International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Evaluation of Healthcare Professionals' Perspectives on Lifelong Learning with Artificial Intelligence: A Study and Web Platform Development

[1]Rakan S. Rashid, [2]Shakir Fattah Kak

Submitted: 02/11/2023 **Revised**: 23/12/2023 **Accepted**: 01/01/2024

Abstract: Introduction: Healthcare requires lifelong learning and knowledge improvement. Innovations in technology, especially artificial intelligence (AI), are changing the game and holding the promise of greater accuracy and efficiency. However, privacy and moral issues continue. The combination of AI with lifelong learning is vital because it promotes expertise and flexibility. Research examines healthcare workers' receptivity to AI-integrated lifetime learning and their expectations for successful education.

Aim and objectives: This study examines the perspectives of healthcare professionals about continuous learning using artificial intelligence and creates a web-based platform to improve educational opportunities.

Method: This qualitative cross-sectional network sampling research investigates 110 health professionals' views on lifelong learning. The study provides a personalised AI-enabled learning platform that emphasises user interaction, democratic decision-making and strategic implementation. The research examines respondents' motives, challenges, and demographic impacts on lifelong learning, providing insights into knowledge generation and preservation in dynamic domains like healthcare and technology. To improve learning, the systematic knowledge assessment platform centralises assessments and provides thorough analytics. The extensive online questionnaire was pilot-tested for validity.

Results: Among the 110 people who took part in the poll, a large majority are well aware of the resources available online, 63.63 percent are actively involved in continuing education programs, and 81.81 percent are interested in formalised training. Proving flexibility and a well-rounded strategy for skill development, self-reflection, and self-directed learning in the ever-changing healthcare environment, health experts demonstrate a dedication to continuous learning (90.90%).

Conclusion: This study concluded that, in this age of artificial intelligence, it is more crucial than ever for health professionals to engage in lifelong learning as part of their professional growth.

Keywords: *artificial intelligence (AI), healthcare, transformative.*

1. Introduction

Continuous growth in the healthcare realm necessitates an enduring commitment to knowledge, skill, and mindset enhancement throughout a professional journey—a concept encapsulated by lifelong learning. It isn't merely about acquiring academic qualifications; it embodies a steadfast dedication to staying abreast of cutting-edge advancements, ensuring the delivery of top-tier patient care. This enduring process encompasses a blend of formal avenues—like conferences and courses—and the less structured terrain of experiential learning, reflection, and collaborative exchanges with peers. Adaptability to evolving healthcare landscapes, technologies, and evidence-driven protocols stands as the hallmark of this lifelong learning ethos, indispensable for healthcare professionals striving for optimal patient outcomes [1-5].

Lifelong learning in healthcare stands as an essential guide through the ever-evolving landscape, ensuring professionals stay updated with the latest advancements and practices. It's the cornerstone for competence, refining clinical skills and critical thinking, directly impacting patient outcomes and elevating healthcare standards. Beyond adaptation, it sparks innovation, fostering a culture of continuous improvement and growth. This pursuit nurtures leadership, communication, and teamwork, serving as a catalyst for professional ascension, while embracing change, driving innovation, and fortifying excellence in care [6-9].

Over time, technology has intricately woven itself into the fabric of healthcare, sparking a profound metamorphosis in its landscape. Its transformative touch spans from the seamless automation of data processing to the advent of interconnected care tools, reshaping the very essence of healthcare delivery. The canvas of innovation boasts a myriad of milestones—electronic health records, digital healthcare marvels, the outreach of telemedicine, the ubiquity of wearable devices, the

[1]*IT Department, Bardarash Technical Institute*
Akre University for Applied Sciences
rakan.rashid@auas.edu.krd
[2]*IT Department, College of Informatics*
Akre University for Applied Sciences
shakir.fattah@auas.edu.krd

prowess of artificial intelligence, and the precision of robotics—all converging to elevate the caliber of care and elevate patient outcomes. Yet, amid this remarkable progression, a tapestry of challenges unfurls. Trust, security, privacy, and accuracy stand as sentinel concerns, casting a shadow on the sustainable evolution of the healthcare domain, necessitating steadfast attention for enduring progress [10-15].

The ascent of artificial intelligence (AI) within healthcare beckons a transformative era, poised to redefine the very essence of the field. Its potential to enhance efficiency, precision, and patient outcomes spans across diagnostics, treatment strategies, and vigilant monitoring. AI's prowess lies in deciphering vast data troves, unveiling intricate patterns that elude human perception. This translates to swifter disease detection, bespoke treatment blueprints, and remarkably accurate prognostications for patient well-being. Yet, the fusion of AI with healthcare unfurls a tapestry of crucial considerations. Legal and ethical quandaries loom large, entwined with the delicate threads of data privacy, necessitating an ardent call for meticulous regulation and oversight to ensure a harmonious symbiosis [16-22].

