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Perceptions, Preparedness and Pedagogical challenges in Incorporation of Artificial Intelligence in Pharmacy Curriculum

Dr. Leena Farooq[1], Dr. Dimitrios Petropoulos[2]
[1] Department of Pharmacy Education, University of Sharjah, Sharjah, UAE
[2] Faculty of Health Sciences, National and Kapodistrian University of Athens, Athens, Greece
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Abstract:
The advent of artificial intelligence (AI) in medical practice is changing how pharmacists provide care to patients and this necessitates changes that pharmacy education should make. This paper set out to determine perceptions, preparedness, and pedagogical issues of integrating AI into pharmacy curricula. One cross-sectional survey was carried out in six pharmacy schools with a total of 278 students and 54 faculty members taking part in the research. The poll showed that out of the 82 percent of the students who felt that knowledge on AI is critical to their prospective careers only 19 percent felt they were well equipped to implement the concepts on AI. Among the potential obstacles to the integration of AI curriculum, less than half of the faculty, namely 63 percent, cited a completeness of training and 47 percent stated curricular overloading. The results indicate a preparedness deficiency in students as well as faculty preparedness to deliver AI concepts. To tackle such issues, the research featured the necessity of structured digital health units, faculty development initiatives, and more significant interdisciplinary cooperation to be able to integrate AI competencies into the pharmacy curriculum effectively.

Keywords: ***Artificial Intelligence, pharmacy education, curriculum, digital health, student readiness, faculty attitudes, interdisciplinary cooperation.***

1. Introduction

1.1 AI in healthcare Emergence

The prospect of combining Artificial Intelligence (AI) and healthcare is quickly transforming medical practice, and positively impacting patient outcomes. Machine learning algorithms, predictive analytics, natural language processing, and other AI applications are all transforming the field of clinical decision making, drug discovery and development, personalized medicine, and management of patient care. The innovations have not only augmented the need of professionals in the sphere of healthcare but also in need of professionals who are not only familiar with the concept of AI technologies but also can implement them in practice efficiently. Pharmacists, especially, will be in a unique position to use AI in their practices, especially when it comes to the management of drug therapy, drug safety, patient counseling and in pharmacovigilance.

And as AI usage in the sphere of pharmaceutical practice grows, it is the responsibility of pharmacy educators to make sure that the next wave of pharmacists is ready to adapt to this new technological wave. With the integration of AI into the healthcare systems, it is important that the pharmacy curriculum is developed, with the appropriate education on AI integrated that will allow students to progress with development of the digital literacy and technological competence to provide effective practice.(1)

1.2 The significance of Digital Literacy to Future Pharmacist

It is hard to overestimate the role of digital literacy in healthcare. To be able to work with AI-driven systems efficiently, pharmacists not only have to be informed about the opportunities behind AI, but also about its defects and ethical issues. Digital literacy embraces:

Learn about Artificial Intelligence, including machine learning, data analysis, and algorithm interpretation.

Test the effectiveness, safety, and appropriate use of AI tool in clinical practice.

Discuss with patients and the healthcare community in an effective manner regarding AI-based decisions.

Since AI technologies become a significant part of decision-making that must be taken when it comes to prescribing drugs, conducting a diagnosis, and designing an adequate treatment protocol, pharmacists will have to collaborate with AI-enabled instruments as closely as possible to be ready to maintain the safety of patients and improve the efficiency of the treatment. There is therefore a need to integrate digital literacy and AI competency

in pharmacy education in ensuring that the future pharmacists are prepared to work within an AI-augmented healthcare setting.

1.3 Existing Lack in Pharmacy Uncertainty Education Concerning AI

Although there has been a rise in awareness of the use of AI in healthcare, the use of AI in the pharmacy curriculum is still in early development. An evaluation of existing activities carried out in the process of pharmacy education demonstrates the following main gaps:

Scarcity of AI-related materials: Pharmacy courses, especially those in the postgraduate classes, remain highly focused on conventional subjects, like pharmacology and therapeutics, with little or no training in digital health or AI implementation.

Faculty training: The absence of faculty knowledge in AI must be regarded as a major problem. Since the field of AI is relatively new, a number of faculty lack experience or training on AI-related technology, thus they find it harder to incorporate AI into the teaching process.(2)

Curricular overload: Pharmacy curricula are already dense and the further filling of the educational content by the information related to AI can be considered just one more burden than a required update.

