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Review Article

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# New insights and possibilities in pharmacy education: Integration of new technologies and internationalization at home

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**Abstract** Pharmacy education is significantly transformed by active learning, ongoing development, and innovative educational approaches. The rapid advancement of technology, particularly the integration of artificial intelligence, is enhancing educational tools and methods. Additionally, the COVID-19 pandemic has highlighted the potential of virtual exchanges, making global education more accessible through internationalization at home. Both educators and students are adapting to these contemporary advancements, reshaping the education landscape. In pharmacy education, combining theoretical knowledge and practical skills is crucial for developing problem-solving, discussion, and critical thinking abilities. Problem-based learning is increasingly utilized as a novel educational method in this field. This paper explores new perspectives and possibilities in pharmacy education by presenting case studies that illustrate the application and benefits of problem-based learning and internationalization at home.

**Keywords** Pharmacy education · Technology integration in education · [Generative] artificial intelligence · Internationalization at home · Problem-based learning

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## INTRODUCTION

Methods and tools used in pharmacy education are continuously explored and updated according to advances in pharmacy science and recent social and technological revolutions. In this regard, one of the most critical expectations is students' interest, curiosity, and engagement in learning, which ensures analysis and practice of the achievements of the subject or course. Therefore, the tools and approaches used are crucial to involve the students in the learning approaches and to get their ideas and thoughts out loud and in open discussions. These developments influence students' demands and expectations from the learning environment.

Active learning pedagogy is emphasized in the curriculum development standards of the Accreditation Council for Pharmacy Education (ACPE, 2024). The ability to select, develop, and effectively use current technologies required for pharmaceutical applications is among the objectives of the pharmacy-educational program demanded by the National Pharmaceutical Education Program Accreditation Standards of Turkey (ECZAKDER, 2024). Particularly in pharmacy education, team-based learning as an active learning approach (Attia & Mandour, 2023), educational programs that use social media as an educational tool, peer collaboration activities on social media, and professional services delivered through social media (Benetoli et al., 2015), use of Wikis, blogs, and podcasts (Zhang et al., 2015), game-based learning (Oestreich & Guy, 2022), virtual patients (VPs), computer-based simulation (CBS) (Phanudulkitti et al., 2023), and distance teaching methods, especially within and after the COVID-19 pandemic (Law et al., 2021), are suggested and/or used tools and programs.

Based on recent technologies and trends, this study focuses on the inevitable rise of artificial intelligence (AI) in education. Secondly, internationalization and internationalization at home (IaH) are discussed as globalization tools that allow for face-to-face and virtual exchanges (VE). Finally, the internationalization of face-to-face and VE in higher education will be illustrated through case studies.

## Integration of New Technologies in Pharmacy Education

Developments in technology have enriched pharmacy education, which is an interdisciplinary, specialized, and scientific area. We can summarize some of the changes caused by this variety in the pharmacy education curriculum as follows: simulation technologies such as virtual patients and computer-based simulations that support teaching and students' knowledge, skills, motivation, and engagement for learning in pharmacy education (Lee & Lee, 2021; Phanudulkitti et al., 2023; Smith & Benedict, 2015); pharmacoinformatics integration and informatics education to train students who want to become bioinformatics experts in designing, developing, implementing, and evaluating health information technology (Fox et al., 2017; Zainal et al., 2017); digital health education (Mantel-Teeuwisse et al., 2021); competency-based education (Moreau et al., 2019) to train qualified professionals to cope with increasingly complex pharmaceutical services. Integrating active learning and high-impact teaching practices into pharmacology courses can enhance students' ability to recall concepts and apply clinical skills effectively. This approach can reduce inappropriate medication prescriptions and unnecessary expenses while increasing students' confidence as they transition into clinical education (Collins & McLain, 2021). Researchers and educators in pharmacy education have explored how students learn better and how to develop digital strategies in education by taking advantage of their cross-country teaching, research experiences, and expertise to improve teaching and learning (Fung et al., 2024).

Since novel technologies and concepts in education need to reach instructors and students permanently, all stakeholders should be prepared, flexible, and ready to use the new ideas for maximum benefit. In addition, students should accept these technologies, which will result in problem solving, discussion, and developing critical thinking skills. Eventually, after graduation, pharmacists qualified to handle and contribute to the evolution of pharmacy science. One novel technology to focus on is artificial intelligence.