Within the realms of both medical practice and education, artificial intelligence (AI) casts an expansive net of innovation. In the clinical sphere, its adeptness spans diagnosis, treatment decisions, and prognostic foresight, navigating through oceans of medical data—genomic intricacies and intricate imaging landscapes—to illuminate pathways in disease detection and therapeutic strategies. Fields like radiology, cardiology, and oncology bask in their precision, where accuracy and efficiency in diagnoses and treatments find their zenith. Simultaneously, in the realm of medical education, AI emerges as a beacon, offering personalized feedback, aiding in assessments, and enriching curriculum structures. However, the seamless integration of AI into these spheres necessitates a meticulous journey of validation, traversing technical hurdles, and delicately threading through ethical considerations for a harmonious fusion [23-28].

The interplay of lifelong learning and AI forms an intricate nexus bridging diverse realms. AI's constant evolution aligns seamlessly with lifelong learning's role as a guiding force, enabling professionals to adapt to AI's dynamic progression. Beyond skill adaptation, this synergy spans healthcare, robotics, and finance, nurturing domain-specific expertise and facilitating AI's integration. At its core, AI's adaptability finds a partner in lifelong learning, fostering incremental growth, predictive precision, and resilience against disruptions. Together, they shape an ever-evolving ecosystem where lifelong learning fuels AI's evolution, fostering adaptability and expertise at the forefront of continual advancement [29-31].

This study aims to gauge healthcare professionals' receptiveness to lifelong learning integrated with AI, assessing their perceptions, challenges, and willingness to adopt new AI-driven educational methods. It seeks to identify their specific needs, concerns, and preferences regarding AI-based learning tools and strategies, ultimately informing the development of tailored, effective lifelong learning platforms within healthcare.

2. Experimental Method

Research Design

This qualitative cross-sectional study aimed to collect data from health professionals. It used a non-probability network sampling technique to reach out to people in various roles within the health industry, such as doctors, administrators, research teachers, engineers, and medical assistants. Network sampling, often known as snowball sampling, involves originally recruited participants suggesting more persons for the study at the researcher's request. AI-enabled learning platform with data collection, pattern identification, and adaptivity for personalised learning. Intelligent feedback, action suggestions, and a learner model that captures different data are core features. Using healthcare professionals' skills, developing confidence, and adopting democratic decision-making is crucial. Implementation requires training, open communication, and user feedback loops for improvement.

Design of the platform

This research presents a dynamic AI-powered platform to help health science professionals throughout their careers. Thorough study and an innovative digital platform for healthcare professionals are required for the project. A dynamic web interface with an overview page explaining the platform's benefits and capabilities is the main goal to help people comprehend it. An simple navigation menu improves the platform's user experience by making resources accessible. To quickly access important information, scholarly papers, and professional development tools, a document download form is included. A specialised document table simplifies file management, letting users track, manage, and recover downloaded files. The platform lets users erase undesirable files to keep their workplace clean. Users may restart studies, annotate papers, and monitor progress using a resume button. Personalised homepage usernames provide authenticated users a feeling of ownership. The book page provides a complete list of available papers for quick download. This dynamic platform uses artificial intelligence to simplify health science professional learning, enabling continuing

knowledge acquisition and professional growth while improving user experience (Figure 1).

