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The future of pharmacology education: a global outlook

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1. Introduction

Pharmacology educators play a unique role in higher education, at the intersection of basic biological, and clinical sciences. They teach a on wide range of courses including undergraduate and postgraduate medicine, pharmacy, nursing, dentistry, physiotherapy, osteopathy, veterinary science and biomedical science (1). Note that this is far from an exhaustive list.

Significant changes have taken place in pharmacology education in response to advances in pharmacology, developments in educational approaches and learning technologies, changes in healthcare education delivery, and the massification and internationalisation of higher education. These challenge the educator, whose role is increasingly recognised as encompassing teaching, leading and scholarly activity (2). The future of pharmacology education depends on our ability to navigate these changes. We argue that there are sets of interrelated **knowledge**, **skill**, and **attribute** competencies that pharmacology educators must master to ultimately enable their students to succeed, discussed in detail in the following sections (see Figure 1).

2. Knowledge, Skills, and Attributes of Pharmacology Educators

2.1 Knowledge

The Organisation for Economic Co-operation and Development (OECD) Learning Framework, a product of the OECD Future of Education and Skills 2030 project, distinguishes four different types of knowledge: disciplinary, interdisciplinary, epistemic and procedural (3). Students of pharmacology must master the core concepts of our discipline, apply these concepts, and others, across a range of other disciplines. They also need to understand the habits of mind of experts, and must gain skills in solving problems using learned strategies.

When educators decide what knowledge students need to master in a programme, they face a daunting task. First, they must negotiate local school and programme dictates and conventions. Then, there are often specific objectives required by accreditors, and other guiding documents such as the “Knowledge Objectives in Medical Pharmacology” for US medical educators (4) or the British Pharmacological Society resources for clinical pharmacology for medical students (5) and undergraduate pharmacology (6). Combining this information with their own knowledge to produce a curriculum that employs evidence-based approaches such as active learning (7), is not easy.

These tasks may become easier if the structure of the teaching is focused on the big ideas of the discipline – the content that matters for students and graduates. Indeed, the OECD Future of

Education and Skills 2030 project describes “key concepts” or “big ideas” as one of the cornerstones of curricula design. A team working under the umbrella of the International Union of Basic and Clinical Pharmacology (IUPHAR) produced just such a list in 2022 (1), and more recently defined, unpacked, and concept mapped 24 core concepts of pharmacology education (1, 8).

When deciding what to do in valuable class time or when developing online materials and resources, educators also need to develop pedagogical content knowledge: the specialised knowledge that educators possess, combining subject matter expertise with effective teaching strategies to create meaningful learning experiences for students (9). Communities of practice such as the IUPHAR Education Section (IUPHAR-Ed), or other similar networks, may be a critical resource for young educators.

2.2 Skills

In terms of technical and organisational abilities, lecturers need to possess a wide range of skills. We need to design lectures, learning resources and curricula in both traditional and technology-based forms. We must also manage courses in person, blended and online, use our presentation (and sometimes acting) skills to teach students new content, facilitate engaging activities, supervise research projects and assess learning in creative ways (2). In the current times, these skills are being pushed to their limits; the Covid pandemic and other disruptions to learning (e.g. the Fees must fall protests at South African Universities) caused us to pivot to online teaching at a moment's notice, and the advent of artificial intelligence (AI) poses challenges for assessment integrity. Our ability to navigate these challenges has been met with our adaptability and flexibility, skills that lecturers need daily to improvise when faced with unexpected questions or unexpected findings in our research. This flexibility and adaptability are also needed when teaching different cohorts of students, from science students to medical students and more recently humanities students (10). Furthermore, in an era where there is a shift towards integrated curricula and even integration of disciplinary departments, we also need to be champions of pharmacology to ensure that it maintains its place in both the curriculum and assessment (11). More recently, the advent of artificial intelligence (AI) and Large Language Models (LLMs; a type of AI) brings challenges and opportunities for pharmacology educators. Student use of LLMs (e.g. ChatGPT) for assessments has raised challenges for assessment integrity, spurring universities to ‘AI proof’ assessments. On the flip side of this, recent work shows that AI can pass national Medical Licensing Assessments suggesting that it could be used as a teaching tool (12). As AI becomes integral to our lives, preparing students for its future impact is crucial. In clinical pharmacology, AI offers practice-enhancing opportunities (13, 14). However,

fostering students' understanding of its limitations is essential. By integrating AI into teaching and assessment, we can empower students to use it responsibly and reliably. Such integration will require continued development and refinement of educators' technological skills (see Figure 1).

