Developing a Postgraduate Program for AI in Medicine with Kern's Six-Step Curriculum Development Approach in Singapore

Chang Cai[1], Michelle Jong[2], Yih Yng Ng [1,3], Jo-Anne Elizabeth Manski-Nankervis [1], Kum Ying Tham [1], Preman Rajalingam [4], Boon Keong Ang [5], Jennifer Anne Cleland [1], Joseph Sung [1], Xiuyi Fan [1,6]

[1]Lee Kong Chian School of Medicine, Nanyang Technological University
[2]Department of Endocrinology, Tan Tock Seng Hospital
[3]Department of Preventive and Population Medicine, Tan Tock Seng Hospital
[4]Mohammed Bin Rashid University of Medicine and Health Sciences
[5]National Healthcare Group
[6]College of Computing and Data Science, Nanyang Technological University
chang023@e.ntu.edu.sg, michelle_jong@ttsh.com.sg, yihyng.ng@ntu.edu.sg, joanne.mn@ntu.edu.sg, kytham@ntu.edu.sg, preman.rajalingam@dubaihealth.ae, louis_bk_ang@nhg.com.sg, jennifer.cleland@ntu.edu.sg, josephsung@ntu.edu.sg, xyfan@ntu.edu.sg

Abstract

Artificial Intelligence (AI) has rapidly transformed the medical field, necessitating significant changes in medical education to prepare healthcare professionals for future work requirements. However, the integration of AI into medical curricula has been slow and lacks standardization. In this paper, we present our work in developing a year-long postgraduate-level AI in Medicine program offered by a medical school at a public university in Singapore. Our curriculum design follows Kern's six-step approach to medical curriculum development, organized into a four-session framework. These sessions involved collaboration with hospital and university administrators, educators, industry experts, and healthcare professionals. The program is structured around three core courses: Foundational Healthcare AI, Clinical Applications of Healthcare AI, and Governance and Ethics for Healthcare AI. Each course comprises multiple modules with associated projects, emphasizing hands-on learning. The program adopts a problem-based learning approach, supported by a blended learning environment to accommodate the schedules of working healthcare professionals. Evaluations by industry experts highlight the program's potential to address critical gaps in the healthcare sector. This study contributes to the integration of AI into medical training by providing a standardized approach that can be adapted globally.

Introduction

As the adoption of Artificial Intelligence (AI) in healthcare continues to rise, numerous studies emphasize the importance of incorporating AI training into medical curricula (Charow et al. 2021; Lee et al. 2021; Ma et al. 2024; Pupic et al. 2023). From a clinical perspective, acquiring AI knowledge empowers physicians to understand AI mechanisms and assess the reliability of AI-generated results (Martinho, Kroesen, and Chorus 2021). As a bridge between AI and patients, AI-proficient physicians can effectively explain AI outcomes and their potential benefits, thereby enhancing patient trust and acceptance of AI (Derevianko et al. 2023; Wartman and Combs 2018). Furthermore, AI introduces ethical challenges, such as patient privacy, data security, and fairness (Martinho, Kroesen, and Chorus 2021). Physicians with AI knowledge can critically evaluate AI applications to ensure they meet ethical standards. From a development perspective, AI-trained physicians can provide clinically informed feedback, facilitating the adaptation of AI technologies to specific medical practice needs (Maassen et al. 2021). Although the growth of AI over the past two decades has been recognized as a chance to improve healthcare quality, medical education has been slow to adapt, leading to a lack of AI training in medical schools (Pupic et al. 2023).

In Singapore, the importance of a comprehensive education program for AI in Medicine is pronounced, given the nation's commitment to providing high-quality healthcare services to its residents (Haseltine 2013; Tan et al. 2021). As one of the fastest-aging populations, Singapore faces increasing healthcare demands (Tan et al. 2021), and AI is seen as a key part of the solution, promising personalized treatments and optimized care delivery (Ahmad et al. 2021; Ta et al. 2022). As outlined in the Smart Nation Program, Singapore's vision is to create a digital-first society, driving transformation in healthcare and government services (SmartNation 2024). To achieve these, it is essential to nurture a new generation of "AI-proficient" healthcare professionals. These individuals will effectively leverage AI in their work, collaborate with engineers to co-develop new AI tools, and explain complex data insights to patients (Wartman and Combs 2018). We believe that developing a dedicated postgraduate course providing in-depth AI training for professionals with existing medical knowledge and clinical experience is the best approach to cultivating such a cohort.

This study sets out to address **how to utilise Kern's six-step approach to design the curriculum of AI in Healthcare.** We applied this six-step framework (Thomas et al. 2022) and integrated an interdisciplinary co-design strategy. As summarized in Figure 1, our process involves co-design

