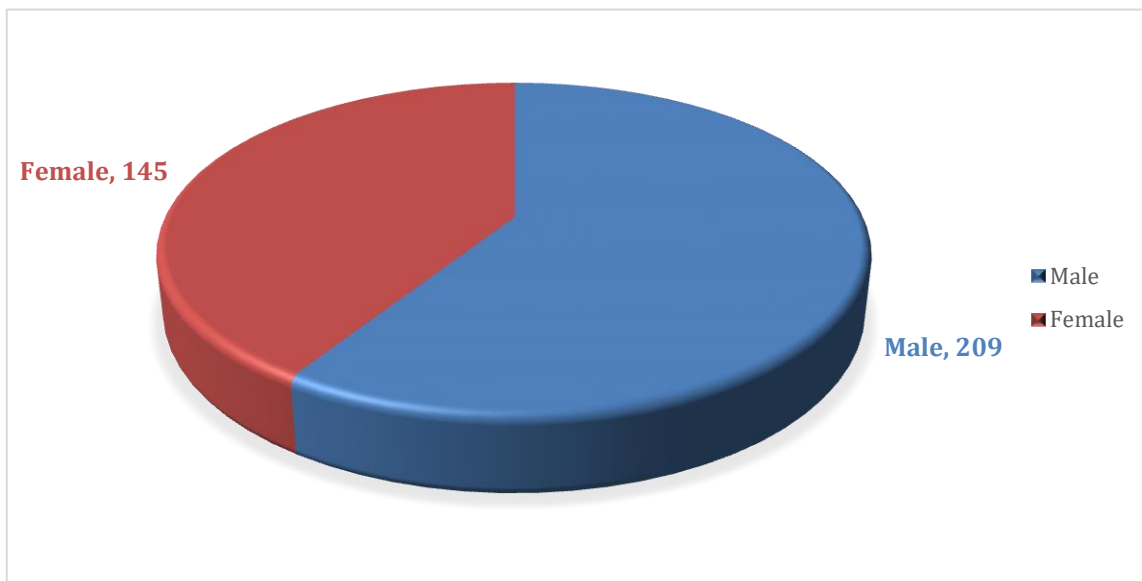

Fig. 2: Gender distribution of the undergraduate students who attended the AI course (n= 354).

Assessment of the difference in undergraduate medical students' knowledge before and after the implementation of the AI course:

Comparison of pre- and post-test scores among undergraduate medical sudents across AI-related subthemes

Table 2 revealed the difference between knowledge before and after the course as there was a statistical significance in the McNemar test values of the undergraduate medical students' McNemar test values all over the course subthemes at p-value < 0.001, which means that there is significant improvement in the undergraduate medical students' knowledge of the AI after attending the course.

Table 2: Comparison of pre- and post-test knowledge scores among undergraduate medical sudents across AI-related subthemes

Pre & posttest with sub themes	Pre				Post				McN	P
	Incorrect		Correct		Incorrect		Correct			
	No.	%	No.	%	No.	%	No.	%		
Basics of AI										
Q1	273	77.1	81	22.9	12	3.4	342	96.6	255.094*	<0.001*
Q2	266	75.1	88	24.9	62	17.5	292	82.5	179.170*	<0.001*
Q3	272	76.8	82	23.2	63	17.8	291	82.2	197.553*	<0.001*
AI in Healthcare										
Q4	304	85.9	50	14.1	100	28.2	254	71.8	196.233*	<0.001*
Q5	304	85.9	50	14.1	66	18.6	288	81.4	228.329*	<0.001*
Q6	294	83.1	60	16.9	95	26.8	259	73.2	174.240*	<0.001*
AI in medical education										
Q7	274	77.4	80	22.6	77	21.8	277	78.2	180.357*	<0.001*
Ethical considerations during using AI tools										
Q8	273	77.1	81	22.9	117	33.1	237	66.9	112.266*	<0.001*

McN: McNemar test

p: p-value for comparing between pre and post

*: Statistically significant at p ≤ 0.05

AI: Artificial Intelligence

Difference between mean scores of pre and posttest of AI course among students (n= 354)

