From Complex Understanding to Complex Learning- Adopting 4C/ID Model for Teaching And Learning Of Pharmacology Threshold Concepts

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Introduction

Pharmacology education presents several challenges that adversely affect the successful integration of discipline-centered knowledge, skill, and attitude into competency when performing complex tasks such as prescribing. Therefore, instruction should encourage students to build a diverse knowledge network, enabling them to draw upon various types of knowledge when encountering unfamiliar challenges, while educators should aim designing activities that facilitate the assimilation, coordination, and transfer of knowledge to new settings (Complex learning). To tackle this problem, we designed a blueprint to assist students in grasping complex concepts by integrating their knowledge, skills, and attitudes including pivotal threshold concepts of pharmacology that shape leaners' ways of thinking and practising.

Methods

We employed the four-components instructional design (4C/ID) paradigm, which integrates knowledge, skill, and attitude into a holistic, task-centric framework. In preparation for the module, we commenced with a meticulously crafted web of concepts (Figure 1) and a well-organized hierarchy of prescription writing (Figure 2). The web of concepts (inclusive of identified threshold concepts of pharmacology as represented by the tunnel metaphor in Figure 1) is revolved around the procedural threshold or constituents' skill of decision-making underlying prescription writing. Furthermore, the skill hierarchy, outlining both routine and non-routine sub-skills crucial for prescription writing, directed the formulation and integration of performance objectives with relevant concepts underlying those skills. Having established the performance objectives, we crafted the "Antimicrobial Module" to facilitate students' understanding of the identified threshold concepts through a holistic task-based approach guided by the 4C/ID principles.

Results

Our blueprint for the exemplar pharmacology "Antimicrobial Module" incorporates four components as specified by the model: a) Real-life based tasks with varying degrees of complexity from pre-clinical to clinical years, b) Supportive information at the task level, including general information, modelling examples, and case studies, c) Provision of procedural information, and d) Part-task practices to help develop high-level automaticity of recurrent skills. Table 1 shows an overview of an educational framework for the Antimicrobial module, with task activities based on the 4C/ID model and centered around pharmacology threshold concepts.

Discussion

A comprehensive approach to teaching threshold concepts offers a paradigm shift for overcoming procedural threshold in pharmacotherapy. The learners are challenged with whole-task activities and are assisted in transferring their learning to real-world situations through mental models, procedural knowledge, and repetitive practice. We aim to adopt a blended learning approach for this module, using proven strategies in other domains. This module provides a promising solution to current thresholds that may impact learners' ways of thinking and practicing in pharmacology.