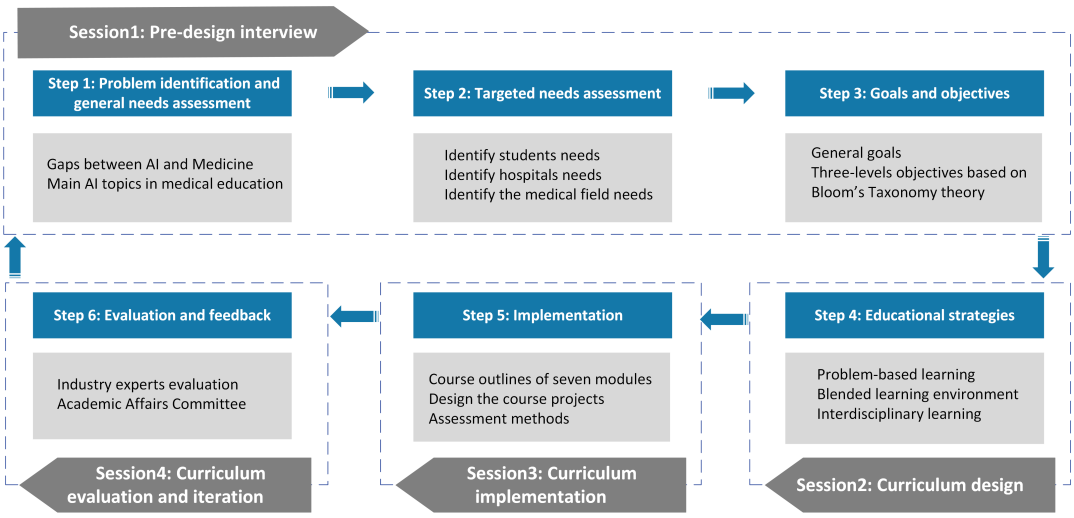

Figure 1: Our AI in Medicine program development framework based on Kern's six-step approach for curriculum development.

sessions with hospital administrators, university instructors specializing in AI and medicine, and healthcare professionals from various fields for problem identification, needs assessment, and learning objective development. After designing the curriculum, we conduct evaluation meetings with industry experts and the Academic Affairs Committee (AAC) of our medical school to ensure the program meets industry demands and educational objectives.

We believe our curriculum makes several contributions to the broader medical-AI education community. First, it helps healthcare professionals adapt to AI-driven transformations. Second, it promotes medical education reform by innovating curriculum structures and breaking down traditional disciplinary boundaries. Lastly, the program has the potential to enhance overall patient care quality and improve patient acceptance of AI-driven treatment plans.

Background and Related Work

Curriculum Design for AI in Medicine Courses As AI becomes increasingly pervasive in the medical field, enhancing patient care and supporting clinical decision-making (Ahmad et al. 2021; Hamet and Tremblay 2017; Ngiam and Khor 2019; Pillai 2023; Shuaib, Arian, and Shuaib 2020), research has started to explore and advocate for integrating AI education into medical curricula. Jackson et al. (2024) highlighted the strong demand among medical students for structured AI training, particularly in areas such as reducing medical errors (76.9%) and addressing ethical issues (79.4%). Similarly, Banerjee et al. (2021) reported that 81% of physicians supported the inclusion of more formal AI training in medical education, and Teng et al. (2022) found that 63.36% of medical students believed that gaining basic AI knowledge should be a standard part of their curriculum. Even students who were initially resistant to AI recognized the need to incorporate a basic understanding of AI into their education (Teng et al. 2022). Through a systematic evaluation of various aspects of AI, Pupic et al. (2023) provided evidence-based recommendations for implementing AI educational programs in the global undergraduate medical curriculum. Several studies have investigated implementing extracurricular programs to improve AI literacy, such as the workshops series for medical students and lectures for radiology residents (Hu et al. 2022; Lindqwister et al. 2021). These initiatives were mostly extracurricular and focused on specific areas, indicating that AI training for physicians is still in its early stages. In Figure 2, several courses incorporating AI in medical education are shown (Hu et al. 2022; Lindqwister et al. 2021; NUS 2024; Stanford 2020).

Previous studies have identified several challenges associated with integrating AI training into medical education. One challenge is the lack of unified medical courses and consensus on what and how to teach AI in medical education (Lee et al. 2021; Pupic et al. 2023). Besides, varying levels of AI literacy among faculty and curriculum leaders have been discussed as major barriers to the successful implementation of AI programs (Charow et al. 2021; Lee et al. 2021; Ma et al. 2024). Furthermore, the cross-disciplinary nature of the AI in Medicine course resulted in heterogeneous prior knowledge among students, requiring educators to address the diverse needs of learners (Hu et al. 2022).

Region	Learning Topics	Type	Target Audience
Overseas	Biostatistics fundamentals; Machine learning; Case study	Five weeks workshop	Medical undergraduates
Overseas	Foundational models in AI	Seven lectures	Radiology residents
Overseas	Fundamentals of ML	Eleven hours online course	Medical physicians
Singapore	Foundation of AI; AI in healthcare	Thirteen weeks live online	Professionals with or without a medical background

Figure 2: Courses incorporating AI in medical education.

Given these challenges, a co-design approach, which brought together diverse stakeholders to jointly develop a curriculum, has shown significant benefits in AI education (Xie et al. 2024). Involving researchers, practitioners, and communities in the co-design process was crucial for shared responsibility in healthcare education program design, as emphasized by Iniesto, Charitonos, and Littlejohn (2022). The inclusion of a wide range of stakeholders led to the development of educational programs that were close to the needs of society (Hoat et al. 2009). Moreover, the integration of AI into the medical curriculum required hiring educators from computer science to keep pace with changing knowledge (Paranjape et al. 2019). Thus, involving researchers, medical practitioners, and AI educators in the co-design process was essential for creating a standardized AI in Medicine curriculum that bridged the disciplinary gap between AI and medical education. While several studies have applied co-design methods in health education (Iniesto, Charitonos, and Littlejohn 2022), little research has investigated how to apply these methods to design AI training in medical education.