Interdisciplinary collaboration: Cross-disciplinary collaboration should take place among pharmacy, computer science and health informatics to create integrated teaching modules to fill knowledge gaps.

Such issues highlight the necessity of a strategic plan to integrate AI curriculum in the education of pharmacists to make sure that students have sufficient preparation into the future of healthcare.

S.4 Objectives of the Study

The first purpose of the study is to determine the perceptions, preparedness, and the hindrances to the inclusions of AI within the pharmaceutical education curriculum as viewed by the faculty and students. The particular objectives are:

To analyse the role that AI knowledge plays in their future profession as pharmacists in the minds of students.

In order to measure the readiness of students to use AI in their professional practices.

To establish the issues that faculties encounter when integrating AI in their teaching methods.

To consider possible ways of adding AI training to the curriculum of pharmacy education as well as targeted development of such faculty, digital health modules, and interdisciplinary interactions.

The proposed study will help to understand better the present situation in AI education in pharmacy and give guidance on how pharmacy schools should educate learners on the changes brought by AI-based healthcare.

2. Methodology

2.1: Study Design: Cross sectional survey

A cross-sectional survey study was used to assess the perceptions, preparedness and impediments of the introduction of artificial intelligence (AI) into pharmacy courses. The cross-sectional design of the research permitted the gathering of the information that covers the current state of views and experiences of students and faculty on including AI in their education and their approaches to teaching.(3)

An organized questionnaire proved to be created and presented to students and faculty members in numerous pharmacy schools to determine whether people are ready and willing to embrace AI in pharmacy learning. In the survey, there were four major themes, which entailed an assessment of AI relevance perceptions, preparedness to integrate AI, obstacles to integration, and recommendations on curriculum improvement.

2.2 Participating and Demographic Overview

The survey was carried out in 6 pharmacy schools three of which are situated in Brazil, whereas three are in Germany. These countries were chosen because of their educational systems and health care facilities, and this will give a broad scope on how to integrate AI and the opportunities that exist in pharmacy education.

Twenty-seven eight students and 54 faculty involved themselves with the research. All the students were third/fourth year pharmacy students and belonged to a diversity of demographic backgrounds and included:

- Age: between 20 and 30 years
- Gender: 60 percent women, 40 percent men
- Skills gained: 15 percent of them received formal exposure to AI during elective courses/ workshops.

The faculty respondents were professors, lecturers, and clinical preceptors in the teaching core subjects in the pharmacy programs such as pharmacology, therapeutics, and pharmacy practice. The members of the faculty were

chosen according to their participation in teaching works and their reputed awareness of digital health tools and AI applications.

2.3 Development and validation of Survey Tool

The survey tool was created on the basis of literature reviews, interviews with experts and pilot testing. The survey included both reservable and constructive questions that would give the total picture of faculty and student response towards integration of AI into pharmacy curriculum.(4)

Survey Structure:

Demographic Information: Questions that will ask about the background, educational level of the participant as well as whether the participant has heard about AI or not.

Perceptions of AI Relevance: 5 point Likert scale items that capture the belief of participants on the significance of AI knowledge and future pharmacy practice (e.g. AI knowledge will be crucial to future pharmacists).

Preparedness: Equipment on the self-perceived willingness of the participant to employ AI in his / her professional activity (e.g., "I think I am ready to apply AI tools to pharmacy practice").

Barriers: Open-ended and Likert scale questions to determine perceived barriers to AI integration, such as faculty training, curricular overload, and resource constraints.

Possible Topics of Integration: Open questions that can be asked to come up with suggestions of integrating AI into the curriculum, e.g. adding digital health modules or working with other fields.

The survey instrument was tested by the means of a survey that was administered to the small number of students and faculty members who did not participate in the final study group. Based on responses received during the pilot test, the survey questions were clarified, completed, and made reliable.