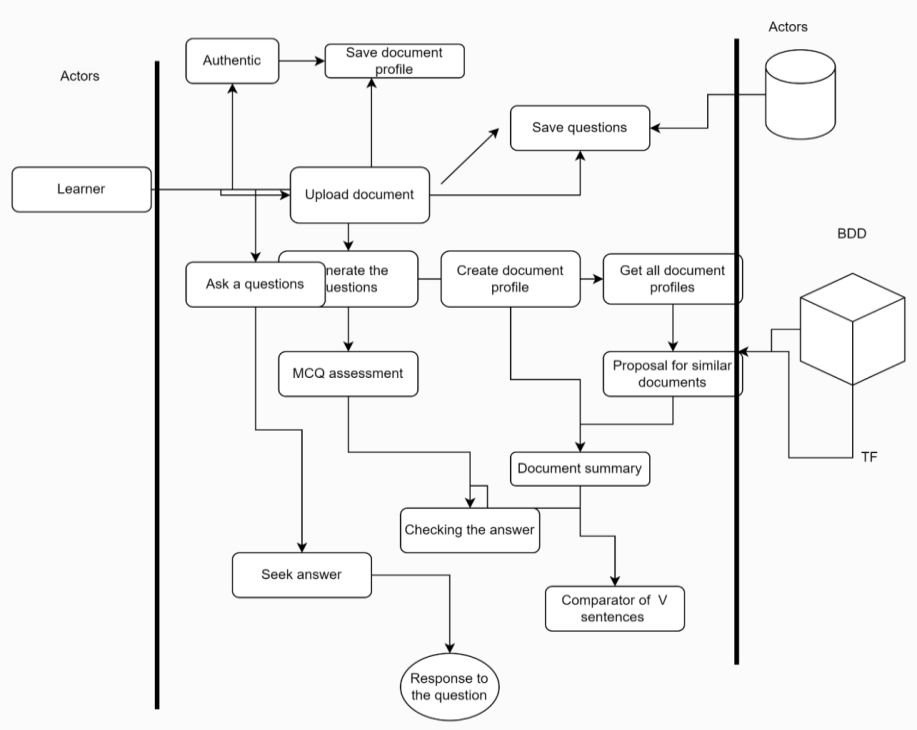

Fig 1: Use case platform

Based on the inclusion and exclusion criteria, 110 health professionals were selected to participate in the survey. People who took the exam before were not included. Healthcare professionals' perspectives on lifelong learning were explored via the use of a structured questionnaire. Based on their experiences, existing knowledge, and environmental interactions, people actively generate, interpret, and organise knowledge. It requires critical thinking, synthesis, and mental models or frameworks to comprehend the world. Constructivist approaches emphasise that learners shape their knowledge. This dynamic method promotes deeper, more meaningful learning via reflection, collaboration, and participation. Knowledge creation promotes holistic and flexible learning by acknowledging the learner's involvement in creating unique interpretations and connections (Figure 2).

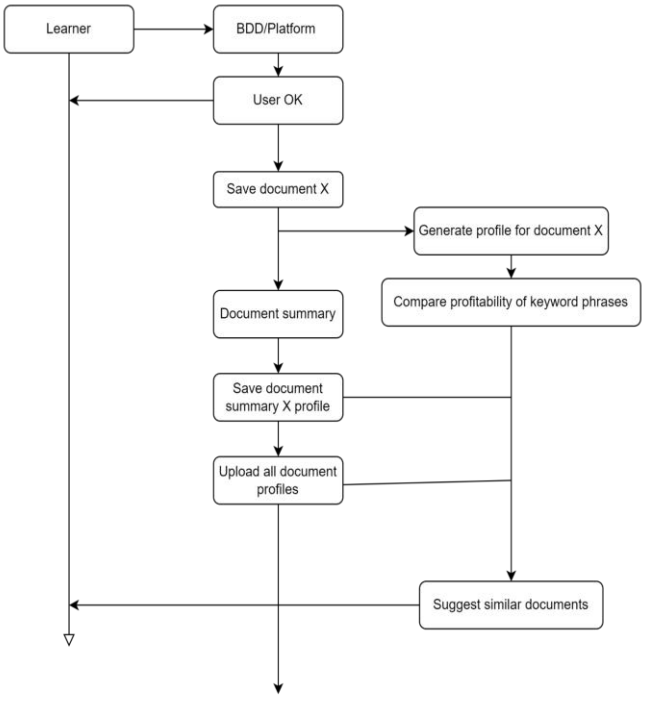

Fig 2: Activity diagram/knowledge construction.

The research study explored the respondents' perceptions of, motivations for, and barriers to engaging in activities that promote lifelong learning. Furthermore, age, gender, years of experience, and professional responsibilities was included in the demographic data set to examine its potential influence on attitudes towards lifelong learning. A systematic knowledge assessment platform centralises and organises evaluations of knowledge and skills across disciplines. Quizzes, examinations, projects, and practical demonstrations are used to test knowledge and abilities on this platform. Targeted tests for certain topics or competencies might reveal users' strengths and weaknesses. Detailed reports from the platform's analytics help educators and organisations make data-driven choices, change teaching tactics, and improve learning results. The use case platform provides systematic and informed knowledge evaluation, promoting continual learning and skill development (Figure 3).

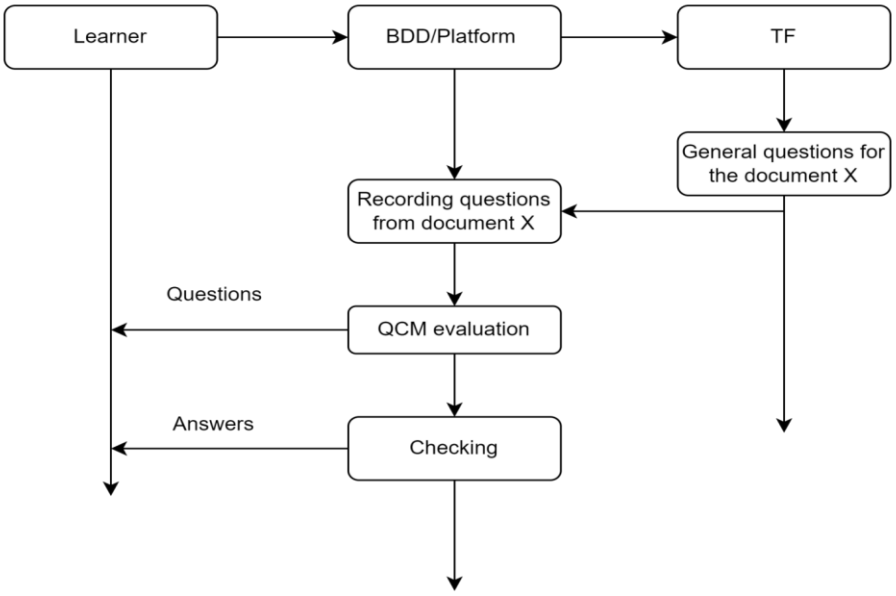

Fig 3: Systematic knowledge assessment

Participants completed a 53-item online questionnaire from November 2022 to October 2023. 10 participants served as a pilot test to ensure the questionnaire's validity. Knowledge maintenance involves conserving, updating, and keeping learned knowledge and abilities relevant. In fast-changing domains like technology, healthcare, and science, people and organisations must actively manage and maintain their knowledge base. This requires ongoing learning, remaining current, and responding to domain changes (Figure 4).