2.3 Attributes

Harden and Lilley (2018) argue that the attributes of an excellent teacher are a combination of disciplinary knowledge, technical abilities and approach to teaching, but that encompassing all these is professionalism – the requirement to demonstrate appropriate behaviours and attitudes such as passion, enthusiasm, and authenticity (2). We propose that in addition to the knowledge and skills outlined above, pharmacology educators need to model various attributes and attitudes, including being a team worker and collaborative, innovative and experimental and culturally competent. We must demonstrate professionalism in relation to our own practise: evaluating our practice in relation to knowledge and skills, keeping up to date with approaches to teaching, and engaging in pedagogical research (see Figure 1).

The increase in videoconferencing and online working catalysed by the Covid pandemic has increased worldwide interconnectedness and the ease with which we can collaborate internationally. Consequently, organisations such as IUPHAR-Ed have blossomed, with international educators collaborating on the development of core curricula, and sharing knowledge, expertise, and resources through projects such as the Pharmacology Education Project (PEP) (15), and the Core Concepts of Pharmacology project (CCP) which to date has engaged over 300 pharmacology experts from 23 countries across 6 continents (1, 8).

The changing methods of education, from a focus on transmission of knowledge and skills, to active learning approaches, has required us to innovate and experiment. Adaptation of educational approaches requires us to be bold, imaginative, and creative, with a growth mindset. The design, development or adoption of new learning technologies (e.g. virtual reality, ChatGPT, HP5) or approaches (e.g. simulation- or team-based learning) in the classroom, push us out of our comfort zone and require us to experiment to find what works best in a particular context.

Not only are educational approaches and tools changing, but diversity across degree programmes is increasing. Internationalisation and widening participation agendas have expanded the diversity in the classroom, heightening the importance of cultural competency in the educator (16). Guilding et al., 2021 highlight cultural differences including differences in individualism/collectivism orientation,