Kern's Six Stage Approach for Medical Curriculum Development Kern's Six-Step Approach (Thomas et al. 2022) is a widely recognized model for developing medical curriculum (Chen et al. 2019). The six steps are:

1. *Problem Identification*, which involves recognizing gaps or challenges that the curriculum aims to address.
2. *Needs Assessment*, which involves analyzing the needs of the targeted group of learners and learning environment.
3. *Goals and Objectives*, which involve setting broad goals and objectives for what the curriculum aims to achieve.
4. *Educational Strategies*, where teaching and learning methods are selected to achieve the set objectives.
5. *Implementation*, focusing on putting the curriculum into practice with the necessary resources and faculty.
6. *Evaluation and Feedback*, which assess the performance of both individuals and the curriculum, informing future improvement.

Kern's six-step approach has been successfully applied to the development of various medical curricula, such as the integration of health systems science curricula into medical education (Singh, Gullett, and Thomas 2021), a standardized corneal laser refractive surgery curriculum (Evangelista et al. 2023), and an anaesthesiology specialist training based on simulation education (Savoldelli et al. 2024). These studies demonstrated the method's effectiveness in achieving consensus on assessing needs, establishing learning objectives, and implementing curricula (Evangelista et al. 2023; Savoldelli et al. 2024). However, despite its widespread application, there is minimal application of Kern's approach in the development of AI in Medicine programs.

Methods

Interdisciplinary Co-design Group We have formed an interdisciplinary team to ensure the curriculum's comprehensiveness and scientific rigor. This team included hospital administrators, university instructors, and healthcare professionals. Specifically, six hospital administrators from Singapore's public hospitals and government departments, with experience in management and policy-making, were included. These administrators provided a macro perspective on the hospital's need for medical students to learn AI. Our team also included ten university instructors from a public university and a public healthcare organization in Singapore, each with over five years of teaching experience in AI or medicine. They ensured that the instructional design and course content met both students' needs and educational theories. Additionally, eight healthcare professionals from different departments contributed their clinical experience to ensure the program aligned with medical practice. Following the principles of Research-Practice Partnerships (Penuel et al. 2015), this interdisciplinary co-design group fostered collaboration through knowledge sharing, bridging the gap between AI knowledge and its application in healthcare.

Industry Evaluation Group Five independent industry reviewers were invited to evaluate the course, providing ongoing suggestions for optimization and improvement during its implementation. These reviewers came from diverse backgrounds, including experts in computer science, medicine, and education. They represented diverse fields relevant to AI in medicine, ensuring a comprehensive evaluation from multiple perspectives.

Academic Affairs Committee (AAC) The AAC of our medical school, consisting of 16 members, provided recommendations for the curriculum. The AAC included administrators from leading medical schools in Europe and Singapore, as well as representatives from Singapore's government ministries. This diverse composition ensured a comprehensive evaluation, covering medical education, healthcare policy, clinical practice, and AI technology. The AAC's multidisciplinary approach allowed for a thorough assessment, ensuring the AI in Medicine program aligned with clinical contexts and the learning community's needs.

Implementing Kern's Six-Step Approach with a Four-Session Co-Design Process

We implemented Kern's six-step approach in a four-session process outlined as follows.

Session 1: Pre-design Interview and Surveys Aligned with Kern's first three steps—problem identification, needs assessment, and objective setting—we conducted in-person semi-structured interviews with our interdisciplinary co-design group and used online surveys to gather their perspectives. As shown in Table 1, all design surveys (HA, UI, HP) gathered insights on the need for AI in Medicine, the broader and specific goals of the course, and the key competencies that learners should possess. The survey for healthcare professionals (HP) also collected critical areas where AI could enhance medical practice, setting the stage for a focused and relevant course design.

Session 2: Curriculum Design In this phase, the focus was on Kern's fourth step, selecting educational strategies to facilitate the course goals. The online survey (UI) was used

Survey Type	Open Questions	Multiple Choices	Participants
Design (HA)	4	2	6
Design (UI)	6	0	10
Design (HP)	9	0	8
Evaluation (IE)	11	9	5

Table 1: Surveys Information: HA refers to hospital administrators, UI refers to university instructors, HP refers to healthcare professionals, and IE refers to industry experts.

for university instructors to discuss the course structure, implementation challenges, and appropriate pedagogical methods. Then, the teaching team designed the course structure.

Session 3: Curriculum Implementation During the implementation phase, corresponding to Kern's fifth step, the teaching team developed a detailed program outline, including lecture modules, assessment methods, and projects. The program outline was presented to the industry experts.

Session 4: Curriculum Evaluation and Iteration After presenting the outline, an online survey (IE) was used to collect feedback from industry experts. Feedback guided the final design of the program. This iterative process allowed for continuous improvement and adaptation of the course based on feedback. Finally, the background and detailed course design were presented to the AAC for recommendation in a face-to-face meeting.

Data Collection and Data Analysis

Online surveys with both open-ended questions and multiple choices were used extensively in our study. For course co-design sessions, three distinct sets of surveys were designed for different stakeholders. For course evaluation, an additional set of surveys was designed for the industry experts group to gather their opinions on the course design (See Table 1). During the data collection process, strict ethics and privacy protection principles were adhered to, ensuring that responses were anonymized to maintain confidentiality. To identify and categorize the participants, each was assigned a unique ID. The first two letters represented their position and the number indicated their code. Six healthcare administrators were assigned codes HA1 to HA6, ten university instructors were assigned UI1 to UI10, and eight healthcare practitioners were assigned HP1 to HP8.

