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Review

Prescription writing through the lens of the threshold concept framework: a narrative review

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Abstract

Background: Although challenging, writing prescriptions is an essential practical competency of medical graduates. This process is transformative as it reflects medical students' ways of thinking and practising. A conceptual framework, similar to "way of thinking and practising", known as 'threshold concepts' can help students to establish meaningful connections between the transformative and conceptually difficult ideas underlying prescription writing. This enables them to think, practice and demonstrate the competence required for rational drug prescription conducive to effective pharmacotherapeutic care.

Methods: A narrative review was conducted on a subset of articles retrieved during the course of an another literature review using four bibliographic databases from 15th August to 15th September 2019. The literature review is focussed on instructional interventions and their impact on university-level students learning pharmacology. Seminal papers on threshold concepts were also included to draw a comparison between prescription writing and key attributes of the threshold concepts framework.

Results: An alignment supported by examples was observed between different aspects and challenges of prescription writing and key attributes of the threshold concept framework.

Conclusion: Using the threshold concepts framework as a lens in prescription writing offers an insight to the curriculum designers employing it as a pedagogical utility in transforming medical students' way of thinking and practising for rational prescribing. Moreover, it also informs the likelihood of unidentified threshold concepts for beginners within the course of prescription writing.

Introduction

Prescription writing is an essential skill of medical graduates. It is the cumulative progress to mastery that prepares medical students to apply their basic sciences concepts of pharmacology and therapeutics in a health context. This process is transformative as it reflects students' "ways of thinking and practising" and helps foster their role as a physician with genuine command and authentic mastery for rational and safe prescribing of drugs. The transformation begins when students start to think of drugs in terms of drug selectivity, dosage regimen, and severity of the clinical problem. The potential exists for successive and more profound transformation when students begin to take patient care and safety into account while choosing drugs.

However, prescribing is also a troublesome aspect of pharmacology and therapeutic medicine, considering the ever-increasing trend and alarming rate of global medication error, which are principally attributed to:

1. Limited regulatory and basic knowledge of prescribing among physicians[1]
2. Weak correlation between factual knowledge of pharmacology (mechanism of action and side effects) and effectiveness of the treatment plan for common clinical scenarios[2]
3. Consistently inadequate level of self-assessment of application-oriented knowledge during a student's medical education.[3]

The above-mentioned aspects highlight key epistemological transitions which can become obstacles

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for students if not learned properly. Such epistemological transitions not only encompass what learners know but how they know.[4] For instance, if students learning pharmacology cannot adequately translate their knowledge of drugs into an effective pharmacotherapeutic plan in a clinical context, this epistemological transition will remain a persistent difficulty for them in clinical practice. This keeps the student caught in a place of liminality where their attempts to understand, misunderstanding, or limited understanding are comparable to mimicry.[5] Mimicry, as an individual device or coping strategy, offers a refuge for students to conceal limited knowledge or poor understanding. The majority of prescribing errors due to inappropriate selection of therapies for common diseases[6,7] is in large part attributed to pre-clerkship and final-year medical students and their lack of knowledge about drug interactions and contraindications.

Furthermore, these epistemological roadblocks can hamper the process of ontological transformation, which is characterized by a change in the learner's perspective, personal identity, and, ultimately, a reconstruction of subjectivity. For example, uncertainty is recognized as an inevitable factor for inappropriate antibiotic prescribing. A variation has been observed in the tolerance for uncertainty and concern for bad outcomes among physicians in primary care.[8] The mastering of tolerance of uncertainty clearly holds an ontological dimension and can bring about a shift in the learner's subjectivity.[9]

This review attempts to fill the gap in literature relating to students' way of thinking and practising prescription writing. It throws light on the troublesome knowledge and various other determinants of prescription writing that can influence epistemological transitions and ontological transformations of a novice learner. Providing a rational model to understanding therapeutic regimens can optimize the overall intended therapeutic outcomes.[10] This review proposes that identification of and bridging the 'troublesome knowledge' inherent in the challenging task of prescribing can aid learners' transformation, thus improving both their thinking and practising for appropriate pharmacotherapeutic management.

Materials and Methods

The articles for this review were retrieved during the course of an another literature review that focused on instructional interventions and their impact on university-level students learning pharmacology. The bibliographic databases used for the literature review included Medline (OVID), EBSCO-hosted ERIC, SCOPUS, and Embase (OVID) from 15th August to 15th September 2019.

The combination of key search terms and phrases used for this review employed the following Boolean phrasing: "medical students" OR "college-level students" OR "university-level students" AND "teaching strategy" OR "educational method" AND "pharmacology education" OR "therapeutic education" OR "drug knowledge" OR "drug prescribing" OR "prescription writing" AND "students competence" OR "students skills." The key search terms also included "troublesome knowledge" OR "threshold concepts."