Figure 3 demonstrated that there is a notable improvement in the knowledge of undergraduate medical students before and after the course across the four subthemes as well as the overall knowledge. The minimal overlap between the error bars, indicating a statistically significant difference. This suggests that the course was effective in enhancing the students' knowledge about AI across these areas.
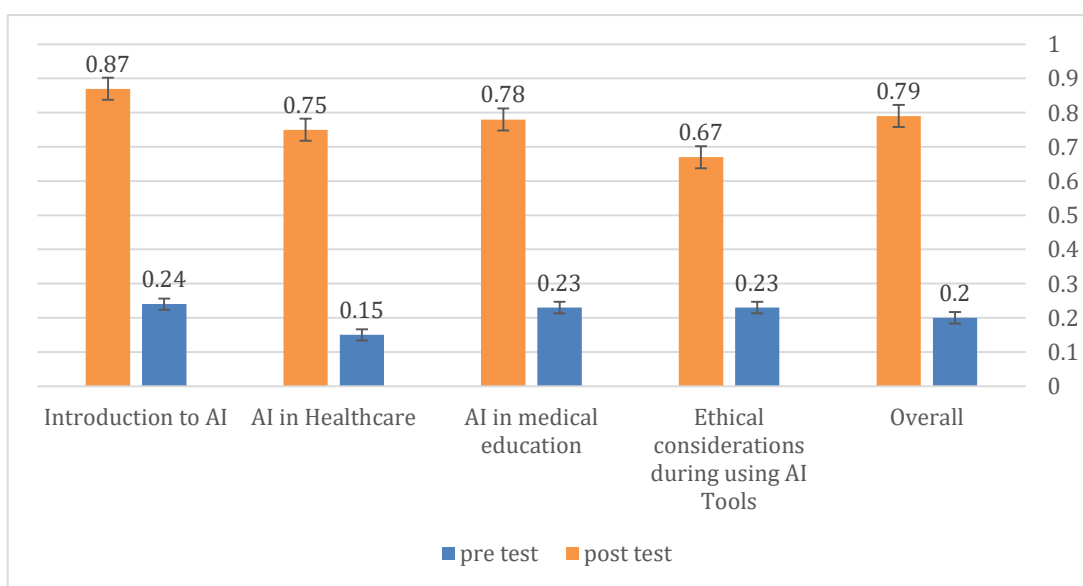

Fig. 3: Difference between mean scores of pre and Post-tests of AI course among students (n= 354)

Assessment of undergraduate medical students' attitude after implementation of the AI course:

Undergraduate medical students' optimistic perspectives towards AI in healthcare:

As shown in Table 3, the majority of undergraduate medical students had a notable positive attitude toward the integration of AI in healthcare. Most of them expressed an impression of AI's transformative potential in the medical field, an increased interest in the medical field due to AI advancements, and a belief that AI will enhance their ability to make informed management decisions for patients. Additionally, there was a widespread expectation that AI would alleviate administrative burdens, consequently affording more time for direct patient care.

Furthermore, approximately two-thirds of participants expressed a willingness to use AI for treatment recommendations, and about three-fourths expressed a desire to utilize AI for verifying their diagnoses in clinical cases.

Table 3: Distribution of undergraduate medical students' optimistic perspectives towards AI in healthcare items (n = 354).

Q	optimistic perspectives towards AI in healthcare	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
		No.	%	No.	%	No.	%	No.	%	No.	%
1	I am impressed by what AI can bring to the medical field	6	1.7	7	2.0	25	7.1	107	30.2	209	59.0
2	I am more interested in medicine with the development of AI	10	2.8	5	1.4	31	8.8	91	25.7	217	61.3
3	When I become a physician, I will use AI to recommend treatment for my patients	8	2.3	33	9.3	78	22.0	182	51.4	53	15.0
4	I believe that with the help of AI systems, doctors can make better management decisions for patients	7	2.0	5	1.4	42	11.9	232	65.5	68	19.2
5	I believe that when I become a physician, I will have more time for my patients when AI relieves me of administrative tasks	9	2.5	13	3.7	44	12.4	107	30.2	181	51.1
6	When I become a physician, I will use AI to check my diagnosis of cases	11	3.1	16	4.5	63	17.8	119	33.6	145	41.0

AI: Artificial Intelligence

Undergraduate medical students' concerns towards AI in healthcare:

Table 4 revealed concerns among undergraduate medical students regarding AI in healthcare. Slightly more than half expressed apprehension about how AI processes input data and had concerns about the potential diminishment of their role value as physicians and increased dependency if AI became widely adopted in the medical field. The participants agreed that they would be overwhelmed by the integration of AI into their daily work and that AI could contribute to a reduction in diagnostic errors. Approximately half of the participants did not express worry about job loss due to the replacement of numerous medical processes by AI technologies.