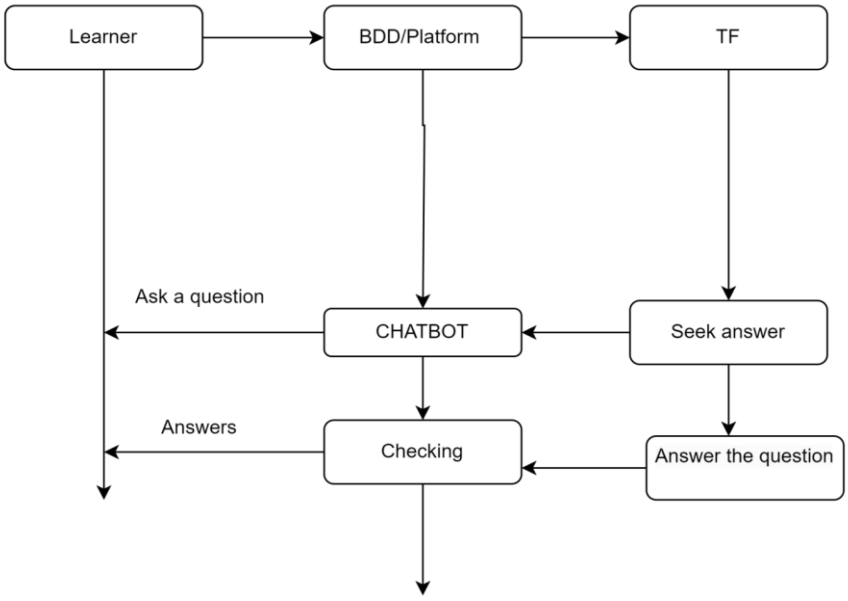

Fig 4: Diagram/knowledge maintenance

Freedom of participation and anonymity were two of the many ethical concerns that were honored.

Inclusion and exclusion criteria

Inclusion

Physicians, nurses, chemists, and other healthcare workers who are actively engaged in patient care are considered healthcare professionals.

Exclusion

People who are not employed in the healthcare industry and participants in pre-test studies.

Statistical analysis

The statistical analyses were obtained by the use of a modified statistical tool. We used the survey tools to gather data on the study model's components. To make them applicable to health practitioners, we adjusted all of the components. We used 5-point Likert scale questions with *strongly agree* to *strongly disagree* as our measure for the constructs.

3. Results

Table 1 shows that respondents are interested in institutionalised training, with 81.81% (90 people) expressing a desire for it. Alternatively, 13.63% (15 people) show no interest, while 4.54% (5 people) say they are unsure by choosing I don't know. The data in the table represent the opinions of 110 people who took the survey on institutionalised training. The overwhelming favorable answer indicates a great desire to participate in these types of training programs, which highlights their possible usefulness and popularity among the people who took the poll.

Table 1: Interest in institutionalized training

Queries	Effective	Percentages
Yes	90	81.81
No	15	13.63
I don’t know	5	4.54
Total	110	100

Table 2 shows that 63.63 percent of respondents (70 people) are actively involved in some kind of continuing education program. While 27.27% of the population sometimes takes part (use the Sometimes option), 9.09% of the population actively does not participate (ten people). The aggregate data from 110 participants shows a varied pattern of involvement, with most showing a favorable tendency toward furthering one's education. The results show how important these classes are, as many people who took the poll took advantage of the chances to further their education and advance their careers.

Table 2: Participation in continuing education courses

	Effective	Percentages
Yes	70	63.63
No	10	9.09
Sometimes	30	27.27
Total	110	100

Table 3 shows the prevalence of different types of online conversation and research tools among the respondents. Results show that most people are aware of these platforms; for example, 36.36 percent of respondents knew about Moodle, 90.90 percent about Google Meet, 72.72 percent about Google Scholar, 97.27 percent about the Zoom app, and 81.81 percent about the Teams app. The sample has a high degree of technical literacy since these numbers indicate a widespread familiarity with various digital technologies. Virtual communication and collaboration technologies have a profound impact on education and research, as shown by the widespread usage of Google Meet and Zoom.