Both quantitative and qualitative analyses were used to identify the main findings from the responses. This multifaceted evaluation approach allows us to triangulate and provide a comprehensive assessment of the curriculum's potential impact and effectiveness. The ranking results were derived by calculating the proportion of responses for each option in the multiple-choice questions, allowing us to determine the level of consensus for each key idea. Content analysis was employed to systematically code responses from the online surveys (HA, UI, HP) according to a coding scheme. Two researchers independently coded 33.33% of the responses to establish coding reliability. Then, Cohen's Kappa, commonly utilized in content analysis, is used to measure the agreement level among coders. In this work, the Cohen's Kappa score between the coders was 0.83, indicating good inter-coder agreement (Emam 1999). The two coders resolved differences through discussion, reaching a consensus on the content analysis results. Following this, the first author independently coded the remaining responses.

Results

Kern's Step 1: Problem Identification and Generalised Needs Assessment

Data collected from healthcare professionals revealed several challenges in the implementation of AI in healthcare. Firstly, the general lack of AI expertise among healthcare professionals limited their ability to effectively use AI. Secondly, the difficulty of customizing off-the-shelf AI solutions to meet local needs was highlighted. Concerns about data privacy and AI reliability were also raised, as professionals were wary of how AI handles sensitive patient data.

Based on responses from the online surveys (HA, UI, HP), we identified five learning topics for students to learn essential aspects of using and developing AI in medicine:

1. AI Fundamentals: Foundational knowledge of AI.
2. AI Ethics: Ethical issues of AI in healthcare.
3. AI Governance: Regulatory frameworks governing medical AI and strategies for ensuring responsible AI use.
4. AI Development: Hands-on experience in developing AI models specifically for healthcare settings.
5. Clinical Application: Evaluating and utilizing AI for clinical decision-making and enhancing patient care.

Kern's Step 2: Targeted Needs Assessment

Identify Students Needs Most participants (N=17) highlighted the importance of healthcare professionals understanding basic AI concepts for effective application. A significant number of participants (N=16) highlighted the need for high-level skills such as AI literacy, computational thinking, and design thinking. For example, a hospital administrator (HA2) stated *"The most important skill for healthcare professionals to learn through this course is AI literacy, as it forms the foundation for understanding and effectively utilizing AI technologies in clinical practice."* Nine participants noted that enhancing healthcare professionals' ability to leverage AI in medical contexts is a crucial learning need. This capability aided in identifying needs, selecting appropriate AI solutions, making informed decisions, and mitigating AI-related risks. Two university instructors (UI6 and UI9) emphasized the need for better planning of career pathways through this course. Lastly, two hospital administrators (HA1 and HA2) indicated that the opportunity for continuing education was an important learning need for students.

Identify Hospitals Needs We identified three primary needs for hospitals. (1) Six participants highlighted the need to enhance overall operational efficiency through AI automation. (2) Six participants mentioned improving patient care by increasing diagnostic accuracy and treatment outcomes using AI as a need. (3) Two university instructors

(UI3 and UI6) emphasized the importance of cost management, including resource allocation and financial planning.

Identify the Medical Field Needs There were three needs identified in this area. Eight participants emphasized that the course promoted effective collaboration between healthcare professionals and AI developers; and such collaboration was crucial for the successful application of AI in clinical contexts. Four stakeholders highlighted the need to drive the evolution of ethical and regulatory policies, which would shape the future of healthcare by educating healthcare professionals about AI. Additionally, one hospital administrator (HA5) underscored the need to increase the adoption of AI in medical practice and to prepare healthcare professionals for their evolving roles, particularly the shift from traditional practices to AI-assisted decision-making.

Kern's Step 3: Goals and Objectives

Based on the various needs identified and UNESCO AI competency frameworks (UNESCO 2024), we set the broad goal of our program as to **empower healthcare professionals to become proficient AI users and active co-creators throughout the entire life-cycle of clinical AI systems**. By providing a comprehensive educational experience, we aimed to equip clinicians with the knowledge and skills necessary not only to understand AI but also to actively contribute to its development and responsible utilization. Additionally, the course could offer ongoing educational opportunities to keep professionals updated with the latest advancements in AI, preparing them for the evolving healthcare landscape.

This program offered a structured curriculum comprising three main courses: (1) Foundational Healthcare AI, (2) Clinical Applications of Healthcare AI, and (3) Governance and Ethics for Healthcare AI. For each course, we developed three specific learning objectives—cognitive domain, psychomotor domain, and affective domain—based on Bloom's taxonomy (Bloom et al. 1956).

Course 1: Foundational Healthcare AI

- *Cognitive Domain*: Students will learn fundamental concepts of AI, including machine learning, deep learning, as well as applications that are important to healthcare AI, such as computer vision and large language models.
- *Pychomotor Domain*: Students will gain practical skills in applying AI models to medical contexts, using algorithms for regression, classification, and clustering. They will gain practical experience in Python programming and applying software development practices to real-world healthcare applications.
- *Affective Domain*: Students will develop a positive view of AI algorithms' potential in healthcare, feeling responsible for solving healthcare challenges with data-driven approaches. They will stay updated with advancements in AI in healthcare with a thoughtful perspective.