### *Integrating [Generative] Artificial Intelligence into Pharmacy Education*

Artificial intelligence (AI) was initially defined as a technology that simulates actions such as decision-making, reasoning, and intentional behaviour (Shukla Shubhendu & Vijay, 2013). This definition has become incomplete with the strengthening of this technology with new branches, such as machine learning and neural networks. AI can process much more significant amounts of data faster as well. Routley (2023) asked the definition of generative artificial intelligence to artificial intelligence and summarized the answer as follows: "a type of AI that uses machine learning algorithms to create new and original content like images, video, text, and audio."

Considering the discussions on how AI can be reflected in pharmacy education, the following advantages can be listed: personalization in the learning process, improving the learning process through its contributions to increasing efficiency and motivation (Ebrahimnejad et al., 2023), ensuring that pharmacy students are familiar with pharmacy practice and artificial intelligence applications in drug development before

graduation (Culp et al., 2024); accelerating drug discovery in pharmaceutical research, predicting drug safety and efficacy, and optimizing clinical trial designs (Singh et al., 2024); explaining complex topics, using interactive tools that help develop patient counselling skills, such as facial expression and emotional communication (Nakagawa et al., 2022; Sallam et al., 2023). Cain et al. (2023) summarized potential uses of AI for teaching and learning as lectures (outline for lectures, topics to cover, learning objectives, sample activities, etc.), clinical cases (draft scenarios), assignments, exam questions; clinical information evaluation activities; retrieval-based learning activities (course content, peer-reviewed literature, etc.); and syllabi.

By leveraging the capabilities of AI, pharmacists can provide better patient care and contribute to improving healthcare. Asad (2024) expresses how impressive the dream of artificial intelligence-supported virtual reality (VR) simulations that mimic real-world pharmacy environments, allowing students to practice complex clinical scenarios and make informed decisions, is. AI-powered virtual simulations enable students to make decisions, encounter virtual patients, and explore different scenarios. This immersive learning experience develops critical thinking, decision-making, and self-confidence.

Generative Artificial intelligence (GenAI) has significant potential in pharmaceuticals and life sciences, influencing drug discovery, clinical trials, data analysis, disease diagnosis, personalized medicine, medical education, and public health surveillance (Lewis, 2023). Pharmacy education is a challenging educational process that requires the integration of different disciplines. With the development of internet technologies, access to this information has become more accessible, but the increase in the mass of information makes learning difficult. GenAI tools such as ChatGPT and Quillbot offer pharmacy students opportunities such as research and concept learning, adjustment of the learning process according to their level and speed, and explanation of information repeatedly and in different ways according to the level of the student (Batson & Mara, 2024). Learning strategies are "behaviours and thoughts in which a learner engages and are intended to influence the learner's encoding process" (Weinstein & Mayer, 1983). Examples of learning strategies include spaced practice, structured practice, elaboration, dual coding, interleaved practice, etc. Like learning strategies, pharmacy students' study strategies may vary according to their background, preferences, and culture. Sometimes, it can be time-consuming to develop a learning strategy. Getting help from GenAI to generate mnemonics, limericks, and rhymes will help students retain their learning. Tools such as Taskade, Algor Education, and ChatGPT are also available to help the subject content with tables, concept maps, flowcharts, and visual elements. Other areas where GenAI can be utilized in the pharmacy field include creating cases (Cain et al., 2023) and solving problems in these cases, balancing workload and time management, making accurate calculations, voicing long articles, books, and documents in a tone close to the human voice, and capturing different perspectives. A pharmacy student needs to develop written and oral communication skills. GenAI will likely help with the communication skills they need to build in formal and informal situations with a patient or professional (Batson & Mara, 2024).

Practical skills development might also be enhanced in pharmacy education through various methodologies. Peer-to-peer learning, collaborative and team-based activities, and experiential learning can lead students to real-world professional settings and interprofessional environments. The World Health Organization (WHO) Framework for Action on Interprofessional Education and Collaborative Practice states that "Interprofessional education occurs when two or more professionals learn about, from and with each other to enable effective collaboration and improve health outcomes" (WHO, 2010). Additionally, fostering self-assessment through reflective practices can strengthen knowledge retention and understanding. Traditional rote memorization-focused assessments should be replaced with more diverse formats like open-book online exams using claim-evidence questions, objective structured clinical exams with simulated interactions, and portfolio-style evaluations.