2.4 Methods of Data Collection and Data Analysis

Data Collection:

The survey was implemented online by means of a secure survey service. The survey link was sent to participants through an email and an invitation to take the survey in their free will was included. The data was collected within four weeks to provide the sample ample time in answering back. To receive optimal participation and corresponding rates of response, a reminder email was provided.(5)

Data Analysis:

Survey data (quantitative data) were analyzed with the help of descriptive statistics composed of frequencies, percentages, averages, and standard deviations. The data were divided by country, student/faculty, and the degree of AI exposure to make differences between the subdivisions.

The chi-square test andt-tests were applied to compare the difference in perceptions and preparedness between the faculty and students. MINIMUM criteria of statistical significance was $p < 0.05$.

Thematic analysis was applied in analyzing qualitative data in the form of open ended responses and this entailed: Determining the current topics and essential trends within the answers.

Qualitative coding of the data (e.g. into categories, e.g. lack of training, barriers in the curriculum).

Concluding these results to offer a reflection about the problems and potentials regarding the realization of the AI integration in the pharmacy curriculum.

A combination of quantitative and qualitative data allowed obtaining the complete picture of the perceptions, provision, and obstacles to AI curriculum integration and acquiring an evaluation of the faculty and student readiness and opinion of these obstacles.

3. Romanticizing and De-throning the AI in Pharmacy Education

3.1 Student Perceptions: significance, pertinence and anticipated uses

The analysis demonstrated that the students possessed a positive perception of the value and significance of Artificial Intelligence (AI) in pharmacy education and within the subject of future healthcare professions.

Significance of AI Knowledge:

Eight out of every ten students held the view that the knowledge of AI would be necessary to fulfil their future responsibilities as pharmacists. When students were questioned on how AI would affect their possible career growth, they were convinced that AI would hugely affect the following spheres(6)

Personalized medicine and drug discovery: The power of AI to transform the drug discovery procedure was mentioned by many students, including the discovery of new drug targets, optimization of treatment regimes.

Pharmacy practice: Students believed AI could be crucial to enhance the clinical decision-making, medication safety, and patient care, especially on those tools that have the ability to analyze patient data and offer real-time decision support.

Applicability in Clinical Practice:

Even though the relevance of AI was strongly believed, few students were not sufficiently prepared to work with AI tools in clinical practice. Most of the students were worried that they will not know how to use the knowledge about AI appropriately unless they train or get a hands-on experience. This discrepancy indicates that, although the students acknowledge the significance of AI in the scope of pharmacy practice, they still consider themselves ill-prepared when it comes to employing the principles of AI in their practice.

The Pharmacy applications of Artificial Intelligence would be as follows:

The students also pointed out some of their preferences of AI applications to be incorporated in their studies in pharmacy:

Medication Management: Systems that can monitor drug interactions, adverse drug reaction (ADR), and pharmacovigilance were viewed as good initiatives in enhancing patient outcomes, which run on AI.

Clinical Decision Support: A great number of students were aware of the expansion of AI in clinical decision support systems (CDSS) that could guide a pharmacist to prescribe a medication schedule using patient-specific information (age, weight, comorbidities).(7)

Automation of Tasks of Routine Value: Some students foresaw that AI could be used to automate pharmacy practice, since routine tasks with no patient direct contact like inventory management and prescription verification and prescribing may be automated, enabling pharmacists to spend more time performing direct patient care.

3.2 Views of Faculty on relevance of AI and Educational priorities

The shared attitude of faculty members to AI was similar to the one displayed by students: a general awareness of the increased significance of the field in healthcare, and mixed opinions on the role of AI in education, especially as it applied to pharmacy education.

In the context of pharmacy in pharmacy education AI is relevant:

A substantial number of faculty members (75%) also supported the importance of AI in the field of pharmacy practice in the future. They were aware of the possible advantages of AI in clinical practice, including the capacity to increase the level of pharmacovigilance, enhance patient outcomes, and help with clinical decision-making. Nevertheless, a lower rate of faculty believed that the concept of AI is adequately included in the existing curriculum. 63 percent of faculties did not receive formal training on AI and this represented a challenge in imparting the understanding on AI in their classes.

Priorities of Education and Curriculum Consent:

Faculty brought up the need to integrate AI into the curriculum, yet encountered a number of difficulties involved in the process:

Curricular Overload: Curricular overload was a major trail as stated by many faculty members. Since the current curriculum is already densely covered with indispensable content, teaching additional, new, and very complicated themes such as AI could push the teaching schedule. In that respect, 47 percent of faculty members labeled curricular overload as a major obstacle to AI integration.

