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21st Century Pharmacy Education: Approaches To Curriculum Redesigning

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Abstract
A curriculum is an integrated educational tool to prepare students for future needs. Redesigning the curriculum through a systematic and evidence-based approach and implementation provides an opportunity to integrate the required competencies students would need as future-proof skills. In the 21st century, developing creative learning models and incorporating them into the curriculum has been one of the most emerging pedagogical strategies to cope with the profoundly changing world. In addition, ICT (Information and Communications Technology) and simulation technologies such as extended reality (XR), virtual reality (VR), augmented reality (AR), and mixed reality (MR) can improve students' digital competencies, and creative conceptual learning models increase overall engagement in pharmacy curricula and enhance their overall learning experience and outcomes. The roles and responsibilities of pharmacy graduates have changed and will continue to change in this technologically advanced world. Various types of educational strategies are available to support students, but selection of the right method and tool has always been a challenge in the modern era. In this paper, we discussed approaches to enhance curriculum redesign while keeping to the 21st century pharmacy education standards.

Keywords: Pharmacy Education, Curriculum Redesigning, Pedagogical Strategies, Future-Proof Skills, Simulation Technologies

Introduction

Pharmacy is one of the health professions education (HPE) programmes that produces a professionally competent and educated workforce (for example, community pharmacists, hospital pharmacists, industrial pharmacists, clinical pharmacists, academic pharmacists, pharmaceutical scientists, and other pharmaceutical service assistants). Pharmacy education and practice in the 21st century has changed, certainly, with significant advancements in information and communication technologies (ICT). Currently, digital educational frameworks are driving the process of how pharmacists are educated and skilled. The focus is centred on how they apply the knowledge they learn. It is essential that all pharmacy professionals are adequately trained to support the current and future workforce. To align with digital competencies, academic institutions, pharmacy educators, and students need to adopt digital transformation for education initiatives. The International Pharmaceutical Federation (FIP) provides guidelines and a strategic framework to serve as a reference to schools and faculty of pharmacy worldwide for curricular revision. Year 2021 is a remarkable milestone for the global transformation of pharmacy education, science, and practice with the digital transformation initiative by FIP (Sacre, 2021). FIP sets a 10-year transformation programme that is aimed at aligning pharmacy with professional standards across all pharmacy disciplines, with 21st century skills as the essential need. The FIP programme comprises 21 fundamental development goals to enable digital transformation at regional, national, and global higher education institutions offering pharmacy programmes (Figure 1).

Figure 1. The global pharmacy development goals formulated by FIP; graphic created by Vasudeva Rao Avupati with no changes to the original content. (Information adapted from FIP website page https://www.fip.org/fip-development-goals)

The curriculum design of a pharmacy education programme has an extremely significant role in establishing the excellence of pharmacist services that are going to contribute to public health in the profession. There is a huge need for a redesign of the curriculum for pharmacy training and education. Higher education institutions offering pharmacy programmes must shift the education standard in line with the current trends progressing the field of pharmacy education. A well-prepared student to face the challenges of the future is created by the quality of the education provided, the technology-enhanced curriculum, and the teaching strategies and models used to enhance learning effectiveness. Pharmacy education has been developed based on several learning theories, philosophies, and models. The suitable educational strategies and modes of delivery must meet the students' learning needs. It is essential for all pharmacy educators to be cognizant of distinct, promising educational strategies and to try to facilitate students' learning at a comfortable pace with some flexible space while reviewing their curriculum or developing an instructional design for a new program. The aim is to propose adaptable strategies for curriculum redesign that prepare pharmacy graduates with 21st century skills. To kick start this process, the primary objective is to perform a structured need-gap analysis of the existing pharmacy curriculum. Secondary objective, recommend appropriate remedial actions to bridge the need-gaps identified in the curriculum. In this paper, we proposed and discussed the reliability of adopting some educational strategies and learning models suitable for enhancing pharmacy education in higher educational institutions (HEI). Identifying and closing the learning need-gap is the process of improving the quality of learning to achieve intended student learning outcome.