Course 2: Clinical Applications of Healthcare AI

- *Cognitive Domain*: Students will acquire basic healthcare data analytics concepts, including data collection, data cleaning, and statistical analysis techniques relevant to clinical contexts. They will also gain insight into the role of AI in clinical decision support systems, understanding how AI algorithms can be integrated into clinical workflows to improve decision-making and patient outcomes.
- *Pychomotor Domain*: Students will develop the ability to do data analytics using programming languages such as Python and R, as well as integrate AI into practical scenarios such as analysing electronic health records. In addition, they will gain the skills to evaluate AI methods and enhance clinical decision-making processes.
- *Affective Domain*: Students will appreciate the evolving role of AI in enhancing clinical decision support and will be encouraged to stay updated on cutting-edge strategies. They will also foster a critical perspective on using AI in clinical settings, recognizing the limitations and benefits of AI for medical practices.

Course 3: Governance and Ethics for Healthcare AI

- *Cognitive Domain*: Students will gain an understanding of the principles and importance of AI governance in healthcare, including knowledge of existing regulatory frameworks and standards that guide the use of AI in medical contexts. They will also acquire a solid grasp of ethical considerations related to AI in healthcare, such as patient consent, data privacy, and the potential biases and impacts of AI systems on patient care.
- *Pychomotor Domain*: Students will develop the ability to apply governance frameworks and regulatory guidelines to ensure the ethical and compliant use of AI technologies in healthcare settings. They also became skilled in identifying and addressing ethical dilemmas related to AI applications, including implementing strategies to mitigate biases and protect patient rights.
- *Affective Domain*: Students will cultivate a proactive and responsible attitude towards the governance and ethical challenges of AI in healthcare. Additionally, students will appreciate the critical role of ethics in AI applications in healthcare and uphold high ethical standards.

Kern's Step 4: Educational Strategies

From our survey data, we have identified four major challenges in teaching the AI in Medicine course: (1) the diverse backgrounds of healthcare professionals, (2) distrust and low adoption rates of AI, (3) resistance to change within healthcare and educational systems, and (4) the time management required for professionals to engage in additional training. After the initial evaluation and iteration of the course, we decided to employ a Problem-based Learning (PBL) approach with group projects that enable students to collaborate and address real-world healthcare challenges using AI.

PBL, with its emphasis on experiential learning, is established as the core educational strategy for our program. Additionally, collaboration with interdisciplinary partners is key to achieving our comprehensive objectives. Our teaching team, composed of experts from diverse AI and medical fields, provides resources and guidance to help students develop meaningful engagement projects. Furthermore, the team fosters collaboration among students from

different medical departments and professions, e.g., clinicians, nurses, and pharmacists, who share common interests.

To better accommodate time-constrained healthcare professionals, we implement a blended learning environment, which encourages flexibility and affords accessibility by combining online and face-to-face interactions. With prerecorded lectures and in-person tutorials, this program facilitated a well-rounded educational experience.

Given the diversity of the student body in terms of disciplines, all instructors are encouraged to teach at an introductory graduate level to ensure that students with varying levels of AI knowledge could benefit. Additionally, we adopt flexible learning pathways, enabling learners to tailor their educational journey to meet their specific learning goals, professional commitments, and interests.

Kern's Step 5: Implementation

To deliver the three courses in our program, we further divide them into seven modules, each delivered with PBL and through blended learning. Each module is to be completed in six to eight weeks, with the overall program length lasting an academic year. The course structure is illustrated in Figure 3. Students first acquire foundational knowledge through lectures, and then collaborate in small groups on assigned projects. The projects were broken down into manageable assignments, with a final project. Weekly tutorial sessions are used to guide students in their project development.

After careful planning, we secured support from all stakeholders to ensure smooth curriculum implementation. The provision of adequate resources, faculty development programs, and logistical support for coordinating various activities was ensured. The AI in Medicine course is set to be implemented in 2025 at our medical school, which is a part of a public university in Singapore.

Kern's Step 6: Evaluation and Feedback

The evaluation survey results among industry experts evaluated the course across two main dimensions: (1) course content and structure as well as (2) the potential popularity of the course. Despite some challenges, the evaluation results reflected a highly positive attitude towards our AI in Medicine program. Based on this valuable feedback, we further refined and optimized the course. Finally, the course was evaluated by the AAC. Below are the detailed evaluations provided by industry experts and the AAC.

Course Content and Structure The survey results indicated that the scope and overall objectives of the program were highly suitable for training healthcare professionals to work in AI-related healthcare environments. All respondents rated the course scope and objectives as "Very appropriate" or "More than appropriate." Regarding the course outline, 80% of respondents believed it exceeded the standards expected for the degree or qualification and the remaining 20% considered it met the average standard.

Potential Popularity of the Program Experts provided positive feedback on the comprehensiveness of the program. One reviewer noted, *"The program is well-structured to meet the interdisciplinary needs of its target audience, integrating core principles of AI with specific applications in healthcare. It emphasizes practical skills, ethical considerations, and the development of AI solutions, addressing the critical need for AI competence in healthcare."*

All respondents believed the program would likely be well received, indicating a promising outlook among potential students. However, some reviewers noted the existence of similar online courses, such as Stanford's *Fundamentals of Machine Learning for Healthcare.* This highlights the need to emphasize the program's unique features and advantages, particularly in a local context, as well as the in-class interactions that cannot be replicated in online courses.