Table 4: Distribution of undergraduate medical students' concerns towards AI in healthcare items (n = 354).

Q	Concerns towards AI in healthcare	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
		No.	%	No.	%	No.	%	No.	%	No.	%
7	I am concerned that there is transparency about how AI systems digest the feeding data	23	6.5	71	20	59	16.7	102	28.8	99	28
8	I believe that the doctor-patient relationship can be negatively affected by increasing use of AI in medicine	43	12.1	103	29.1	56	15.8	97	27.4	55	15.5
9	I fear that my work as a physician will be less valued if AI gets widely used in the medical field	17	4.8	47	13.3	64	18.1	80	22.6	146	41.2
10	I am concerned that I will have more dependency at work with the development of AI	12	3.4	46	13.0	70	19.8	176	49.7	50	14.1
11	I expect to be overwhelmed with the use of AI in my daily work	94	26.6	118	33.3	54	15.3	57	16.1	31	8.8
12	I am worried about losing my job as a physician in the future due to replacement of many work processes in medical field by AI technologies	61	17.2	120	33.9	47	13.3	81	22.9	45	12.7
13	I am afraid that my income will be negatively affected by the development of AI in medicine	87	24.6	35	9.9	59	16.7	49	13.8	124	35.0
14	I am concerned that AI will increase the percentage of errors in diagnosis	80	22.6	130	36.7	67	18.9	11	3.1	66	18.6

AI: Artificial Intelligence

Undergraduate medical students' attitude towards AI in healthcare:

The results indicate that undergraduate medical students were generally optimistic about AI's potential to enhance their work as physicians(Mean ± SD: 4.29 ±0.63; 1–5 scale). However, they also harbored some concerns about the growing use of AI in the medical field (Mean ± SD: 3.13 ±0.63; 1–5 scale) as shown in figure 4.
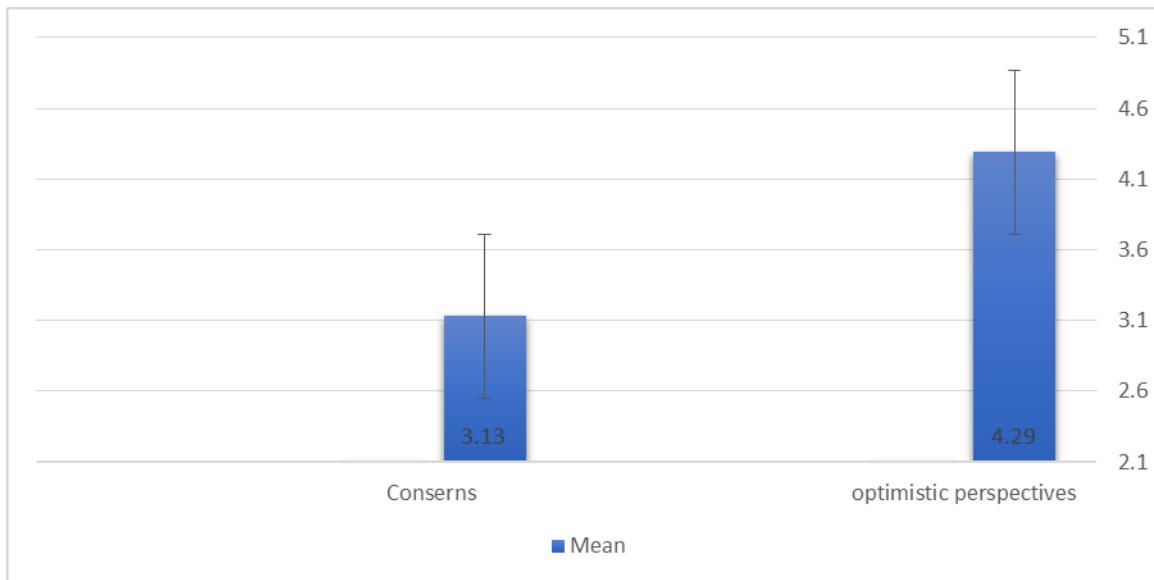

Fig. 4: The undergraduate medical students' attitude towards AI in healthcare.

Undergraduate medical students' optimistic perspectives towards AI in medical education:

As revealed in Table 5, undergraduate medical students were strongly interested and trusted in AI tools for their learning and assessment. The majority expressed a desire for additional education focused on AI in medicine, found virtual reality technology as an AI tool enjoyable, believed that AI could aid in their comprehension of challenging topics and concepts, and advocated for integrating AI education into medical training.