Methodology

Curriculum Analysis

We have described a model approach to performing curriculum analysis by selecting an existing pharmacy education curriculum from a higher education institution offering a graduate pharmacy program. This process has been structured in a more generalised way to prevent any conflicts that may arise with respect to a specific region or nation's context. While the whole process aims to enhance graduate competencies and prepare pharmacy students to achieve or fulfil the global needs in the pharmacy profession as described by FIP, as a first step, a close, structured need-gap analysis must be performed. Therefore, we took a close look at the selected curriculum content and its status of alignment with global professional needs. From our constructive analysis, the team of subject experts worked together and reviewed all the curriculum components branched under the basic pharmaceutical science course modules, such as pharmaceutical chemistry, pharmaceutical technology, pharmacy practice, pharmacology, and health sciences, respectively. However, we discovered a need for curriculum content redesign in order to improve professional education standards in terms of the current versus desired state of education, practice, and skills. We found that this need-gap analysis exercise is an important task that enables all stakeholders to understand the situation clearly and strategize remedial action plans as part of the bridging the gaps initiative to be implemented in the respective pharmacy school, which further leads to a 21st century integrated curriculum redesigning exercise. The objectives that need significant consideration to be upgraded were also aligned with FIP development goals (Sacre, 2021). Taking suitable remedial action to close the identified gaps will certainly improve the ability of pharmacy graduates to achieve higher-order skills and competencies. There are several domains that come into this task force to address the various factors associated with change management. Our approach in this study is specifically covered in a curricular aspect since pedagogy comes first, and all other elements are integrated into the flow while moving forward. Our findings related to this model exercise are shown in Table 1.

Curriculum Redesigning

Outcome-Based Education (OBE) is a main educational tool that intends to redesign the pharmacy curriculum with specific intended course learning outcomes (CLOs) to achieve students' graduate competencies and prepare them for the future-task force (Slavcev, 2013). To do this, the CLOs must be constructively aligned to the programme learning outcomes (PLOs) and further mapped to the programme educational objectives (PEOs). This design and formulation must be an integral part of the institution but must be based on feedback from stakeholders to meet the demands of the profession. The conceptual basis of OBE is construed as identical with learning as competency-based education (CBE) (Katoue, 2020). In the educational context, competencies are described as the development of students' knowledge, skills, attitudes, and behaviours through academic education, training, and/or employment. When mixed, these fundamental competencies form the basis for a competency framework. A further framework gives a blueprint that drives the process of defining the competencies and behaviours of pharmacists in their professional practice. The OBE implementation starts with establishing PEOs and PLOs, aligning PLOs with Bloom's Taxonomy (BT), followed by defining Course Learning Outcomes (CLOs), subsequent mapping of individual course with PLO at appropriate levels of BT. The mapping further continues with the preparation of a lesson plan to deliver the course, mapping between CLO and PLO, besides that each CLO must be properly mapped to the pedagogical methods of delivering CLOs and assessment method defined with rubrics to measure the students' performance, and assess achievement of the intended CLOs, PLO and finally PEOs. This whole process is supported by an educational theory called Constructive Alignment (CA) (Thian, 2018). CA is an educational approach where the alignment of teaching, learning, and assessment activities in a way that allows learners to achieve the intended course learning outcomes (CLOs) of an academic programme. The figure below depicts additional CA elements such as Topic Learning Outcomes (TLOs), Teaching and Learning Strategies (T&LSs), Assessment Tasks (ATs), Learning Activities (LAs), and Learning Resources (LRs), as well as their internal mapping in relation to an academic programme (Figure 2).

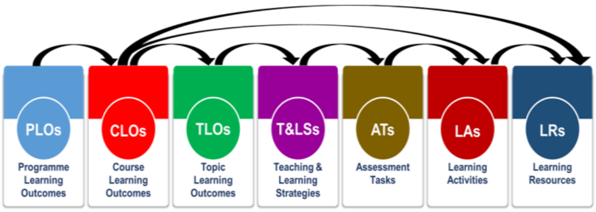

Figure 2. Constructive alignment in an academic programme with their course modules (Referred from Rundle & Gurney 2017) modified with additional content by Vasudeva Rao Avupati