Table 3: Familiarity with online discussion and research platforms and applications

Queries	Yes	No	Total
Do you know the Moodle platform?	40 (36.36 %)	70 (63.63 %)	110 (100.00%)
Do you know the Google Meet?	100 (90.90%)	10 (9.09 %)	110 (100.00%)
Do you know the Google Scholar?	80 (72.72%)	30 (27.27 %)	110 (100.00%)
Do you know the Zoom application?	107 (97.27%)	3 (2.72%)	110 (100.00%)
Do you know the Teams application?	90 (81.81%)	20 (18.18%)	110 (100.00%)

Table 4 shows how health specialists feel about continuing their education throughout life. Among the most encouraging findings is that 90.90 percent of those surveyed agree that the ever-changing health sciences need ongoing research and development. In addition, 81.81 percent say they love learning, and 68.18 percent say they're always looking for ways to learn more. The findings show that a lot of people are taking the initiative to improve their careers, as 63.63 percent of people think that continuing to learn new things is their job. The research also shows that people have a balanced mentality. 59.09% of them are open to criticism, and 54.54% of them know that self-directed learning is important. On the whole, the results show that health professionals are very dedicated to keeping up with the ever-changing health sciences industry and improving their abilities on a regular basis.

Table 4: Attitudes towards lifelong learning among health experts

Items	Totally agree	Agree	Disagree	Totally disagree	Total
I recognize my need to constantly acquire new knowledge	60 (54.54%)	49 (44.54%)	1 (0.90%)	0	110
Rapid changes in the health sciences require constant updating of knowledge and the development of new professional skills	100 (90.90%)	10 (9.09%)	0	0	110
I regularly read professional journals in my field	30 (27.27%)	55 (50.00%)	25 (22.72%)	0	110
I have a list of learning objectives	35 (31.81%)	50 (45.45%)	25 (22.72%)	0	110
I like to learn	90 (81.81%)	20 (18.18%)	0	0	110
I regularly look for opportunities to deepen my knowledge and expertise	75 (68.18%)	33 (30.00%)	2 (1.81%)	0	110
I never get defensive when someone offers comments that could improve my knowledge and skills	65 (59.09%)	40 (36.36%)	5 (4.54%)	0	110
I actively participate in learning experiences	60 (54.54%)	48 (43.63%)	1 (0.90%)	1 (0.90%)	110

I sometimes contact national and international experts in my apprenticeship	30 (27.27%)	50 (45.45%)	25 (22.72%)	5 (4.54%)	110
I take personal responsibility for my own learning	60 (54.54%)	40 (36.36)	5 (4.54%)	5 (4.54%)	110
I regularly search computer databases to learn about new developments in health sciences	50 (45.45%)	50 (45.45%)	10 (9.09%)	0	110
I think I would fall behind if I stopped learning about new developments in health sciences	70 (63.63%)	35 (31.81%)	3 (2.72%)	2 (1.81%)	110
Lifelong learning is a professional responsibility of all health professionals	70 (63.63%)	30 (27.27)	10 (9.09%)	0	110
I take every opportunity to acquire new knowledge/skills important for my profession	65 (59.09%)	40 (36.36)	5 (4.54%)		110
I always take the time to learn on my own, even when I have a busy work schedule and other obligations	40 (36.36%)	60 (54.54%)	10 (9.09%)		110

4. Discussion

In investigating AI's role in radiology, a study by Chen et al. (2021) engaged 18 semi-structured interviews with 12 radiologists and 6 radiographers across five NHS breast units. A notable disparity emerged in the awareness and knowledge of AI between these professional groups. Radiologists, buoyed by expansive networks, conferences, and industry connections, exhibited a deeper understanding of AI's potential applications compared to radiographers, who primarily relied on localized networks for information. Distinct attitudes surfaced regarding AI's impact on professional roles: radiologists envisaged AI shouldering repetitive tasks, freeing them for more stimulating work, while radiographers harbored apprehensions about potential job alterations and their ability to navigate evolving technologies. The study highlights the nuanced interplay between professional identities, knowledge domains, and perceptions toward AI, challenging assumptions about AI's descriptive impact and emphasizing the necessity for AI integration while preserving professional autonomy. Overall, while both groups recognize AI's potential benefits in lifelong learning, further integration and support are deemed imperative to navigate AI's influence on their respective roles within radiology [32].

In a study by Aquino et al. (2023) exploring the intersection of healthcare AI and deskilling concerns, 72 professionals steeped in AI expertise and/or clinical involvement underwent qualitative, semi-structured interviews. A multifaceted tapestry of perspectives emerged, unraveling contentious threads woven around three pivotal issues. Firstly, divergent views surfaced regarding the extent of AI's role in healthcare automation, igniting debates on which clinical tasks were deemed suitable for AI-enabled automation, with identified task characteristics influencing these deliberations. Secondly, discordant expectations veiled the impact of AI on clinical skills, oscillating between potential enhancements and apprehensions regarding healthcare quality. Implicitly, contrasting models—a human-centric versus technology-centric approach—underpins differing values and priorities in healthcare work vis-à-vis AI automation. Our study underscores divergences among professional stakeholders, encapsulating both the promise of AI in augmenting healthcare and the intricacies surrounding its integration into clinical practice, rooted in nuanced perceptions and contrasting values governing healthcare's interface with AI-enabled automation [33].

AI in healthcare presents a myriad of benefits, enhancing lifelong learning by bolstering diagnostics, care planning, and clinical decision-making. Yet, professionals grapple with multifaceted concerns—from safety and patient autonomy to cost implications and data biases—amplifying the need for ethical considerations and robust security measures. Navigating its integration involves a web of challenges, spanning regulatory compliance, data privacy, and ethical dilemmas, demanding a holistic approach to unlock AI's full potential in healthcare [34-37].