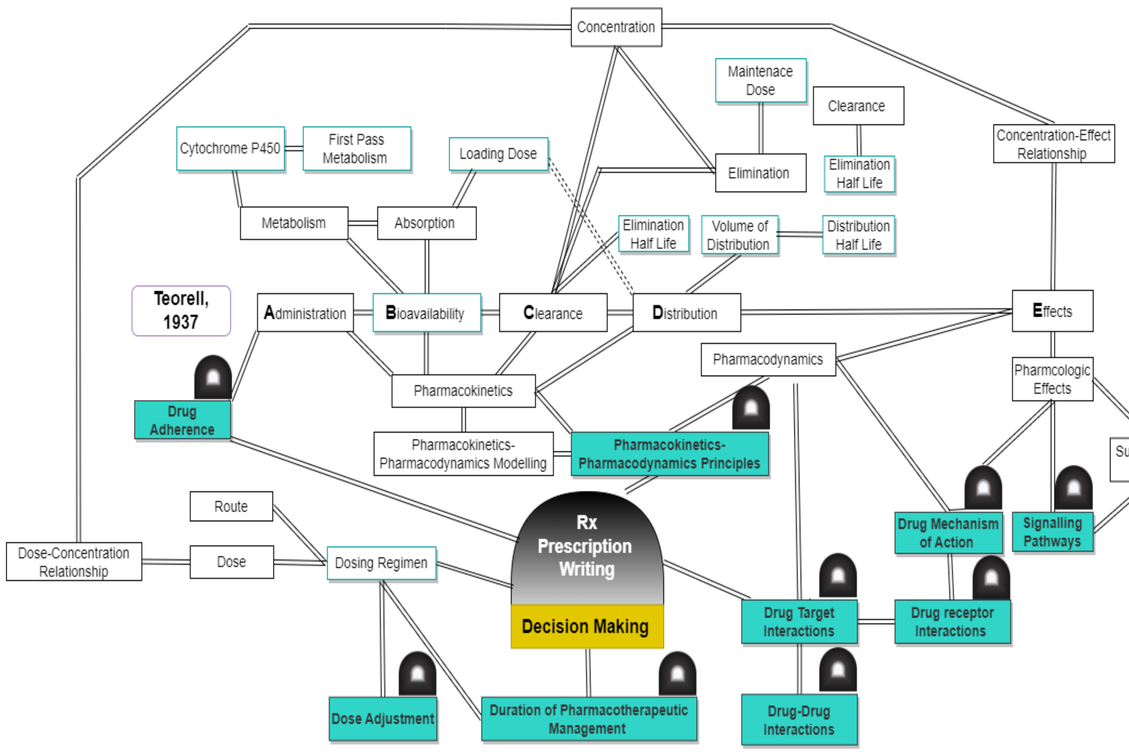

Figure 1. Web of concept revolved around the constituent skill (decision-making) of prescription writing. The concepts in green boxes are the threshold concepts identified via consensus generation in our nominal group research