Outcomes of the Curriculum Analysis

Table 1. Model structured need-gap analysis of the pharmacy curriculum

Learning Objective	Current State	Desired State	Need-Gap Identification	Need-Gap Description	Remedial Actions
To develop simulation skills related to pharmacy practice.	Limited exposure to simulation technologies in teaching and learning.	Pharmacy graduates' readiness for digital workplace	Simulation skills	Digital health services such as patient counselling and medication safety	Use of simulation technologies to bridge the gap between knowledge, skills, and attitudes in pharmacy practice related modules. (Frenzel, 2018)
To enhance innovation, research, and development skills in medicinal and pharmaceutical chemistry.	The traditional teaching component is high. Didactic teacher-centered component needs to be revisited.	Pharmacy graduates equipped with new medicine design and development competencies.	Innovation, research, and development skills	Drug design, discovery, and development is a complex process that involves a multi-disciplinary approach that needs conceptual understanding on the content of the medicinal chemistry.	Use of active learning strategies as a strategy to bridge the gap between theory and practice of medicinal chemistry related modules. (Gupta, 2021)
To develop lifelong learning skills	Currently, some learning tools have copyright restrictions to access from outside the school campus.	Pharmacy graduate's empowerment towards his or her career growth and continuing professional development (CPD)	Life-long learning ability	Pharmacy professional skills development.	Use of open-educational resources as a tool to bridge the gap between principles of pharmacy practice and professional skills development. (Min, 2021)
To demonstrate effective communication skills.	Currently, no significant mobile learning apps are available for students learning.	Pharmacy graduate's competency to adopt to flexible (anytime, anywhere) learning environments.	Interprofessional skills	Pharmacist is an integral part of an interprofessional network in a clinical setting, need to be an adaptable flexible learning environment.	Use of mobile-based online learning approach as a tool to bridge the gap between professionalism and effective communication skills among the health professions. (Floren, 2020)
To apply the theories and principles of pharmaceutical sciences.	Currently, more small group learning activities are in force.	Pharmacy graduates skilled with innovative and creative minds.	Critical thinking skills	Pharmacist is an integral part of the research and development units of the pharmaceutical industry. There he or she needs to work as a team in a multi-tasking environment. The scientific contribution to the overall success of new drug development is totally dependent on research pharmacists' ability to think critically in applying pharmaceutical sciences.	Use of team-based learning as a tool to bridge the gap between conceptual understanding and creativity through the course modules. (Silberman, 2021)
To interpret the concepts of the pharmacology.	Currently, content co-creation exercise is not included in the standard teaching practice.	Pharmacy graduates must be a competent pharmaceutical service provider.	Conceptual learning ability	Clinical reasoning and understanding of pharmacotherapeutic interventions of various drugs depends on pharmacists' ability to gain conceptual understanding over various parameters used for the diagnosis and clinical examination of a patient in an in-patient ward.	Use of inquiry-based learning as a tool to bridge the knowledge gap between mechanism of drug action and pharmacotherapeutic intervention in concepts pharmacology integrated modules. (Chary, 2021)
To review case-studies related to clinical pharmacology.	Currently, students are not well exposed to the conceptual learning framework.	Preparing pharmacy graduates for future education 2030.	Problem-solving skills	As a pharmacist, problem-solving and decision-making skills are very important, especially in matters related to clinical cases, managerial, ethical, and legal situations. Since pharmacists must be prepared to face critical circumstances in some cases.	Use of task-based learning as a tool to bridge the gap between pharmacology and clinical pharmacology. (Li, 2017)
To strengthen digital literacy skills in pharmacy setting.	Current problem-based learning is more functional, however there is a room for the improvement.	Preparing pharmacy digital health workforce	Digital literacy	Being a pharmacist is a frontier line health care worker, so there is a need to continuously update his or her knowledge. In this digital health system, pharmacists' digital literacy skills must be competent enough to practice effectively and adopt to the changing global professional settings.	Use of digital case-based learning as a tool to bridge the gap between pharmacy skills and ICT skills. (Singh, 2021)
What is the objective?			Gaps identified and analyzed		Remedial actions

Discussion on the Curriculum Analysis and Redesigning

An evidence-based reflective discussion has been presented with suitable remedial actions for brining expected changes in the educational standard. As pharmacy educators, we have the responsibility to facilitate the education and training of learners with future-proof skills. However, we believe that no single strategy will fit for curriculum revision that fulfils the desirable needs of the global pharmacy profession. Knowing what the strategies are to be integrated into curriculum to develop students' 21st century skills is important. As part of the identification of the remedial actions to propose an evidence-based actions, we have reviewed recent literature related to the best strategies adapted by various pharmacy schools across the globe to improve their students' skills and competencies. We found suitable, validated educational strategies that effectively facilitated students' learning and engagement shown in Table 1 under the column remedial actions. Based on our model need-gap analysis in the curriculum, it is very clear that a set of skills as shown in Table 1 are essential and must be pursued by 21st century pharmacy graduates. In view of urgent demands, in this need-gap analysis report, we emphasized proposed remedial actions which are beneficial to achieve the learning needs as part of patching the gaps effectively.