The shortage of Resources and Training: 63 faculty also said they had not received training in how to teach AI, which also compromised the ability to deliver that material. Faculty members did not feel qualified enough to structure and present effective AI-based modules without any training.(8)

Interdisciplinary Collaboration: A few faculty members were of the opinion that joint efforts between the university and other departments including health informatics and computer science may be facilitated to develop the required expertise in integrating AI. That would assist in closing the knowledge gaps and cross-disciplinary in learning AI.

Curriculum Enhancement:

Most of the faculty members also agreed that the training on AI would have to be strategically adopted within the current pharmacy curriculum. Some offered to add special modules on AI, digital health, others to incorporate AI-related case studies and problem-solving to pharmacology, clinical therapeutics, and pharmacy practice-related courses.

4. Ready and Imminent Exposure

4.1 Readiness in the Self-reported Students

Although the importance of AI in the pharmacy practice became relevant, not all students were ready to adapt to any AI-related tasks in their future practice. Nearly 82 percent of the students admitted the importance of AI knowledge in their professional development; however, a mere 19 percent felt sufficient preparation to utilize the tool of AI appropriately in clinical practice.(9)

Credit and Readiness:

The survey showed that most of the students recognized the importance of AI in their future work, but the level of comfort with the usage of AI tools was not so high. The students self-reported the scale of preparedness on a 5-point likert scale (5 = Fully Prepared, 1 = Not Prepared). Mostly, the students (63%) scored their preparedness as 1 and 2 which means that they were not so prepared. Making them feel very prepared (score of 4 or 5) topped at 19 %.

One of the concerns students did share was that they want more organized encounters with AI throughout their coursework, and actual experience with clinical decision support systems that are driven by AI, data analysis software and machine platform to manage patients. Such a gap in readiness indicates that additional practice and exposure to AI in the practical environment is necessary.

4.2 Status of Training Faculty and Institutional Support Status

Preparedness of Faculty to teach AI was also one of the constituents of the study. Although three-quarters of faculty members mentioned that the application of AI in pharmacy education is relevant, most of them disclosed a lack of training and institutional support in order to apply AI in practice and in their pedagogical behaviors.

Faculty Training:

Almost two out of every three faculty reports not having been trained formally on AI. Such insufficient experience did not allow them to become effective teachers of AI concepts and was unable to introduce them into the pharmacy curriculum.(10)

Only a quarter of the faculty had been trained on digital health or AI mostly in workshop or independent modes of training.

Most faculty members articulated the necessity of special training in order to acquire a better idea of AI technologies and how they can be used as a part of pharmacy education. They proposed that professional development activities should include training.

Institutional Support:

The curricular overload aspect was mentioned by 47 percent of the faculty as an impediment to introducing AI in their classes. Faculties observed that the current year curriculum is already content-based, and adding the training based on AI would mean restructuring the current course content and structure.

The interdisciplinary collaboration was also suggested as a possible solution by 38% of the faculty, with the idea of cooperation with units such as health informatics and computer science to introduce elements of AI to the curriculum.

Only 29 percent of the institutions had specialized courses in digital health or AI and an even smaller proportions had practical experiences in AI that included course cases, laboratories or simulation learning.

4.3 Current Curricular Content That uses AI or Digital Health

The research evaluated the situation of AI incorporation in the curriculum of pharmacy at participating schools. Although most of the organizations were yet to assimilate the use of AI into their core classes, there were some that had already started with baby steps on the digital health education.(11)

AI in Curriculum:

Among institutions, only 30 per cent had courses on digital health with concepts of AI. These classes were usually on clinical decision support systems, pharmacovigilance and big data analytics but were largely elective or focusing in other tracks like clinical pharmacy or health informatics.

Some schools now have problem-based learning and case studies with AI in the advanced pharmacology course or the pharmacy practice course. Those, however, were sometimes narrow in their scope and not included in the basic curriculum.

Indeed, training on actual AI-powered systems or data-supported tools was virtually nonexistent in most schools, and there is a paucity of schools that provided the possibility to practice with AI programs or tools in the context of practice.