The landscape shaping healthcare professionals' readiness or reluctance toward AI-infused learning orbits around multifaceted factors. Their adeptness and comfort with technology, and perceptions of AI's impact on professional roles, coupled with privacy and security apprehensions, are pivotal influencers. Moreover, the availability of comprehensive training and support serves as a linchpin. Strategies designed to foster and fortify AI integration in lifelong learning encompass multifaceted approaches: robust training programs tailored to diverse skill sets, dispelling concerns and misconceptions, nurturing a culture steeped in continual learning ethos, and anchoring AI technologies' usage within ethical and responsible frameworks. These strategies align with the dynamic milieu, aiming to galvanize healthcare professionals for seamless AI assimilation into their learning ecosystem [38, 39].

Healthcare professionals' insights stand as linchpins in refining AI-based learning tools, offering crucial guidance to pinpoint improvement areas and enhance tool efficacy. Tailoring platforms to users' distinct needs and concerns underscores the essence of personalized learning experiences, augmenting effectiveness. Ethical discourse should delve into biases, privacy, and AI transparency, fostering open dialogue among stakeholders to address these multifaceted challenges. Regulatory frameworks, addressing algorithmic biases, data privacy, and fostering accountability, are imperative to instill responsible and trustworthy AI practices within educational realms, ensuring ethical integration and bolstering credibility in the educational landscape. These strategic imperatives align with the quest for responsible AI integration, balancing technological innovation with ethical considerations in the realm of education [40-43].

The envisioned AI-enabled learning platform draws its blueprint from study findings, embodying pivotal features like data recording, pattern detection, and adaptivity to foster personalized learning experiences. Its core functionalities include providing intelligent feedback and action recommendations, bolstering students' self-regulation, and integrating a learner model that encapsulates diverse data facets for tailored learning experiences. Crucially, aligning platform development with healthcare professionals' preferences mandates a collaborative approach, leveraging their tacit expertise, fostering trust, and embracing democratic decision-making. Implementation strategies pivoting on training initiatives and transparent communication about the platform's benefits aim to familiarize healthcare professionals, ensuring seamless integration into practice. Further, the integration of user feedback loops stands as a linchpin for continuous refinement, actively engaging healthcare professionals and learners to enhance platform efficacy and user experiences iteratively. These strategic imperatives underscore a dynamic iterative process, fostering continual evolution and optimal user engagement within the learning ecosystem [44-49].

5. Conclusion

This study concluded that, in this age of artificial intelligence, it is more crucial than ever for health professionals to engage in lifelong learning as part of their professional growth. By improving simulations and training, easing remote learning, summarising and organising material, and offering personalised learning suggestions, AI may substantially improve and enable lifelong learning in the health sciences. Healthcare providers may better serve their patients by keeping themselves abreast of new research and best practices via the use of AI that supports lifelong learning. Professionals must be cognizant of AI's limits and committed to lifelong learning if they are to remain relevant and productive in their fields. The primary contribution of the research is, in a nutshell, the creation of an interactive platform that strengthens chances for health science professionals to engage in lifelong learning. The platform allows professionals to continuously enhance their knowledge and abilities, leading to better healthcare. Some of the features include the power of artificial intelligence, simple navigation, personalisation, and fast document management. This research analyses healthcare workers' views on AI-integrated lifelong learning, however, key obstacles and preferences may be missing. Further research regarding AI's effects on healthcare jobs, including ethics, privacy, and data security, may improve knowledge. AI-integrated education might benefit from focused interventions to solve identified issues in future studies. Explore the long-term effects of AI on healthcare workers' abilities and patient outcomes, and adjust the web-based platform depending on user input, to promote AI-enabled lifelong learning in healthcare.

References:

[1] 1Madewell, J. E. Lifelong learning and the maintenance of certification. *Journal of the*

American College of Radiology: JACR,2004;*1*(3):199–203.

[2] Putoto, G. Teaching and Continuing Professional Development: an Italian experience. *Clinical Chemistry and Laboratory Medicine*,2006;*44*(6):704-7.

[3] Kosht, N. M., Palladino, C., Ange, B., & Richardson, D. Measuring health professions students' orientation toward lifelong learning. *Journal of Allied Health*,2014;*43*(3):146-9.

[4] Kind, T., & Evans, Y. Social media for lifelong learning. *International Review of Psychiatry (Abingdon, England)*,2015;*27*(2):124–132.

[5] Mahajan, R., Badyal, D. K., Gupta, P., & Singh, T. Cultivating lifelong learning skills during graduate medical training. *Indian Pediatrics*,2016;*53*(9):797–804.

[6] Collins, J. Lifelong learning in the 21st century and beyond. *Radiographics: A Review Publication of the Radiological Society of North America, Inc*,2009;*29*(2):613–622.