The AAC Evaluation AAC recognized that the course:

- Address a skill gap by empowering healthcare professionals to become proficient AI users and co-creators.
- Offer a comprehensive curriculum covering aspects of healthcare AI, from programming to AI governance.
- Meet a unique market need, as it is specifically tailored for the healthcare sector, unlike existing AI programs.
- Provide flexibility for working professionals through its modular structure and online delivery components.

Discussion

In this work, we designed a postgraduate-level AI in Medicine program using Kern's six-step approach. The program may address the critical need for standardized AI training in medical education by integrating key domains such as AI fundamentals, clinical applications, ethics, and governance. By leveraging a co-design method that involved diverse stakeholders, we ensured the curriculum's relevance and adaptability to real-world medical contexts. Additionally, our curriculum design is grounded in established learning theories and pedagogical approaches. On one hand, the PBL strategy aligns with constructivist learning theory, promoting knowledge construction. This method addresses key objectives in medical education, including structuring knowledge for clinical use, developing clinical reasoning, enhancing self-directed learning, and increasing motivation (Barrows 1986). On the other hand, the modular structure of the curriculum facilitates scaffolding learning, enabling learners to progressively build their AI competencies.

Our findings align with existing literature that emphasizes the importance of AI literacy in medical education (Charow et al. 2021; Lee et al. 2021; Ma et al. 2024; Pupic et al. 2023). Unlike previous efforts that primarily focused on specific areas of AI or were limited to extracurricular activities (Hu et al. 2022; Lindqwister et al. 2021; NUS 2024; Stanford 2020), our program offers a scalable course that can be implemented globally, making several key contributions to AI education research. First, it demonstrates the effectiveness of adapting Kern's six-step approach, traditionally used in medical curriculum development, to the emerging field of AI in medicine. This adaptation provides a structured framework for developing AI curricula in specialised domains. Second, our interdisciplinary co-design process offers a model for involving diverse stakeholders

Course	Module	Project	Assessment	Duration
Foundational Healthcare AI	Foundation of Programming and Software Development for Healthcare AI	Developing a Chatbot for Healthcare Appointment Scheduling	Group Assignments (40%) Project Presentation (60%)	26 hours
	Introduction to Machine Learning for Healthcare AI	Developing a Machine Learning Model to Predict Patient Length of Stay in Hospitals	Quiz (50%) Assignment (50%)	39 hours
	Deep learning for Healthcare AI	Model for Detecting Pneumonia from Chest X-rays	Paper (40%) Project (60%)	26 hours
Clinical Applications of Healthcare AI	Basic Healthcare Data Analytics	Analyzing Electronic Health Records for Patient Trends and Insights	Group Project (50%) Exam (50%)	26 hours
	AI in Clinical Decision Support	Developing an AI-Powered Clinical Decision Support Tool for Diagnosing Diabetes	Project (50%) Paper (50%)	26 hours
Governance and Ethics for Healthcare AI	Healthcare AI Governance	Diagnosis: Designing a Governance Framework for AI Deployment in Telemedicine	Quiz (40%) Assignment (60%)	26 hours
	Healthcare AI Ethics	Assessing Ethical Implications of AI Use in Patient Care	Project Presentation (50%) Quiz (50%)	26 hours

Figure 3: AI in Medicine Curriculum Overview.

in AI curriculum development, ensuring relevance and applicability across different healthcare contexts. Lastly, our findings highlight the importance of integrating ethical considerations and governance frameworks into AI education, addressing critical gaps in AI curricula.

Our program targets postgraduate education for healthcare professionals for three reasons. First, these students have a solid foundation in medical knowledge, allowing them to bridge AI and medicine. Second, healthcare professionals already have clinical experience, which helps them understand and assess AI applications in real-world medical settings (Xu et al. 2024). This experience allows them to focus on AI tools relevant to their specific fields and immediately apply AI knowledge and skills, leading to practical improvements in medical practices. Third, postgraduate programs often bring together professionals from diverse backgrounds, providing valuable opportunities for collaboration and networking, which fosters interdisciplinary learning.

The curriculum could serve as a model for other institutions, encouraging widespread adoption of AI training in medical education. While our focus is on the healthcare context in Singapore, the program can be modified to suit other geographical and cultural settings, ensuring its broader applicability. By continuously evolving with advancements in AI and healthcare needs, the program can make a lasting impact on the medical profession, shaping how future healthcare professionals are trained to interact with AI.

There are several limitations to this study. Firstly, although the curriculum design is completed, the program has yet to be delivered, and the current evaluation is based on feedback from industry experts and the AAC. The real-world effectiveness of the curriculum remains unassessed at this point. Future work will include longitudinal studies to evaluate the implementation and impact of the program in real-world settings. Secondly, the study focuses on postgraduate education, which may limit the applicability of the findings and recommendations to undergraduate education. Future research should aim to bridge the gap between different educational levels. Finally, as AI in healthcare evolves rapidly, there is a need for continuous monitoring of educational materials to ensure their timely updates and ongoing relevance. Additionally, future work may need to explore new educational models. For example, a subscription-based approach could provide graduates with regular updates, ensuring that graduates continue to be relevant to the space for the next few years after graduation.