Furthermore, AI presents a transformative opportunity to transform research skill development. AI can significantly improve learning outcomes by facilitating data-driven analytical teaching and shifting the focus from purely scientific paper structures to effective scientific writing practices with clear and concise expression. Moreover, AI-powered personalized learning and intelligent tutoring systems have immense potential to empower educators in identifying and supporting disadvantaged students while equipping them with better time management and planning skills. Adapting the pharmacy curriculum to incorporate these advancements is crucial to prepare future pharmacists for the evolving landscape of practice and education that is heavily influenced by AI (Weidmann, 2024).

GenAI also has some disadvantages, such as ethical concerns, concerns about transparency regarding accountability, and difficulties that may be encountered in implementation. Sallam et al. (2023) underlined the need to be careful about risks such as plagiarism, copyright, and academic fraud, as well as the lack of personal and emotional interactions nec-

essary to develop appropriate communication skills in health education. Their concerns include privacy risks, inaccurate or biased (Batson & Mara, 2024), GenAI content (e.g., in fields such as parasitology), overreliance on technology, and diminished critical thinking. There is a need to train "disruptive" educators who have the skills to "promote teaching-learning methods adapted to the digital environment and the use of educational processes suitable to encourage the use of effective disruptive technologies" (Silva et al., 2022) and who can consider the disadvantages and challenges of GenAI (Karataş, 2024)

### *Internationalization of Higher Education*

Recently, with developments in technologies and the context of education, the process of internationalization of higher education (IHE) has been discussed and interpreted in various ways and methods. Hudzik (2014) defined IHE as the intentional and comprehensive process of infusing, through action, international and comparative perspectives throughout the teaching, research and service missions of higher education (HE) institutions. Knight (2017) also supports that the intent of internationalization is moving towards increased integration of international, intercultural or global dimensions into the goals, functions and delivery of existing education in universities. IHE is generally practised through two phases. The first phase of IHE focuses on internationalization abroad (studying abroad) and physical academic mobility (such as exchange programs). The second approach of IHE is called internationalization at home (IaH), which is defined as the 'purposeful integration of international and intercultural dimensions into the formal and informal curriculum for all students within domestic learning environments' (Beelen & Jones, 2015, p. 69).

### *Internationalization at Home*

IaH includes a variety of activities, such as offering courses in English as a medium of instruction (Taquini et al., 2017), increasing international partnerships, collaboration through international research projects, increasing the number of international students and staff, and integrating a global dimension to the curriculum (Altbach et al., 2019). During and after the COVID-19 pandemic, IaH strategies have been recognized as providing significant potential to universities and education due to limited travel and increased digital opportunities. Virtual Exchange projects have been integrated into various courses and curriculas as important IaH activities (O'Dowd, 2021).

Virtual exchange (VE) is an umbrella term used to refer to the engagement of groups of learners in online intercultural interactions and collaboration projects with partners from other cultural contexts or geographical locations as an integrated part of their educational programs (O'Dowd, 2021). VE projects are more cost-effective and safer than studying abroad because they provide an online global experience while taking courses at home universities and participating in collaborative intercultural tasks. Moreover, it has been asserted that VEs offer great potential to develop intercultural competencies, foreign language skills, and media and digital literacy, which could complement physical exchange activities (O'Dowd & Beaven, 2019).

### *Problem-Based Learning Using IHE and IaH Concepts: Case Studies*

Problem-Based Learning (PBL) was initially developed for innovative health (Boud & Fletti, 2013) and has since spread to all fields of education. Savin-Baden (2000) defined PBL as a learner-centered approach in which learners combine practice and application, putting their knowledge and skills to work while generating solutions to a defined problem. She stated that pedagogy includes the ecology of learning, wisdom, and uncertainties, and PBL is the concepts and principles that guide pedagogy. Therefore, it is necessary to find a sufficient amount of information to consider PBL as a method. Savery and Duffy (1995) defined PBL as a student-centered approach: the "co-construction of meaning, deconstruction of knowledge, and learning spaces that are both formal and informal." PBL has advantages in developing essential learning and interpersonal skills, such as communication, prioritizing time and resources, problem identification, teamwork, and task sharing. PBL also can build learner confidence. However, it has some drawbacks, including setting up and facilitating PBL, which is time-consuming, and educators must be prepared to step back from traditional teaching roles (Kilroy, 2004).