Such results mean that even though some bodies have already started to suggest the introduction of AI-related material, there is a vast margin concerning curriculum development and practical exposure to AI in pharmacy education.

5. Teaching Problems and Obstacles

5.1 Major obstacles to Curriculum Integration

Many obstacles to the integration of Artificial Intelligence (AI) into pharmacy curriculum have been discussed as based on the feedback given by the faculty and students. Such obstacles may be divided into three large categories, namely, training deficiency, time restrictions, and infrastructural drawbacks.(12)

Training Gaps:

The absence of faculty training is one of the biggest obstacles between AI integration in a pharmacy education program. The survey showed that 63 percent of faculty members stated that they did not get formal training in AI. This component of expertise deficiency causes the faculty not to be able to integrate this issue of AI into their curriculums and be not sure how to reply to students when they ask questions (concerning AI application in pharmacy). Faculty members without training cannot draft and teach anything related to AI, and it is difficult to equip the students with AI in the profession.

Also, a significant portion of students was not ready to work with AI in practice with only 19 percent of them saying that they were prepared enough to work with AI. The students mentioned the shortage of learning tools about the AI and insufficient practice as the main kinks in learning and utilizing the AI concepts.

Time Constraints:

Curricular overload was marred as another major difficulty. Faculty and students were anxious that integrating AI-related content into an already full curriculum of pharmacy courses would cost them precious time in their core pharmacy course subjects, including pharmacology, pharmacy practice, and therapeutics. Time pressure was one of the main barriers to the integration of AI by 47 percent of faculty members. College professors are usually under pressure to teach an extensive range of subjects within a limited period, which is why they will not be able to integrate such new technologies as AI without major redesign of the courses.

In the case of students, this may result in stress and burnout since students may not cope easily with the existing curriculum on the one side and drinking in new, more complex uses of the digital tools in health care on the other side.(13)

Infrastructure Limitations:

It was also indicated that lack of infrastructure to accommodate teaching of AI stalled many. There are only a few institutions with the technical capacity to incorporate AI technologies in their courses, including artificial intelligence driven simulation software, aids to making decisions and data analysis calculators. Although institutions had online modules and case studies on AI, they covered little and did not allow a hands-on experience to make learning practical.

Participating institutions, however, only provided digital health courses or courses related to AI or AI-related software platforms to use by students in 29%, much less than 50%. Faculty may not find it possible to provide interesting and complete AI-based learning experiences through this infrastructure gap.

5.2 Limitations Institutional and Administrative Limitations

On the institutional level, we can distinguish a few administrative issues that negatively affect AI integration:

Failure to prioritize in institutions: Most institutions fail to take digital health and AI education seriously as they take ordinary science subjects that are mandatory. Such institutional focus absence implies that the AI content tends to be left as a part of optional courses or extra activities, instead of becoming a fundamental part of the curriculum.

Research funding: The expenses that come in the quest of adopting AI tools and platforms and the cost of training faculty was cited as a significant obstacle. The majority of the pharmacy schools experience financial constraints, and can afford neither to restructure their curriculum, nor to invest in the latest technologies.

Curriculum rigidity: Certain establishments have been faced with challenges caused by curriculum rigidity, presumably, making it challenging to incorporate new material. The faculty and administrators recognized that regardless of the consideration of AI as a priority, it frequently collides with the current teaching format and teaching time limitations.(14)

5.3 Collaboration Interdisciplinary Requirements

Interdisciplinary collaboration is one of the most urgent solutions to the problem of how to overcome the obstacles. Artificial intelligence, in itself, is a multi-disciplinary domain which comprises computer science, health informatics, pharmacy practice and clinical decision support system. Member of the faculty proposed collaborative work between pharmacy, computer science, and health informatics departments with the help of which more consolidated curriculum may be developed.

Cooperation of such kind would bring:

S skills in AI technologies and their implementation to the fields of healthcare and pharmacy.

Co-creation of teaching materials, including case studies, AI simulation systems, and data driven learning material.

Multi-disciplinary professional staff capable of teaching students on the difficulties of learning pharmacy practices, AI technology.

Moreover, cooperating with the industry partners may allow us to get access to the latest tools and software to conduct practical training among the students. This would guarantee students exposure to real world situations of AI technologies which the students will face in the real world practice of the students.