Information collected from the literature review articles were summarized and collated for review. A subset of literature discussing the challenges associated with prescription writing emerged as one of the themes. Considering the troublesome nature of prescription writing as a process, a comparison was drawn between prescribing as a process and the threshold concepts framework. For this purpose, seminal papers on threshold concepts were also reviewed. These papers offered an elaborative narration on the theoretical framework and key attributes of threshold concepts. The best way to understand threshold concepts is through the perspective of eight key attributes that together explain what is crucial to effective knowledge acquisition.[11] Those key attributes are defined and examined. For this review, these key attributes have been revisited and discussed in context with the challenging task of prescription writing supported by examples.

Results

Threshold concepts

The conceptual framework of threshold concepts introduced by Meyer and Land emphasized that there are certain concepts in different academic disciplines that can bring about a radical change in a student's understanding of their subject.[4] Meyer and Land compared threshold concepts to a portal that can open a new and previously inaccessible way of thinking about something. Furthermore, the threshold concepts framework offers a transformed way of understanding what is essential to progress in a particular subject.

The conceptual framework of threshold concepts offers a foundation for identification of more difficult aspects of disciplinary learning, thus directing pedagogic efforts towards fostering high-quality learning.[12] The principal idea is that if threshold concepts are identified, the teacher can concentrate teaching efforts for those concepts. This helps to reduce overall coverage, facilitates students in reaching a more comprehensive understanding of their subject and grasp a 'way of thinking and practising' in it. The theoretical framework of threshold concepts endorsed the idea of the "less is more" approach to curriculum design.[13] In addition, it offers a new dimension for teachers, particularly with respect to barriers and enablers to effective learning. It has been recognised among educators as a heuristic tool which can provide insight into previously unexplored traits of learning.[14]

Key attributes of threshold concepts

Certain conceptually difficult concepts are discipline specific or *bounded*. These can be *troublesome* for learners, keeping them in a protracted state of *liminality*, defined

as a suspended frame of mind where comprehension oscillates between confusion and understanding. *Liminality* tends to be transformative in function, as it directs a learner to a medial state of *transformation* that not only changes the learner's internal view of the subject matter and subject landscape but also the learner's world view.[5] Transformation happens when the learner's pre-existing conceptual schema undergoes reconfiguration after *integration* with new knowledge in the liminal state. This helps the learner discard any prior conceptual stance as it contributes to a new configuration incorporating new information.[9]

The reconfiguration associated with integration not only breeds epistemological transition but also fosters ontological shift, known as the *reconstitutive* trait. The acquisition of new understanding helps the learner to cross a conceptual boundary and enter a post liminal state where both the learning and the learner are transformed.[9] This transformation is *irreversible*, as the new understanding gained is not likely to be forgotten until and unless unlearned by considerable effort.[15]

Furthermore, the transformation is *discursive*, demonstrated by a changed use of disciplinary discourse. Disciplinary discourse deals with the manner in which academic knowledge is socially constructed, aiming at the interpersonal features of language.[16] The concepts that not only transform thought or perception but also transfigure identity and help the learner adopt an extended discourse are known as *threshold concepts.*[17]

The comprehensive understanding of threshold concepts is reinforced by the eight key attributes (troublesome, integrative, reconstitutive, bounded, transformative, liminal, irreversible and discursive).

After enlisting the key characteristics of the threshold concepts framework, articles on prescription writing were analysed. A comparison was drawn between the process and challenges associated with prescription writing with key attributes of threshold concept supported by examples as discussed below

A. Troublesome

Most advanced-level knowledge of pharmacology and therapeutics seems conceptually difficult for novice learners. They often approach learning as a 'ritual response': learn the definition linked questions and quantitative problems of the discipline. Academic ideas and knowledge become troublesome if withheld as an isolated object or "inert piece of knowledge" in the learner's mind.[18] However, when their interpretations later resurface in context outside the classroom, students, whether novice or expert, usually find it difficult to integrate these 'chunks' of inert knowledge proactively in diverse clinical scenarios. In fact, what has not been observed is a specific pattern of thinking or disciplinary practice known as 'opportunistic deployment,' which helps a learner proactively notice and follow through circumstances/situations that can be easily missed.[19]