PBL approaches to disseminate basic toxicology concepts, risk assessment, and food and chemical safety among graduate pharmacy and biotechnology students in health sciences are carried out coherently with the IHE and IaH concepts. In this way, a group of tutors from the Faculty of Food Technology and Biotechnology of the University of Zagreb (UZ, Croatia), the Faculty of Pharmacy of the University of Belgrade (UB, Serbia), the Faculty of Experimental Sciences of the Miguel Hernández University of Elx (UMH, Spain), and the Faculty of Pharmacy of Gazi University (GU, Turkey).

Case Study 1. ERASMUS teaching staff mobilities

First, the IHE activities under the ERASMUS teaching staff mobility program occurred three times: in 2014, 2015 and 2017. The first IHE activities were held at UMH, Elche. Teaching activities were based on an overview of current knowledge and workshops on risk assessment, basic concepts, molecu-

lar epidemiology in toxicology, and toxicokinetics and physiology-based toxicokinetics. An international group of tutors provided these activities to the students at the host institution. Finally, the students and teaching staff positively post-evaluated the PBL methodology and the program, which involved lectures, tasks, and task corrections in the classroom environment. In one of these three visits, 50 students from the Faculty of Food Technology and Biotechnology at the University of Zagreb evaluated the PBL program. The program is considered successful and fruitful, with up to 88% of students finding the program "very satisfied" or "satisfied for overall evaluation, design of the approach, and the content" (Table 1). The concepts of toxicology and toxicological risk assessment were prioritized in the PBL approach, and the students found them understandable and contributable to their knowledge. Educators give special importance to the continuation of courses, so the highest satisfaction and interest in participating in similar courses in the future is quite promising. The evaluation is only an approach to provide feedback for the PBL method, content, and tutorial quality of the mobility to shape future teaching activities. No validation and reliability analysis are carried out for the evaluation.

*n = 50 students from the Faculty of Food Technology and Biotechnology at the University of Zagreb in May 2017. The course was 9 hours over three days.*

Based on the experience from Case Study 1, some points can be enhanced in the following projects. A limitation observed was that students from only one faculty benefited from these workshops by incorporating PBL methodology through the ERASMUS teaching staff mobility program. In the following case study, improvements and changes are addressed.

Case study 2. Internationalization at home project-PRODIC

Based on reflections from previous experiences, the IaH may be used to make the experience available to partner faculty's students. In this regard, another PBL in Toxicology teaching activity, based on the IaH concept, has recently been carried out in parallel at the previously mentioned faculties at UZ, UB, UMH, and GU for two consecutive years, for the academic years 2022/23 and 2023/24. Differently and alternatively, the interaction of tutors and students from different faculties through joint PBL teaching activities in an international scientific virtual environment was created. This activity was granted under the "Program of International Teaching Projects at Home (PRODIC)," which is an initiative of the Vice-Rectorate for International Relations of the Miguel Hernández University of Elche (UMH). To date, 118 projects have been implemented at UMH, and 40 new PRODIC projects will be implemented for the academic year 2024/25 (UMH, 2024).

The Google Workspace for Education provided several tools to develop IaH parallel activities at UZ, UB, UMH, and GU. For example, GDrive was used to share lecture slides and recordings and collect student submissions, whereas GMeet allowed virtual classes and meetings. The teaching plan consisted of 4 lectures with their corresponding tasks and task corrections (Figure 1). Overall, the students submitted 425 submissions for the four tasks.