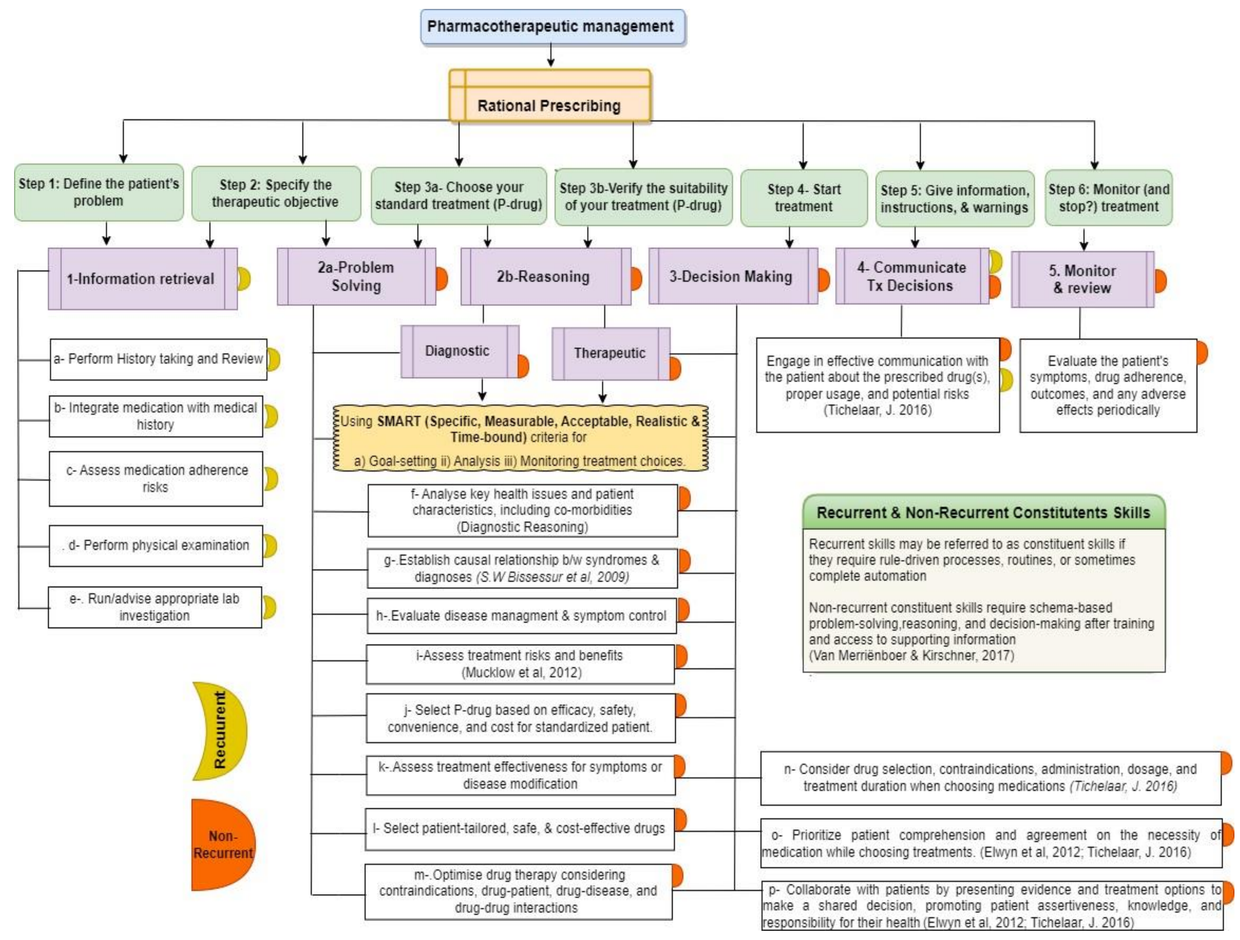

Figure 2. Skill hierarchy of complex process of prescription writing

4C/ID	Pre-Clinical Years			Clinical Clerkship
	Task Session 1	Task Session 2	Task Session 3	Task Session 4
Learning Tasks	*Across the whole-task content, students are:* (a) Presented with a written case study illustrating the relevance of antibiotic nomenclature & mechanisms of action in pharmacotherapy. (b) Presented with adverse drug reports as a case series and asked for their reflections on antibiotic related complications. (c) Provided with a culture and sensitivity report on a patient's sputum with specific bacterial infection, which must be analysed and rationalized for therapeutic intervention.	*Across the whole-task content, students are:* (a) Required to develop a treatment regimen for specific untreatable bacterial infections among a specific group of patients and seek approval from their teacher. (b) presented with a recurrent bacterial infection, are asked to reconsider the therapeutic regimen in light of missing information about screening results and decisive factors. (c) Asked to develop an antibiotic management plan to improve the outcomes of patients with severe bacterial infections	*Across the whole-task content, students are:* (a) Encouraged to determine the Pk parameters for an antimicrobial regimen that the physician may have taken in optimizing the treatment. (b) Required to design a tailored antibiotic regimen for a life-threatening infection according to pharmacokinetic factors that could affect pharmacotherapeutic management.	*Across the whole-task content, students are:* (a) Identify a patient case from their own clinical experience or adopt one from a preceptor for which an antimicrobial regimen should be planned and expert approval is sought. (b) revise the antimicrobial dosing regimen based on a patient's current complaints and medical history, since the prescription chart did not provide information about the dosing regimen.
Supportive Information	*Prior to the task, students* Watch videos of physicians (a) Performing the following tasks: interpreting bacterial culture and sensitivity reports (b) Prescribing antimicrobial combination therapy (c) Discussing adverse drug reactions with interns.	*Prior to the task, students* Hear physician illustrate SAP using think-aloud about choosing/using targeted antimicrobial therapy considering patient factors	*Prior to the task, students* Review an article on the use of pharmacokinetic and pharmacodynamic data to optimize antimicrobial therapy Provided roving teachers with real-time feedback while working on the assigned tasks	*Prior to the task, students* Watched a Modelling example showing an (a) Expert prescriber's think-aloud approach to rationalized prescription writing (b) Clinician discussing drug prescription chart of a patient with a duty nurse.
Procedural Information	*During the task, students are:* Provided with step-by-step instructions from sample preparation to data analysis.	*During the task, students are:* Acquainted with different biomolecular steps critical for the action and resistance mechanisms of antibiotics.	*During the task, students are:* Shown steps for customized PK/PD-guided antibiotic dosing.	*During the task, students are:* Provided with guidelines pertaining to the WHO's six-step rational prescribing process
Part-Task Information	*During the task, learners are:* Competed to determine the therapeutic drug monitoring (TDM) of frequently monitored antibiotics to optimize clinical outcomes in patients with a variety of infections.	*During the task, learners are:* N/A	*During the task, learners are:* Given data on four infectious disease cases, and they are asked to calculate the dosage and therapeutic index of antibiotics applied to the cases.	*During the task, learners are:* Engagement in part-task practice is not permitted if they have fully acquired the recurrent knowledge of prescription writing.

Table 1. Snapshot of the whole task activities based on 4C/ID model for antimicrobial module centered around threshold concepts of pharmacology

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