Three-fourths of the participants agreed they would receive personalized feedback if an AI system assessed them during a clinical exam. Additionally, almost two-thirds believed objective assessments would result from AI system evaluations during clinical exams.

Table 5: Distribution of undergraduate medical students' optimistic perspectives towards AI in medical education items (n = 354).

Q	optimistic perspectives towards AI in medical education	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
		No.	%	No.	%	No.	%	No.	%	No.	%
15	I believe that will receive objective assessment if an AI system assesses me in the clinical exam	6	1.7	26	7.3	76	21.5	116	32.8	130	36.7
16	I will receive personalized feedback If an AI system assesses me during clinical exam	2	0.6	26	7.3	59	16.7	118	33.3	149	42.1
17	I will be confident if I receive information from a teaching robot	109	30.8	95	26.8	54	15.3	63	17.7	33	9.3
18	I would like to receive more teaching focusing on AI in medicine	3	0.8	11	3.1	51	14.4	218	61.6	71	20.1
19	I think that virtual reality technology as an AI tool is attractive and fun to use	6	1.7	8	2.3	40	11.3	116	32.8	184	52.0
20	I think AI will help me in better understanding of difficult topics and concepts	2	0.6	5	1.4	41	11.6	114	32.2	192	54.2
21	I think using AI tools will be important for me to keep up with my peers academically	6	1.7	16	4.5	55	15.5	217	61.3	60	16.9
22	I believe that AI education should be part of medical training	5	1.4	10	2.8	48	13.6	205	57.9	86	24.3

AI: Artificial Intelligence

Undergraduate medical students' concerns towards AI in medical education:

Table 6 demonstrates undergraduate medical students' concerns regarding AI in their learning. Nearly three-

quarters of the participants expressed apprehension about the accuracy of information provided by AI tools, potential accusations of answer copying when using such tools, excessive reliance on AI affecting the development of their critical thinking skills, and possible privacy risks associated with AI tool usage.

Approximately two-thirds of the participants disagreed that including AI in undergraduate medical education could be overwhelming.

Table 6: Distribution of undergraduate medical students' concerns towards AI in medical education items (n = 354).

Q	Concerns towards AI in medical education	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
		No.	%	No.	%	No.	%	No.	%	No.	%
23	I am concerned about the accuracy of the information provided by AI tools	6	1.7	28	7.9	62	17.5	120	33.9	138	39.0
24	I am concerned that using AI tools will get me accused of copying answers	9	2.5	28	7.9	57	16.1	207	58.5	53	15.0
25	I am worried about relying too much on AI tools and not developing my critical thinking skills	5	1.4	25	7.1	48	13.6	107	30.2	169	47.7
26	I am afraid of using of AI will be a violation of academic and university policies	81	22.9	31	8.8	75	21.2	90	25.4	77	21.8
27	I am concerned about the potential privacy risks that might be associated with using AI tools	5	1.4	16	4.5	61	17.2	123	34.7	149	42.1
28	I will be overwhelmed if AI is included in undergraduate medical education	95	26.8	143	40.4	66	18.6	17	4.8	33	9.3

AI: Artificial Intelligence

Undergraduate medical students' attitude towards AI in medical education:

Undergraduate medical students demonstrated a mixed attitude towards AI in medical education. They showed optimism about AI's potential to enhance medical education (Mean ± SD: 3.88 ± 0.53; 1–5 scale). However, they also had some reservations about AI in medical education (Mean ± SD: 3.57 ± 0.54; 1–5 scale), as shown in Figure 5.
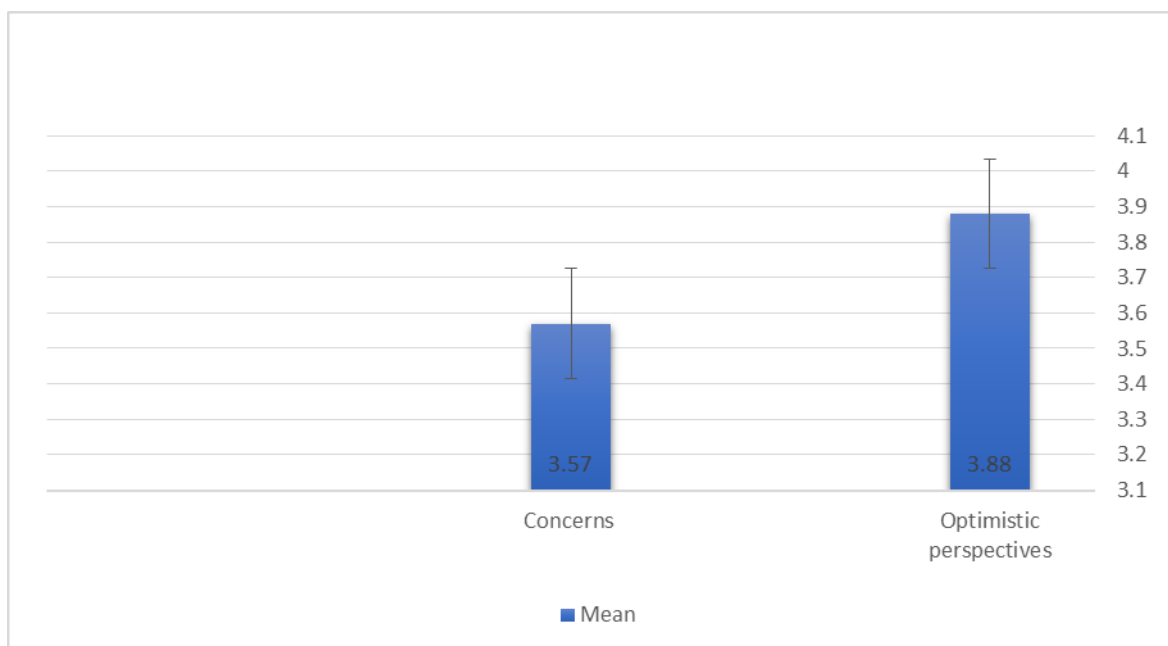

Fig. 5: The undergraduate medical students' attitude towards AI in medical education.

Assessment of undergraduate medical students' satisfaction regarding the AI course:

The vast majority of undergraduate medical students expressed their satisfaction with the overall structure of the course. Most participants affirmed that the course content met their expectations, encompassing the perception that it covered valuable topics, possessed clearly defined objectives, was relevant to their future careers, exhibited well-organized content, and utilized effective visual aids as demonstrated in table 7.

Table 7: Undergraduate medical students' satisfaction regarding the AI course structure.

Q	Course Structure	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
		No.	%	No.	%	No.	%	No.	%	No.	%
1	The course content leveled up to my expectations	3	0.8	3	0.8	18	5.1	118	33.3	212	59.9
2	The course Content covered useful items	5	1.4	4	1.1	20	5.6	103	29.1	222	62.7
3	The course objectives were clearly defined	3	0.8	5	1.4	18	5.1	118	33.3	210	59.3
4	The content was relevant to my future career	2	0.6	6	1.7	29	8.2	109	30.8	208	58.8
5	The content was well organized	5	1.4	5	1.4	18	5.1	108	30.5	218	61.6
6	The visual aids were effective	3	0.8	8	2.3	30	8.5	107	30.2	206	58.2

Undergraduate medical students' satisfaction regarding the instructor's teaching expertise & delivery of the AI course

Table 8 shows that most undergraduate medical students are satisfied with the course's instructor expertise and delivery. Many of them agreed and strongly agreed that the instructor demonstrated mastery of the topic, exhibited a good presentation style, effectively covered the subject matter, and responsively addressed questions.

Table 8: Undergraduate medical students' satisfaction regarding the instructor teaching expertise & delivery of the AI course

Q	The instructor teaching expertise & delivery	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
		No.	%	No.	%	No.	%	No.	%	No.	%
7	The instructor mastered the topic	2	0.6	4	1.1	29	8.2	119	33.6	200	56.5
8	The instructor's presentation style was good	4	1.1	4	1.1	26	7.3	112	31.6	208	58.8
9	The instructor covered the topic well	3	0.8	5	1.4	23	6.5	106	29.9	217	61.3
10	The instructor responded to questions	3	0.8	5	1.4	26	7.3	104	29.4	216	61.0

Undergraduate medical students' satisfaction regarding the design of the AI course.

The majority of the undergraduate medical students are satisfied with the course design. Most of them agreed that the course was well moderated, tasks and the alignment of tasks and activities with the course content, the appropriateness of the allocated time, and interaction and participation were encouraged as illustrated in table 9.