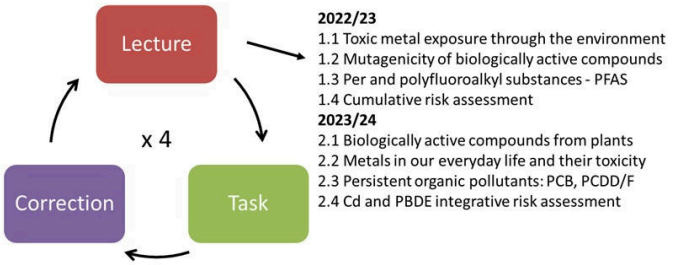



**Figure 1.** Workflow of PBL-based teaching activities within the framework of PRODIC over two academic years.

**Table 1.** Student Evaluations of PBL during ERASMUS Staff Mobility at the University of Zagreb

| **Evaluations** | **Likert-type choices (in terms of %)** | | | | |
|---|---|---|---|---|---|
| | very satisfied | satisfied | neutral | dissatisfied | very dissatisfied |
| How did you find the workshop overall? | 20 | 66 | 10 | 2 | 2 |
| | very satisfied | satisfied | neutral | dissatisfied, too short | dissatisfied, too long |
| How do you feel about course length? | 20 | 52 | 10 | 18 | 0 |
| Has the course contributed to your toxicology knowledge? | strong agreement | agreement | neutral | disagreement | strong disagreement |
| | 16 | 72 | 10 | 0 | 2 |
| Has the course improved your understanding of risk assessment? | strong agreement | agreement | neutral | disagreement | strong disagreement |
| | 10 | 70 | 14 | 4 | 2 |
| Are you interested in participating in a similar course in the future? | strong agreement | agreement | neutral | disagreement | strong disagreement |
| | 52 | 42 | 4 | 0 | 2 |
| Would you recommend this course if it were reorganized in the future? | strong agreement | agreement | neutral | disagreement | strong disagreement |
| | 40 | 46 | 12 | 0 | 2 |

The evaluation of the first PRODIC among the students raised some obstacles to implementation. Coordinating the timing of lectures and tasks for each faculty member, English language proficiency challenges for non-native speakers, and technology integration tools (such as tablets, phones, internet, and website platforms) were among the difficulties. As a result, these factors have collectively hindered the seamless implementation of IaH. Several measures have been taken to address the challenges of IaH. The recording of lectures provided flexibility for the timing and accessibility of the lectures more than once, preventing language- and technology-based missing information. Complementary to this, the tasks were designed with flexible planning but adhered to specific deadlines set by each university. The task scores were integrated into the course grading system to maintain a consistent evaluation system across different contexts. While promoting interaction between international students was a cross-cutting objective, it was submitted to a future VE project, which requires better planning and implementation. These measures were seen as making a positive contribution to the current project.

Students shared their PRODIC experiences at the meetings (Figure 2). They found the international environment a fruitful and novel opportunity that broadened their perspectives. After successful participation, the certificate (Figure 2) provides another source of academic affordance and motivation. Students expressed their appreciation and eagerly asked for similar future initiatives.

## DISCUSSION AND CONCLUSION

AI is transforming pharmacy education by making it more interactive, efficient, and personalized. AI analyzes complex data, recognizes patterns, provides intelligent recommendations, improves learning outcomes, personalizes education, and streamlines pharmacy practices. The emergence of robust AI platforms provides a chance to reimagine pharmacy education. Instead of combating students' misuse of AI for workload reduction and grade inflation, we should priorities fostering critical thinking skills—specifically, the ability to ask insightful questions and assess information for problem solving. While AI may excel at answering questions, it cannot currently identify pertinent questions or offer nuanced opinions and ethical guidance. "Augmented intelligence," the synergistic combination of AI and human intelligence, presents a promising avenue for exploring AI's role in education and practice. AI's generative nature strengthens information processing technologies; however, it remains susceptible to errors and lacks expert-level human intuition. Instructors can leverage AI to enhance academic efficiency by, for example, generating problem-based learning cases, crafting exam questions, and fostering discussions about literature (Cain et al., 2023).

IHE and IaH experiences in Problem-Based Learning, both with the ERASMUS and PRODIC approaches, enable students to experience task-sharing, problem-solving learning environments that are multicultural and international, as well as insight into new perspectives in toxicology, which is part of pharmacy education.

In line with these technological advancements, IaH activities, such as VE in pharmacy education, offer a valuable opportunity for students to gain global perspectives and intercultural competence at the international level without the need for travel. These activities can enhance the overall learning experience and prepare students for a diverse and interconnected world by providing equal learning opportunities to all students. By engaging in VE or virtual meetings/lectures, students can develop essential skills such as communication,




**Figure 2.** The students who participated in PRODIC shared their experiences at the Fourth National Pharmacy Education and Accreditation Congress.

collaboration, and adaptability, which are necessary in today's globalized society.

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