Impact of patching the need-gaps with remedial actions leads to the expected outcome of equipping students with simulation skills is aligned with the achievement of the FIP pharmacy development goal, which is Goal-19: patient safety recognized for the transformation of the global pharmacy workforce (Figure 1). Likewise, the expected outcome of facilitating students using active learning strategies is aligned with the achievement of the FIP pharmacy development goal, which is Goal-1: academic capacity recognized for the transformation of the global pharmacy workforce (Figure 1). Similarly, the expected outcome of engaging students using open-educational resources is aligned with the achievement of the FIP pharmacy development goal, which is Goal-9: continuous professional development recognized for the transformation of the global pharmacy workforce (Figure 1). In the same order, the expected outcome of engaging students in mobile-learning is aligned with the achievement of the FIP pharmacy development goal, which is Goal-7: advancing integrated services recognized for the transformation of the global pharmacy workforce (Figure 1). In addition, the expected outcome of facilitating students in team-based learning is aligned with the achievement of the FIP pharmacy development goal, which is Goal-8: working with others recognized for the transformation of the global pharmacy workforce (Figure 1). Equally, the expected outcome of facilitating students in inquiry-based learning is aligned with the achievement of the FIP pharmacy development goal, which is Goal-14: medicines expertise recognized for the transformation of the global pharmacy workforce (Figure 1). Also, the expected outcome of facilitating students in task-based learning is aligned with the achievement of the FIP pharmacy development goal, which is Goal-12: pharmacy intelligence recognized for the transformation of the global pharmacy workforce (Figure 1). Finally, the expected outcome of facilitating students in digital case-based learning is aligned with the achievement of the FIP pharmacy development goal, which is Goal-20: digital health recognized for the transformation of the global pharmacy workforce (Figure 1). Among the Need-Gaps identified, simulation skills and conceptual learning skills captivated our attention, therefore in this paper we considered to propose suitable educational strategies in alignment to the OBE delivery and competency-assessments:

Simulation Skills

In pharmacy education, skill-based activities play a vital role in developing and strengthening student competencies and prepare them for the work readiness, some activities could be challenging to incorporate into the curriculum at undergraduate level curriculum due to instrument maintenance costs, hyphenated equipment, hazardous research materials, handling expertise, or difficulty to transform theoretical concepts into practicals such as performing X-ray crystallographic studies for studying the 3D chemical and biological properties of a therapeutic drug, understanding molecular interactions in the binding site region of the drugs. In the present scenario, adopting technologies which have the power to overcome these challenges, the worldwide higher education sector has acknowledged the significance of Information and Communication Technologies (ICT) based adaptive educational strategies such as simulation, big data analytics, autonomous robots, augmented reality, cloud computing, cyber security, additive manufacturing, internet of things, Extended Reality (XR), Virtual Reality (VR), artificial intelligence (AI), Augmented Reality (AR), and Mixed Reality (MR) system integrations are the industrial revolution (IR 4.0) technologies that could revolutionise education, science, and practice worldwide. VR and AR, also referred to as mixed reality, is a cutting-edge educational tool that bears a concept where people "learn best through experience". Rather than traditional classroom student-teacher interaction, this virtual simulation provides a more lifelike learning experience by creating an effective learning environment through personalised dynamic virtual-physical interaction without the need to be physically present at the school (Lee, 2021). In addition to improving student learning outcomes, these new simulations technology-based teaching approaches has shown to help teachers succeed by encouraging students to become fully immersed in the learning process. It lessened cognitive load, improved engagement, and helped students retain information for longer, especially in subjects like STEM (science, technology, engineering, and mathematics) that are more abstract and have a two-dimensional focus. Furthermore, incorporating a mixed reality into the learning session can help students reach their full potential by tailoring the experience to their learning styles and abilities. Universities across multiple disciplines have made use of this technology. This newer technology can be a significant aid to the pharmacy school curricula.

The use of virtual and augmented reality will make technical education more affordable and accessible by reducing or eliminating the need for expensive classroom and field training as well as costly training equipment. Students can safely practice and master difficult laboratory skills as much they can, whenever and from wherever they want without cost to bear in mind. Case study-based simulations, which are reproducible, can help students gain practical experience while also serving as a useful pharmacy skills development (PSD) tool. This technology also has important benefits in that it encourages collaborative research and hybrid teaching models. Formulating an educational strategy for 21st century learners is important for sustainable education. Our proposed pharmacy educational strategy to bridge the simulation skills need-gap is presented in Table 2.

Table 2. A model pharmacy educational strategy to foster students' simulation skills at pharmacy school.