Table 9: Undergraduate medical students' satisfaction regarding the design of the AI course

Q	The Course Design	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
		No.	%	No.	%	No.	%	No.	%	No.	%
11	The course was well moderated.	2	0.6	4	1.1	28	7.9	92	26.0	228	64.4
12	Tasks and activities were reflective of the course content.	3	0.8	3	0.8	28	7.9	115	32.5	205	57.9
13	The allocated time was appropriate	4	1.1	6	1.7	33	9.3	119	33.6	192	54.2
14	The interaction & participation were encouraged	2	0.6	3	0.8	29	8.2	107	30.2	213	60.2

Discussion:

With the evolution of AI, students' early exposure is crucial for aligning medical education with the evolving needs of the healthcare system [16]. Therefore, this study designed and implemented an AI course for undergraduate medical students at FOM-SCU to enhance their knowledge, skills, and attitude toward AI. The satisfaction of the participating undergraduate students in the AI course was assessed quantitatively, as was their learning. In addition, their attitude towards AI in healthcare and medical education was assessed.

The current study findings revealed improved students' knowledge about AI after implementing the AI course. This may be attributed to the structured, progressive design of the AI course. In addition, starting the course with basic AI concepts and advancing to more complex healthcare applications and ethical considerations allowed the participants to build on their existing knowledge, leading to better understanding and retention. The relevance of the selected content to their future medical careers significantly boosted their motivation and engagement, reflected in their satisfaction with the course's structure, clarity, and usefulness.

Moreover, the new generation of students' inherent interest in technology and AI made them particularly receptive to the material, resulting in notable AI knowledge gains. The use of Microsoft Teams as a virtual learning platform enhanced the experience by providing a comfortable space for interaction and collaboration [17].

The current study's findings on improving medical students' knowledge are supported by Michael's study [18], where a 6-hour AI training for residents, particularly in deep learning. Moreover, a 3-week AI course was integrated into the academic curriculum in Hu's study [19]; this course consisted of live didactic lectures and literature case studies, similar to our current study teaching methodology, leading to enhanced students' knowledge of AI.

Additionally, Kong's study [20] corroborates our findings, showing significant improvements in participants' understanding of AI concepts after a 7-hour course using a flipped classroom approach, including AI and machine learning. However, our designed AI course focused on AI applications in healthcare, medical education, and ethical considerations.

In assessing the undergraduate students ' attitude towards AI in the current study, the participants showed mixed attitudes. They showed optimism about AI's potential to enhance their learning and assessment of AI's the AI role in healthcare. However, they also had some reservations about AI in medical education and healthcare. This would be because the course increased the students' awareness about the beneficial and assistive role of AI in healthcare and medical education, making them optimistic. Still, the course also increased the students' awareness regarding the ethical implications of AI tools, which made them also concerned.

The current study findings are in agreement with several studies' findings, including Jackson et al. [21] and Lareyre et al. [22], regarding the fact that medical students and faculty were optimistic about revolutionizing medical practice by AI and the importance of AI inclusion in medical education and training.

Our findings align with Khater's study [23] at Ain Shams University in Egypt, where medical students exhibited mixed attitudes toward AI in medicine and medical education. Both studies highlighted students' recognition of AI's potential to enhance patient outcomes, the importance of integrating AI into medical curricula, and concerns about the ethical implications of AI.

Similarly, in Jordan, Al-Qerem et al. [24] reported that while students acknowledged the importance of AI education, there was skepticism about AI replacing human teachers or outperforming physicians. In contrast, a study by Doumat et al. [25] in Lebanon revealed students' concerns about AI potentially replacing human roles, while our participants were more focused on ethical issues surrounding AI.

Yüzbaşıoğlu's study [26] in Turkey corroborated our findings, with students emphasizing the need to update medical curricula to reflect AI-driven changes in healthcare. Finally, Santos's study [27] in Germany supported our conclusion that AI will not replace human physicians. These differences in attitudes across regions may be attributed to varying levels of readiness and exposure to AI in healthcare and differences in cultural and educational contexts specific to each region [24].

As AI continues to reshape the healthcare landscape, the knowledge, attitudes, and practices of health professions students will play a pivotal role in shaping its impact on patient care and medical education.

The strengths of the current study are that it is the first implemented course in FOM-SCU and integrates AI education into medical curricula, which is highly relevant and aligns with current trends in the medical field. Including a relatively large sample size (n=354) enhances the robustness and generalizability of the study's findings [28].

On the other hand, the limitations in the present study are the use of pre-and post-knowledge tests, which could pose threats to internal validity, such as the "testing effect" [29], and the absence of skills assessment, which represents a limitation as without assessing skills, there may be a gap in the evaluation of the course's effectiveness.