[7] Wiljer, D., Tavares, W., Mylopoulos, M., Campbell, C., Charow, R., Davis, D., Okrainec, A., Silver, I., & Sockalingam, S. Data and lifelong learning protocol: Understanding cultural barriers and facilitators to using clinical performance data to support continuing professional development. *The Journal of Continuing Education in the Health Professions*,2018;*38*(4):293–298.

[8] Panda, M., & Desbiens, N. A. An education for Life requirement to promote lifelong learning in an internal medicine residency program. *Journal of Graduate Medical Education*,2010;*2*(4):562–565.

[9] Babenko, O., Koppula, S., Daniels, L., Nadon, L., & Daniels, V. Lifelong learning along the education and career continuum: meta-analysis of studies in health professions. *Journal of Advances in Medical Education & Professionalism*,2017;*5*(4):157-163.

[10] Hatcher, M., & Heetebry, I. Information technology in the future of health care. *Journal of Medical Systems*,2004;*28*(6):673–688.

[11] Simpson, R. L. Need to know: Essential survival skills for the information age. *Nursing Administration Quarterly*,2000;*25*(1):142–145.

[12] Akhtar, N., Khan, N., Qayyum, S., Qureshi, M. I., & Hishan, S. S. Efficacy and pitfalls of digital technologies in healthcare services: A systematic review of two decades. *Frontiers in Public Health*,2022;*10*.

[13] Popov, V. V., Kudryavtseva, E. V., Kumar Katiyar, N., Shishkin, A., Stepanov, S. I., & Goel, S. Industry 4.0 and digitalisation in healthcare. *Materials*,2022;*15*(6):2140.

[14] Park, S., & Jayaraman, S. e-Health and quality of life: the role of the Wearable Motherboard. *Studies in Health Technology and Informatics*,2004;*108*:239-52.

[15] Stegemann, S. The future of pharmaceutical manufacturing in the context of the scientific, social, technological and economic evolution. *European Journal of Pharmaceutical Sciences: Official Journal of the European Federation for Pharmaceutical Sciences*,2016;*90*:8–13.

[16] Jassar, S., Adams, S. J., Zarzeczny, A., & Burbridge, B. E. The future of artificial intelligence in medicine: Medical-legal considerations for health leaders. *Forum Gestion Des Soins de Sante [Healthcare Management Forum]*,2022;*35*(3):185–189.

[17] Paton, C., & Kobayashi, S. An open science approach to artificial Intelligence in healthcare: A contribution from the International Medical Informatics Association Open Source Working Group. *Yearbook of Medical Informatics*,2019;*28*(01):047–051.

[18] Fionda, B., Boldrini, L., D'Aviero, A., Lancellotta, V., Gambacorta, M., Kovács, G., Patarnello, S., Valentini, V., & Tagliaferri, L. Artificial intelligence (AI) and interventional radiotherapy (brachytherapy): state of art and future perspectives. *Journal of Contemporary Brachytherapy*,2020;*12*(5):497–500.

[19] Shah, H., Shah, S., Tanwar, S., Gupta, R., & Kumar, N. Fusion of AI techniques to tackle COVID-19 pandemic: models, incidence rates, and future trends. *Multimedia Systems*,2022;*28*(4):1189–1222.

[20] Wiljer, D., & Hakim, Z. Developing an artificial intelligence–enabled health care practice: Rewiring health care professions for better care. *Journal of Medical Imaging and Radiation Sciences*,2019;*50*(4): S8–S14.

[21] Arora, A. Conceptualising artificial intelligence as a digital healthcare innovation: An introductory review. *Medical Devices (Auckland, N.Z.)*,2020;*13*:223–230.

[22] Sajid, M. I., Ahmed, S., Waqar, U., Tariq, J., Chundrigarh, M., Balouch, S. S., & Abaidullah, S. (2022). Application in medicine: Has artificial

intelligence stood the test of time? *Chinese Medical Journal*,2023. *Publish Ahead of Print*.

[23] Ruiz, G. R. S., & Bustamante, A. A. Edwardsya, a new genus of jumping spiders from South America (Araneae: Salticidae: Freyina). *Zootaxa*,2016;*4184*(1):117-129.

[24] Momtazmanesh, S., Nowroozi, A., & Rezaei, N. Artificial intelligence in rheumatoid arthritis: Current status and future perspectives: A state-of-the-art review. *Rheumatology and Therapy*,2022;*9*(5):1249–1304.

[25] Alsuliman, T., Humaidan, D., & Sliman, L. Machine learning and artificial intelligence in the service of medicine: Necessity or potentiality? *Current Research in Translational Medicine*,2020;*68*(4):245–251.

[26] Briganti, G., & Le Moine, O. Artificial intelligence in medicine: Today and tomorrow. *Frontiers in Medicine*,2020;*7*:27.

[27] Chan, K. S., & Zary, N. Applications and challenges of implementing artificial intelligence in medical education: Integrative review. *JMIR Medical Education*,2019;*5*(1):e13930.

[28] Pieszko, K., Hiczkiewicz, J., Budzianowski, J., Musielak, B., Hiczkiewicz, D., Faron, W., Rzeźniczak, J., & Burchardt, P. Clinical applications of artificial intelligence in cardiology on the verge of the decade. *Cardiology Journal*,2021;*28*(3):460–472.