Pharmacy Educational Strategy (Brown, 2021)	
Competency Domain	Psychomotor (Skill)
Learning Outcome	To develop simulation skills among the students taking pharmaceutical chemistry modules.
Blooms Taxonomy Level	Level 2: Manipulate
Delivery Mode	Face-to-Face (In person, Real Time)
Teaching Strategy	Facilitated Instructional Training
Learning Activity	▪ Computer-Assisted Learning Workshops
Learning Resources	▪ Simulation softwares ▪ Instructional Training Videos (ITV)
Learning Assessment	Summative: CAL Report Formative: Simulation-based Active Learning Exercise
Competency Achievement	Simulation/Computer-Aided Drug Design (CADD) Skills
Learners Group	Students of Bachelor of Pharmacy

Conceptual Learning Skills

Conceptual learning encourages future learning. It has been an emerging new approach that aims on understanding concepts more accurately instead of distributing and organising data. It is positioned on fundamental research questions 'how' and 'why'; a very much-needed shift in the traditional didactic educational system (Smith, 2021). In case conceptual learning is explored further to apply in the pharmaceutical sciences, learners get over theories and practices into understanding to create solution to the real-world problems. It has been built on a solid foundation that cultivates an insight among various concepts. Therefore, a learner must 'remember' limited information. For example, a learner who retains a conceptual knowledge of various phases associated with the drug design, discovery and development can understand his/her role clearly and readily fit into a research and development (R&D) unit. In addition, learners who only possess practical knowledge will experience difficulties to manage as they should remember numerous processes. Conceptual knowledge also empowers students to draw meaningful conclusions from whatever they have understood and use it to comprehend new scenarios. It improves students and teachers equally to create a profound knowledge of exactly how the theories inter-correlate with each other and build up a paradigm that will encourage them during their education and professional career. Conceptual learning is a catalyst for challenging students to think at more advanced levels. The proposed pharmacy educational strategy to bridge the conceptual learning skills need-gap is presented in Table 3.

Table 3. A model pharmacy educational strategy to foster students' conceptual learning skills at pharmacy school.

Pharmacy Educational Strategy (Web, 2019) & (Li, 2016)	
Competency Domain	Cognitive (Knowledge)
Learning Outcome	To develop conceptual learning skills among the students taking pharmaceutical science modules.
Blooms Taxonomy Level	Level 6: Create
Delivery Mode (Flexible)	▪ Face-to-Face (In person, Real Time) ▪ Online-Synchronous (Online, Real Time) ▪ Online – Asynchronous (Online) ▪ Hybrid (In person + Online, In person+ Real Time)
Teaching Strategy	▪ Facilitation
Learning Activity	▪ Problem-based learning (PBL) ▪ Case-based learning (CBL)
Learning Resources	▪ PBL triggers and facilitator guides ▪ Case scenarios and facilitator guides ▪ Open-Educational Resources for reference
Learning Assessment	Summative: PBL activities/CBL activities Formative: Informal group discussion
Competency Achievement	Conceptual learning Skills
Learners Group	Students of Bachelor of Pharmacy

Summary

In summary, the needs-gaps and set of remedial actions highlighted in this paper for proposing a curriculum redesign diverged primarily from rapidly changing professional needs because of technological advancements in this digital era. However, the use of technology/e-learning in pharmacy education has been started for a decade and existed in practise before the COVID-19 pandemic. However, the process of digital transformation has been accelerated due to sudden changes in teaching, learning, and assessment methods (Mirzaian, 2021). As a result, global higher education institutions have taken initiatives to analyse the situation, design an institutional framework for the implementation of online learning, develop effective learning resources, implement online learning through a hybrid classroom approach, and evaluate new pedagogical strategies and frameworks, respectively. Consequently, innovative teaching and learning methods and tools have been originating and coming into existence. From our perspective, this is one of the major positive outcomes that have happened to the education sector since COVID-19. To achieve high quality standards, the redesigned curriculum standards were benchmarked against global leaders who develop sustainable educational standards, such as the International Pharmaceutical Federation (FIP), the United Nations Educational, Scientific, and Cultural Organization (UNESCO), and the Organisation for Economic Co-operation and Development (OECD). These organizations also recognise the significance of conceptual learning and simulation skills as future skill attributes, which include simulation-based learning and conceptual learning models as adaptable strategies to prepare students with graduate competencies. This report mainly focuses on the internal gaps associated with the pharmacy curriculum. The impact of COVID-19 on curriculum gaps and SWOT analysis among various institutions offering pharmacy programmes is not discussed as part of this paper.

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