Conclusion

As AI becomes increasingly embedded in clinical practice, healthcare professionals need to develop a strong understanding of these technologies to ensure they can effectively leverage AI tools to improve patient outcomes. Equipping healthcare workers with AI knowledge not only enhances their ability to interpret AI-generated insights but also empowers them to contribute to the ethical and informed application of AI in medicine. We present the design of a postgraduate-level AI in Medicine program for healthcare professionals, based on Kern's six-step approach. This structured method ensures that the program is designed to address real-world clinical needs while involving a diverse group of stakeholders throughout the process. Our work contributes to the growing body of literature on AI education and provides a model that can be applied globally to enhance AI literacy among healthcare professionals. Such efforts are crucial in preparing the next generation of clinicians to work effectively in an AI-augmented healthcare environment.

Acknowledgments

This research is supported by LKCMedicine Start up grant funding from Ministry of Education Singapore.

References

Ahmad, Z.; Rahim, S.; Zubair, M.; and Abdul-Ghafar, J. 2021. Artificial Intelligence (AI) in medicine, current applications and future role with special emphasis on its potential and promise in pathology: Present and future impact, obstacles including costs and acceptance among pathologists, practical and philosophical considerations. A comprehensive review. *Diagnostic pathology*, 16: 1–16.

Banerjee, M.; Chiew, D.; Patel, K. T.; Johns, I.; Chappell, D.; Linton, N.; Cole, G. D.; Francis, D. P.; Szram, J.; Ross, J.; et al. 2021. The impact of artificial intelligence on clinical education: Perceptions of postgraduate trainee doctors in London (UK) and recommendations for trainers. *BMC medical education*, 21: 1–10.

Barrows, H. S. 1986. A taxonomy of problem-based learning methods. *Medical education*, 20(6): 481–486.

Bloom, B. S.; Engelhart, M. D.; Furst, E. J.; Hill, W. H.; Krathwohl, D. R.; et al. 1956. *Taxonomy of educational objectives: The classification of educational goals. Handbook 1: Cognitive domain*. Longman New York.

Charow, R.; Jeyakumar, T.; Younus, S.; Dolatabadi, E.; Salhia, M.; Al-Mouaswas, D.; Anderson, M.; Balakumar, S.; Clare, M.; Dhalla, A.; et al. 2021. Artificial Intelligence education programs for health care professionals: Scoping review. *JMIR Medical Education*, 7(4): e31043.

Chen, B. Y.; Kern, D. E.; Kearns, R. M.; Thomas, P. A.; Hughes, M. T.; and Tackett, S. 2019. From modules to MOOCs: Application of the six-step approach to online curriculum development for medical education. *Academic Medicine*, 94(5): 678–685.

Derevianko, A.; Pizzoli, S. F. M.; Pesapane, F.; Rotili, A.; Monzani, D.; Grasso, R.; Cassano, E.; and Pravettoni, G. 2023. The use of Artificial Intelligence (AI) in the radiology field: What is the state of doctor–patient communication in cancer diagnosis? *Cancers*, 15(2): 470.

Emam, K. E. 1999. Benchmarking Kappa: Interrater agreement in software process assessments. *Empirical Software Engineering*, 4: 113–133.

Evangelista, C. B.; Larsen, K. L.; Cervero, R. M.; and Samuel, A. 2023. Corneal laser refractive surgery curriculum development in the military: Using the nominal group technique. *Military Medicine*, 188(1-2): e145–e151.

Hamet, P.; and Tremblay, J. 2017. Artificial Intelligence in medicine. *metabolism*, 69: S36–S40.

Haseltine, W. A. 2013. *Affordable excellence: the Singapore healthcare story: How to create and manage sustainable healthcare systems*. Brookings Institution Press.

Hoat, L. N.; Lan Viet, N.; Van Der Wilt, G.; Broerse, J.; Ruitenberg, E.; and Wright, E. 2009. Motivation of university and non-university stakeholders to change medical education in Vietnam. *BMC medical education*, 9: 1–14.

Hu, R.; Fan, K. Y.; Pandey, P.; Hu, Z.; Yau, O.; Teng, M.; Wang, P.; Li, T.; Ashraf, M.; and Singla, R. 2022. Insights from teaching Artificial Intelligence to medical students in Canada. *Communications medicine*, 2(1): 63.

Iniesto, F.; Charitonos, K.; and Littlejohn, A. 2022. A review of research with co-design methods in health education. *Open Education Studies*, 4(1): 273–295.

Jackson, P.; Ponath Sukumaran, G.; Babu, C.; Tony, M. C.; Jack, D. S.; Reshma, V.; Davis, D.; Kurian, N.; and John, A. 2024. Artificial Intelligence in medical education-perception among medical students. *BMC Medical Education*, 24(1): 804.

Lee, J.; Wu, A. S.; Li, D.; and Kulasegaram, K. M. 2021. Artificial Intelligence in undergraduate medical education: A scoping review. *Academic Medicine*, 96(11S): S62–S70.

Lindqwister, A. L.; Hassanpour, S.; Lewis, P. J.; and Sin, J. M. 2021. AI-RADS: An Artificial Intelligence curriculum for residents. *Academic radiology*, 28(12): 1810–1816.

Ma, Y.; Song, Y.; Balch, J. A.; Ren, Y.; Vellanki, D.; Hu, Z.; Brennan, M.; Kolla, S.; Guan, Z.; Armfield, B.; Ozrazgat-Baslanti, T.; Rashidi, P.; Loftus, T. J.; Bihorac, A.; and Shickel, B. 2024. Promoting AI competencies for medical students: A scoping review on frameworks, programs, and tools. arXiv:2407.18939.