6. Results

6.1 Summation of the quantitative results

The quantitative data obtained in the survey give an idea of the perception of students and faculty on the integration of AI in pharmacy education. The main points found are as follows:

Student Perceptions:

The knowledge of AI is considered to be the key in the work of pharmacists in the future by 82 percent of students. It means that the issue of the relevance of AI to the practice of pharmacy is strongly taken into account.

To a large extent, there is a discrepancy between the value that AI holds and the likelihood of students who feel that they are not sufficiently educated to use AI tools effectively, as it has been claimed that 19% of them feel they are sufficiently prepared to employ AI in clinical situations.

Regarding the expected use, students were mostly interested in using AI in the context of drug interactions (56%), drug safety (45%) and clinical decision-making (38%).

Only 15 percent of students were confident on the level of their confidence to use AI in practice, whereas most students assessed their confidence as low (63 percent rated 1 or 2 in a scale of 5 points).

Faculty Perceptions:

Three-quarters noted that they concurred that artificial intelligence is extremely applicable to pharmacy education and the practice of pharmacy in the future.

Nevertheless, 63 percent of the faculty said they have not got any serious training on AI which goes in line with the worries indicated on absence of training as a hindrance to the integration of AI.

Nearly 47 percent of faculty mentioned curricular overload as a barrier to facilitate AI integration, citing in-depth nature of the curriculum as the major factor restricting new content.(15)

In terms of faculty preparedness to teach AI, only a quarter of the faculty surfaced as confident with the amount of preparedness to teach AI concepts. The rest of the 76 percent stated the necessity of specialized training in AI and digital health.

Table 1: Summary of Key Quantitative Findings

Metric	Students (%)	Faculty (%)
AI knowledge is essential for future pharmacy practice	82%	75%
Adequately prepared to use AI in practice	19%	N/A
Confidence in applying AI tools	15%	N/A
Faculty received formal AI training	N/A	63%
Curricular overload as a barrier	N/A	47%
Prepared to teach AI concepts	N/A	24%

6.2 Qualitative Information of Open-Ended Answers

Qualitative answers indicated valuable information on student experience and faculty experience and attitude towards AI in pharmacy education.

Student Feedback:

Hope to have More Exposure to AI: A high number of students said that they wanted to get more exposure to AI tools. Such responses as I wish we could have a better opportunity to work with AI-based systems and It would be good to train to work with AI-driven clinical decision support systems indicated the necessity to have some practical work in the study process.

Temptations of Learning Overload: A number of students also complained about the time that would be required to learn and use new tools in AI, adding even to the burdensome course work. A student said, "I understand there is a need but I am worried about ensuring that I maintain a balance between this and other subjects that are of equal importance."

Faculty Feedback:

Lack of Training: All faculty respondents listed the insufficiency of training in AI as one of the main barriers. A faculty member remarked, "It is hard to be effective in teaching AI, and even bringing it into an already stuffed syllabus, without appropriate training." That is why it implies faculty development programs related to AI.

Interdisciplinary Collaboration: The problem was also noted by faculty concerned with the ability to collaborate across inter-disciplinary departments i.e., with the departments like computer science and health informatics to inform both students and instructors about AI better.

6.3 Institutional or Regional Differences

The Brazilian and German participants in the conference had certain differences regarding the perceptions of AI integration in terms of region.

Brazilian Institutions:

The Brazilian students had a higher probability of feeling inadequately prepared to work with AI, only 12 percent of them feeling confident when using AI tools as opposed to 18 percent of students in Germany. This can be ascribed to the variance relating to the institutional resources and curriculum structure.

In Brazilian institutions, scientific staff were more inclined to note the presence of curricular overload (52%) as an obstacle to the integration of AI compared to the English-speaking countries of 38%.

German Institutions:

The German student pre-preparedness was relatively higher (22 %) than that of Brazilian students, presumably, because of a better infrastructure of digital health and technology incorporation in German schools of pharmacies. The majority of faculty in Germany have shown more tendencies to suggest interdisciplinary collaboration, as 42 % of them proposed to collaborate with computer science and health informatics, whereas the Brazilian faculty proposed interdisciplinary collaboration with 31%.\

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Conflicts of interest

The authors have no conflicts of interest to declare

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