Conclusion:

This study concluded that the designed and implemented AI course achieved promising outcomes and offered a beneficial framework for educating medical students about AI applications in healthcare and medical education to cope with present and forthcoming healthcare challenges. Undergraduate medical students simultaneously expressed both optimism and concern about the role of AI in healthcare and medical education, highlighting the need for a balanced approach to its use in these fields.

Recommendation:

Based on the study findings, the following recommendations were made:

•Integrate AI and provide training opportunities on AI tools and platforms into the FOM-SCU curriculum for undergraduate medical students.

•Implement clear policies and guidelines regarding the ethical use of AI tools in academic settings.

Ethical approval: Approval of the administration of the faculty, represented in its Dean and Vice Dean of Student Affairs was taken. Ethical approval was obtained from the Research and Ethics Committee (REF No: 5360#) at the FOM-SCU.

Availability of data and material:

Data supporting the current study are available from the corresponding author upon a reasonable request.

Conflict of interest:
The authors declare no conflict of interest.
Funding:
No funding.

Author contributions:
All the authors have contributed significantly to the work reported, whether in the conception, study design, execution, acquisition of data, analysis, and interpretation, or all these areas. Additionally, all authors have drafted written, substantially revised or critically reviewed the article. Finally, all authors read and approved the final manuscript.

References:

1. Topol, E. J. High-performance medicine: The convergence of human and artificial intelligence. Nature Medicine.2019;25,44–56.
https://doi.org/10.1038/s41591-018-0300-7
2. Busnatu, Ș., Niculescu, A-G., Bolocan, A., et al. Clinical Applications of Artificial Intelligence—An Updated Overview. Journal of Clinical Medicine. 2022; 11(8), 2265. https://doi.org/10.3390/jcm11082265
3. Mintz, Y., & Brodie, R. Introduction to artificial intelligence in medicine. Minimally Invasive Therapy & Allied Technologies.2019;28(2),73-81.
https://doi.org/10.1080/13645706.2019.1575882
4. Chen, J. H., & Asch, S. M. Machine learning and prediction in medicine—Beyond the peak of inflated expectations. The New England Journal of Medicine. 2017;376(26),2507–2509.
https://doi.org/10.1056%2FNEJMp1702071
5. Paranjape, K., Schinkel, M., Nannan Panday, R., et al. Introducing Artificial Intelligence Training in Medical Education. JMIR Medical Education. 2019;5. https://doi.org/10.2196/16048
6. Wood, E. A., Ange, B. L., & Miller, D. D. Are we ready to integrate artificial intelligence literacy into medical school curriculum: students and faculty survey. Journal of Medical Education and Curricular Development, 2021, 8:23821205211024078.
doi: 10.1177/23821205211024078.
7. Abd-Alrazaq, A., AlSaad, R., Alhuwail, D., et al. Large language models in medical education: opportunities, challenges, and future directions. JMIR Med Educ. 2023; 9, e48291.
https://doi.org/10.2196/48291
8. Grunhut, J., Wyatt, A. T., & Marques, O. Educating Future Physicians in Artificial Intelligence (AI): An Integrative Review and Proposed Changes.Journal of Medical Education Curriculum Development, 2021, 8. 23821205211036836

9. Pizzolla, I., Aro, R., Duez, P., et al. Integrating artificial intelligence into medical education: Lessons learned from a Belgian initiative. Journal of Interactive Learning Research, 2023, 34.2: 401-424. https://doi.org/10.17605/OSF.IO/5YCJW.

10. Ahmed, Z., Bhinder, K. K., Tariq, A., Tahir, M. J., Mehmood, Q., Tabassum, M. S., & Yousaf, Z. Knowledge, attitude, and practice of artificial intelligence among doctors and medical students in Pakistan. Annals of Medicine and Surgery, 2022 76, 103493. https://doi.org/10.1016/j.amsu.2022.103493

11. Kern, D. E., Thomas, P. A., Howard, D. M., et al. Curriculum Development for Medical Education. Baltimore: The Johns Hopkins University Press, 1998. 5:38-53. http://www.uc.pt/fmuc/ gabineteeducacaomedica/recursoseducare/livro12

12. Stewart, J., Lu, J., Gahungu, N., et al. Western Australian medical students' attitudes towards artificial intelligence in healthcare. PLoS ONE, 2023. 18(8), e0290642. https://doi.org/10.1371/journal.pone.0290642