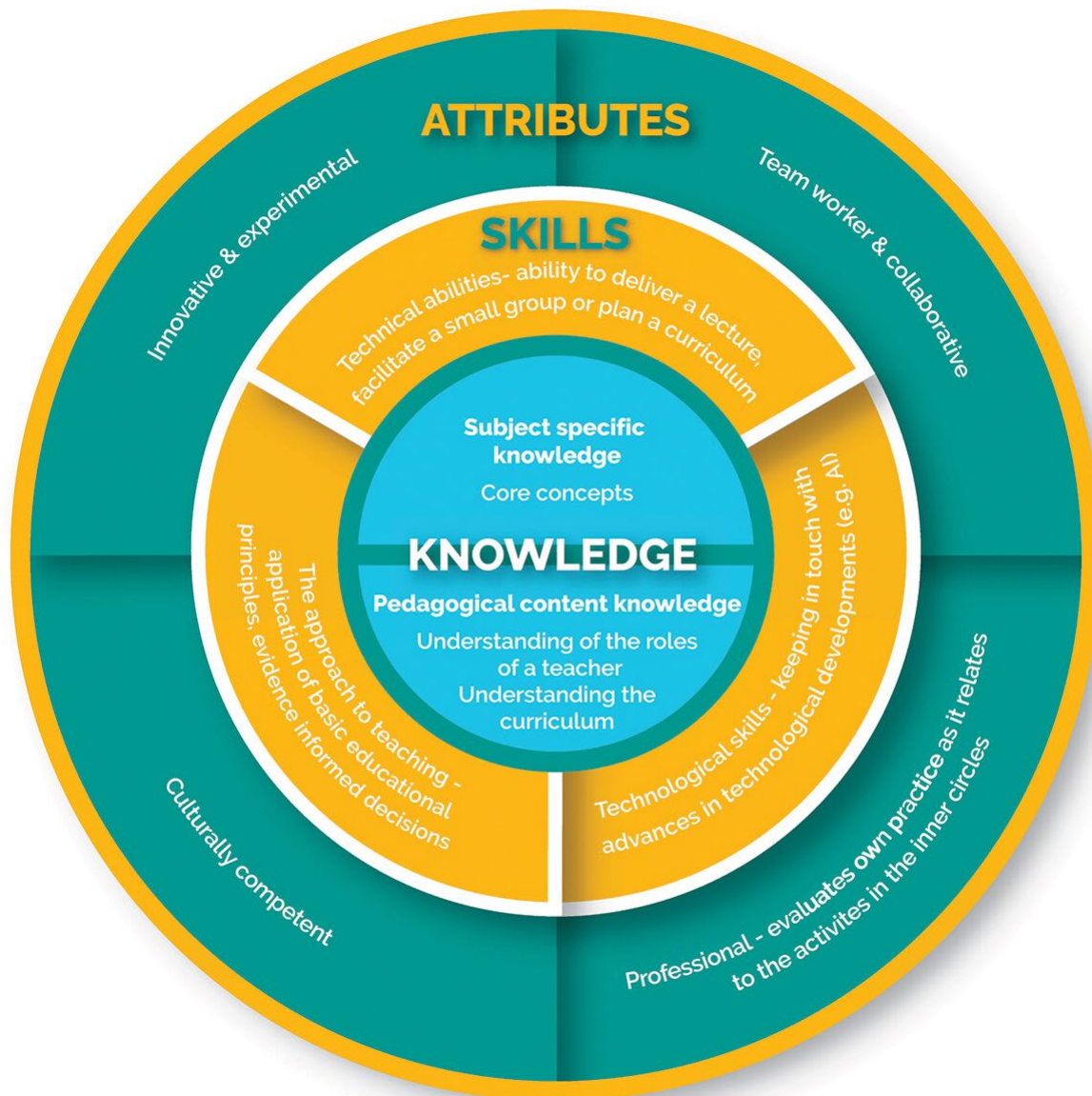
and cultural acceptance of hierarchy, which can influence both expectations of work and interpretations of meaning, including in the context of clinical pharmacology education (17).

3. Expert Opinion

In a world increasingly governed by digitisation, automation, robotics and artificial intelligence, the Fourth Industrial Revolution (4IR), pharmacology students and educators require corresponding 4IR skill sets and attributes including entrepreneurship, complex problem solving, and creativity. The global pandemic catalysed the development of these skills, requiring us to embrace digital learning technologies, re-design our curricula, innovate, and develop pedagogical expertise in online learning (18). Innovative approaches to pharmacology education such as interprofessional learning and high-fidelity simulations can facilitate healthcare students' development of knowledge, skills and attributes which may contribute to safer prescribing practice (19, 20). Hybrid learning, case-based learning, flipped classrooms and gamification are also effective strategies for teaching pharmacology to undergraduate students (18, 21). Yet recent rapid changes have also broadened and highlighted global inequalities in education provision. Nations without reliable internet were less able to pivot to online learning and have less opportunities to take advantage of advancements such as AI. Educators in resource limited countries can struggle to access learning technologies, or the latest journals/textbooks for dissemination of the current knowledge base and educational approaches. Projects such as the PEP have arisen with an aim of providing resource poor countries with free, expert peer reviewed, online pharmacology education content (15). However, as an online resource, inequalities in the digital connectivity hamper access, and the resource is currently only available in English.

The future of pharmacology depends on its educators working as a global community to develop and disseminate not just the knowledge and skills of pharmacology as a biomedical discipline, but also the pedagogical expertise around how we best structure knowledge and teach engagingly. We must reflect on our values and consider the purpose of pharmacology education in the worldwide arena – what are the problems that we as pharmacologists need to solve and how can we work on these in an inclusive manner? National and international pharmacology societies are the hub of global developments, and it is important that these maintain representation from developing countries. There are ample opportunities for colleagues from all nations to engage in building the future of pharmacology education through initiatives such as the PEP and the CCP. The benefits of joining these international initiatives include access to an enormous range of evidence-based resources,

support from like-minded colleagues, and the chance to influence pharmacology education well beyond your own institution - please reach out and join us!



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