Maassen, O.; Fritsch, S.; Palm, J.; Deffge, S.; Kunze, J.; Marx, G.; Riedel, M.; Schuppert, A.; and Bickenbach, J. 2021. Future medical Artificial Intelligence application requirements and expectations of physicians in German university hospitals: Web-based survey. *Journal of medical Internet research*, 23(3): e26646.

Martinho, A.; Kroesen, M.; and Chorus, C. 2021. A healthy debate: Exploring the views of medical doctors on the ethics of Artificial Intelligence. *Artificial intelligence in medicine*, 121: 102190.

Ngiam, K. Y.; and Khor, W. 2019. Big data and machine learning algorithms for health-care delivery. *The Lancet Oncology*, 20(5): e262–e273.

NUS. 2024. AI for Healthcare. https://medicine.nus.edu.sg/continuing-education/course-catalogue/ai-for-healthcare/. Accessed: 2024-09-10.

Paranjape, K.; Schinkel, M.; Panday, R. N.; Car, J.; Nanayakkara, P.; et al. 2019. Introducing Artificial Intelligence training in medical education. *JMIR medical education*, 5(2): e16048.

Penuel, W. R.; Allen, A.-R.; Coburn, C. E.; and Farrell, C. 2015. Conceptualizing research–practice partnerships as joint work at boundaries. *Journal of Education for Students Placed at Risk (JESPAR)*, 20(1-2): 182–197.

Pillai, A. S. 2023. AI-enabled hospital management systems for modern healthcare: An analysis of system components and interdependencies. *Journal of Advanced Analytics in Healthcare Management*, 7(1): 212–228.

Pupic, N.; Ghaffari-Zadeh, A.; Hu, R.; Singla, R.; Darras, K.; Karwowska, A.; and Forster, B. B. 2023. An evidence-based approach to Artificial Intelligence education for medical students: A systematic review. *PLOS Digital Health*, 2(11): e0000255.

Savoldelli, G. L.; Burlacu, C. L.; Lazarovici, M.; Matos, F. M.; and Østergaard, D. 2024. Integration of simulation-based education in anaesthesiology specialist training: Synthesis of results from an Utstein Meeting. *European Journal of Anaesthesiology— EJA*, 41(1): 43–54.

Shuaib, A.; Arian, H.; and Shuaib, A. 2020. The increasing role of Artificial Intelligence in health care: Will robots replace doctors in the future? *International journal of general medicine*, 891–896.

Singh, M. K.; Gullett, H. L.; and Thomas, P. A. 2021. Using Kern's 6-step approach to integrate health systems science curricula into medical education. *Academic Medicine*, 96(9): 1282–1290.

SmartNation. 2024. Transforming Singapore Through Technology. https://www.smartnation.gov.sg/about-smartnation/transforming-singapore/. Accessed: 2024-08-29.

Stanford. 2020. Fundamentals of Machine Learning for Healthcare. https://online.stanford.edu/courses/somxche0010-fundamentals-machine-learning-healthcare. Accessed: 2024-08-29.

Ta, A. W. A.; Goh, H. L.; Ang, C.; Koh, L. Y.; Poon, K.; and Miller, S. M. 2022. Two Singapore public healthcare AI applications for national screening programs and other examples. *Health Care Science*, 1(2): 41–57.

Tan, C. C.; Lam, C. S.; Matchar, D. B.; Zee, Y. K.; and Wong, J. E. 2021. Singapore's health-care system: Key features, challenges, and shifts. *The Lancet*, 398(10305): 1091–1104.

Teng, M.; Singla, R.; Yau, O.; Lamoureux, D.; Gupta, A.; Hu, Z.; Hu, R.; Aissiou, A.; Eaton, S.; Hamm, C.; et al. 2022. Health care students' perspectives on Artificial Intelligence: Countrywide survey in Canada. *JMIR medical education*, 8(1): e33390.

Thomas, P. A.; Kern, D. E.; Hughes, M. T.; Tackett, S. A.; and Chen, B. Y. 2022. *Curriculum development for medical education: A six-step approach*. JHU press.

UNESCO. 2024. What you need to know about UNESCO's new AI competency frameworks for students and teachers. https://www.unesco.org/en/articles/what-you-need-know-about-unescos-new-ai-competency-frameworks-students-and-teachers. Accessed: 2024-09-10.

Wartman, S. A.; and Combs, C. D. 2018. Medical education must move from the information age to the age of Artificial Intelligence. *Academic Medicine*, 93(8): 1107–1109.

Xie, B.; Sarin, P.; Wolf, J.; Garcia, R. C.; Delaney, V.; Sieh, I.; Fuloria, A.; Dennison, D. V.; Bywater, C.; and Lee, V. R. 2024. Co-designing AI education curriculum with cross-disciplinary high school teachers. In *Proceedings of the AAAI Conference on Artificial Intelligence*, volume 38, 23146–23154.

Xu, Y.; Jiang, Z.; Ting, D. S. W.; Kow, A. W. C.; Bello, F.; Car, J.; Tham, Y.-C.; and Wong, T. Y. 2024. Medical education and physician training in the era of Artificial Intelligence. *Singapore Medical Journal*, 65(3): 159–166.