13. Moldt, J. A., Festl-Wietek, T., Madany Mamlouk, A., et al. Chatbots for future docs: exploring medical students' attitudes and knowledge towards artificial intelligence and medical chatbots. Medical Education Online.2023;28(1),2182659. https://doi.org/10.1080/10872981.2023.2182659

14. Grassini, S. Development and validation of the AI attitude scale (AIAS-4): a brief measure of general attitude toward artificial intelligence. Frontiers in psychology,2023.14, 1191628.https://doi.org/10.3389/fpsyg.2023.1191628

15. Sabet B, Khani H, Namaki A, Habibi A, Rajabzadeh S, Shafiekhani S. Evaluation of artificial intelligence fall school program at Smart University of Medical Sciences. Research and Development in Medical Education.2023,12(1),pp.23-23 10.34172/rdme.2023.33142

16. Han, E. R., Yeo, S., Kim, M. J., et. al. Medical education trends for future physicians in the era of advanced technology and artificial intelligence: an integrative review. BMC medical education, 2019. 19, 1-15. https://doi.org/10.1186/s12909-019-1891-5

17. Redfern, S., & Galway, N. Collaborative virtual environments to support communication and community in internet-based distance education. Journal of Information Technology Education. Research, 2002.1, 201. https://doi.org/10.28945/2563

18. Michael, L. R., Patricia, I. O., et al. A "Bumper-Car" Curriculum for Teaching Deep Learning to Radiology Residents. Academic Radiology, 2022, 29(5), 763-770. https://doi.org/10.1016/j.acra.2021.11.016

19. Hu, R., Rizwan, A., Hu, Z., et al. An Artificial Intelligence Training Course for Diagnostic Radiology Residents. Radiology: Artificial Intelligence, 2023. 5 (2), e220170. https://doi.org/10.1148/ryai.220170

20. Kong, S. C., Cheung, W. M. Y., & Zhang, G. Evaluation of an artificial intelligence literacy course for university students with diverse study backgrounds. Computers & Education: Artificial Intelligence. 2021, 2: 100026. https://doi.org/10.1016/j.caeai.2021.100026

21. Jackson, P., Ponath Sukumaran, G., Babu, C. et al. Artificial intelligence in medical education - perception among medical students. BMC Med Educ, 2024. 24, 804 https://doi.org/10.1186/s12909-024-05760-0

22. Lareyre, F., Adam, C., Carrier, M., Chakfé, N. and et al., Artificial intelligence for education of vascular surgeons. European Journal of Vascular and Endovascular Surgery, 2020 59(6), 870-871. https://doi.org/10.1016/j.ejvs.2020.02.030

23. Khater, A. S., Zaaqoq, A. A., Wahdan, M. M., et al. Knowledge and Attitude of Ain Shams University Medical Students towards Artificial Intelligence and its Application in Medical Education and Practice. Educational Research and Innovation Journal.2023; 3(10),29-42. https://dx.doi.org/10.21608/erji.2023.306718

24. Al-Qerem, W., Eberhardt, J., Jarab, A. S., et al. Exploring knowledge, attitudes, and practices towards artificial intelligence among health professions' students in Jordan. BMC Medical Informatics and Decision Making,2023. 23.1: 288.https://doi.org/10.1186/s12911-023-02403-0

25. Doumat, G., Daher, D., Ghanem, N., & Khater, B. Knowledge and attitudes of medical students in Lebanon toward artificial intelligence: A national survey study. Frontiers in Artificial Intelligence. 2023; 5, 1015418. https://doi.org/10.3389/frai.2022.1015418

26. Yüzbaşıoğlu, E. (2021). Attitudes and perceptions of dental students towards artificial intelligence. Journal of Dental Education, 85(1), 60–68. https://doi.org/10.1002/jdd.12385

27. Santos, M. K., Ferreira Júnior, J. R., Wada, D. T., et al. Artificial intelligence, machine learning, computer-aided diagnosis, and radiomics: advances in imaging towards to precision medicine. Radiologia Brasileira. 2019; 52, 387-396. https://doi.org/10.1590/0100-3984.2019.0049

28. EDITORIAL. Consideration of Sample Size in Neuroscience Studies. J Neurosci. 2020;40(21):4076–4077.

29. Flannelly KJ, Flannelly LT, Jankowski KRB. Threats to the internal validity of experimental and quasi-experimental research in healthcare. J Health Care Chaplain. 2018;24(3):107–30. https://doi.org/10.1080/08854726.2017.1421019