[29] Parisi, G. I., Tani, J., Weber, C., & Wermter, S. Lifelong learning of human actions with deep neural network self-organization. *Neural Networks: The Official Journal of the International Neural Network Society*,2017;*96*:137–149.

[30] Sun, G., Cong, Y., Wang, Q., Zhong, B., & Fu, Y. Representative task self-selection for flexible clustered lifelong learning. *IEEE Transactions on Neural Networks and Learning Systems*,2022;*33*(4):1467–1481.

[31] Adaimi, R., & Thomaz, E. Lifelong adaptive machine learning for sensor-based human activity recognition using Prototypical Networks. *Sensors (Basel, Switzerland)*,2022;*22*(18):6881.

[32] Chen, Y., Stavropoulou, C., Narasinkan, R., Baker, A., & Scarbrough, H. Professionals' responses to the introduction of AI innovations in radiology and their implications for future adoption: a qualitative study. *BMC Health Services Research*,2021;*21*(1):813.

[33] Aquino, Y. S. J., Rogers, W. A., Braunack-Mayer, A., Frazer, H., Win, K. T., Houssami, N., Degeling, C., Semsarian, C., & Carter, S. M. Utopia versus dystopia: Professional perspectives on the impact of healthcare artificial intelligence on clinical roles and skills. *International Journal of Medical Informatics*,2023;*169*(104903):104903.

[34] Sharma, M., Savage, C., Nair, M., Larsson, I., Svedberg, P., & Nygren, J. M. Artificial intelligence applications in health care practice: Scoping review. *Journal of Medical Internet Research*,2022;*24*(10):e40238.

[35] Richardson, J. P., Smith, C., Curtis, S., Watson, S., Zhu, X., Barry, B., & Sharp, R. R. Patient apprehensions about the use of artificial intelligence in healthcare. *Npj Digital Medicine*,2021;*4*(1):140.

[36] Smallman, M. Multi-scale ethics—why we need to consider the ethics of AI in healthcare at different scales. *Science and Engineering Ethics*,2022;*28*(6):63.

[37] Nair, A. V., Ramanathan, S., Sathiadoss, P., Jajodia, A., & Blair Macdonald, D. Barriers to artificial intelligence implementation in radiology practice: What the radiologist needs to know. *Radiología (English Edition)*,2022;*64*(4):324–332.

[38] Seo, K., Tang, J., Roll, I., Fels, S., & Yoon, D. The impact of artificial intelligence on learner–instructor interaction in online learning. *International Journal of Educational Technology in Higher Education*,2021;*18*(1):54.

[39] Paranjape, K., Schinkel, M., Nannan Panday, R., Car, J., & Nanayakkara, P. Introducing artificial intelligence training in medical education. *JMIR Medical Education*,2019;*5*(2):e16048.

[40] Rogers, W. A., Draper, H., & Carter, S. M. Evaluation of artificial intelligence clinical applications: Detailed case analyses show the value of healthcare ethics approach in identifying patient care issues. *Bioethics*,2021;*35*(7):623–633.

[41] Winfield, A. F. T., & Jirotka, M. Ethical governance is essential to building trust in robotics and artificial intelligence systems. *Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences*,2018;*376*(2133):20180085.

[42] Dieterle, E., Dede, C., & Walker, M. The cyclical ethical effects of using artificial intelligence in education. *AI & Society*,2022;27:1-11.

[43] Thomasian, N. M., Eickhoff, C., & Adashi, E. Y. Advancing health equity with artificial intelligence. *Journal of Public Health Policy*,2021;*42*(4):602–611.

[44] Ninaus, M., & Sailer, M. Closing the loop – The human role in artificial intelligence for education. *Frontiers in Psychology*,2022;*13*.

[45] Afzaal, M., Nouri, J., Zia, A., Papapetrou, P., Fors, U., Wu, Y., Li, X., & Weegar, R. Explainable AI for data-driven feedback and intelligent action recommendations to support students self-regulation. *Frontiers in Artificial Intelligence*,2021;*4*.

[46] Bellarhmouch, Y., Jeghal, A., Tairi, H., & Benjelloun, N. A proposed architectural learner model for a personalized learning environment. *Education and Information Technologies*,2023;*28*(4):4243–4263.

[47] Fernández-Isabel, A., Cabezas, J., Moctezuma, D., & de Diego, I. M. Improving sentiment classification performance through coaching architectures. *Cognitive Computation*,2023;*15*(3):1065–1081.

[48] Lentz, A., Siy, J. O., & Carraccio, C. AI-assessment: Towards assessment as a sociotechnical system for learning. *Academic Medicine: Journal of the Association of American Medical Colleges*,2021;*96*(7S): S87–S88.

[49] Rudland, J., Wilkinson, T., Wearn, A., Nicol, P., Tunny, T., Owen, C., & O'Keefe, M. A student-centered feedback model for educators. *The Clinical Teacher*,2013;*10*(2):99–102.