The troublesome aspects of prescription writing are shown in Figure 1. Prescription writing can be troublesome for medical students and newly-qualified doctors because they feel unprepared to undertake this high-risk task. This can reflect knowledge deficiency in the area of clinical pharmacology and therapeutics.[20,21] A recent study demonstrated poor prescribing competencies among final-year medical students in Europe that culminated in a number of potentially detrimental prescribing errors.[22] In view of this, research by Kennedy et al, noted that doctors are responsible for making prescribing errors, with the highest rates in the UK amongst junior doctors.[23]

Taking all these shortcomings of prescription writing among medical students into account, prescription writing can be visualised as a threshold concept, or

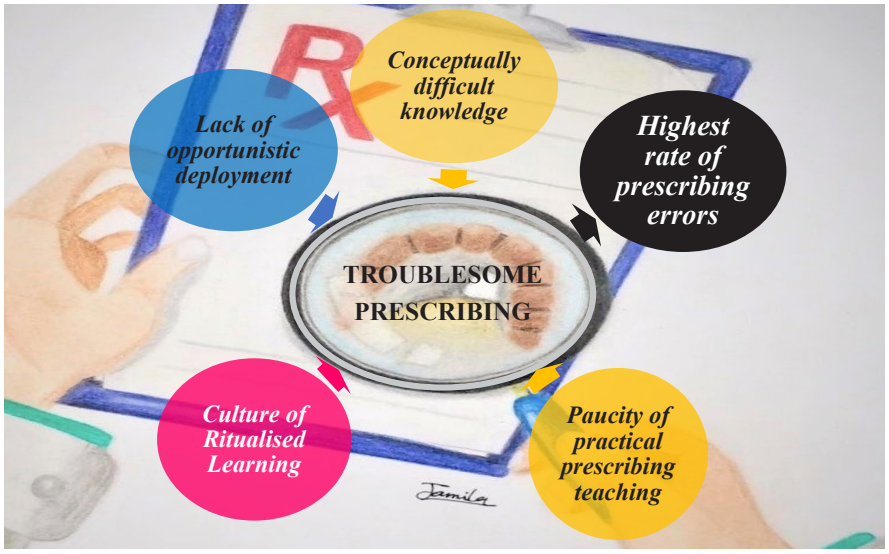

Figure 1. The troublesome aspects of prescription writing.

perhaps a set of several threshold concepts, that affects the transition of learners across a conceptual threshold for a considerable time. Brinkman et al suggested recognition of the practical need of harmonizing and modernizing practical prescribing teaching, learning, and assessment of the rational use of drugs earlier in the medical school course (at the undergraduate level).[22]

B. Integrative and reconstitutive

The integrative trait of threshold concepts illuminates a previously obscure association between fundamental knowledge, concepts and ideas for a more multifaceted understanding. According to Perkins, knowledge remains inert if it is not integrated.[18] Students learn concepts in science but hardly make the connection to the world around them. The threshold concept framework emphasizes that integration of concepts and knowledge supports the learner to conform different aspects of learning and deal with several aspects of knowledge, rather than being simply about the pieces of knowledge themselves.[24] Understanding a threshold concept is often expressed as an 'a-ha' moment which more closely represents integration rather than acquisition of new knowledge.[25]

The difficulty in the integration of knowledge gathered at medical school with prescribing decisions of doctors in a clinical context can lead to prescribing mistakes. These prescribing mistakes are categorised as knowledge-based mistakes (KBMs) or rule-based mistakes (RBMs). KBMs emerge due to poor knowledge of a practical component of prescribing such as 'dosing,' whereas inappropriate application of knowledge can lead to rule-based mistakes.[26]

In addition, prescribing mistakes can arise when knowledge has not been utilized and integrated properly towards effective prescription writing. For instance, polypharmacy progressively becomes the norm for patients with advancing age and multiple comorbidities. Furthermore, advancement in disease management and rapidly expanding drug innovation requires self-learning techniques to incorporate and update new treatment practices with underlying pharmacological principles.[27] Physicians also need to be cognizant of potential interactions between drugs in patients with multiple comorbidities.[28]

The integration of new knowledge during the liminal phase helps to reconfigure learners' prior conceptual schema, letting them discard earlier conceptual stances in preparation for new knowledge. This leads to an ontological and epistemic shift. The integration of knowledge and reconfiguration of the cognitive schema when coupled with the ontological/epistemic shift is known as the reconstitutive attribute of the threshold concept.[9]

A qualitative study by Lewis et al identified prescribing errors made by foundation year 1 doctors, who completed their undergraduate study but who did not have a full license to practice. They conducted face-to-face, in-depth interviews using the critical incident technique with 30 newly-qualified doctors from a variety of medical schools and hospitals. The study found that RBMs in prescribing occurred as a result of automatic and routine tasks that not only undermined the decision-making process but also made self-detection of error difficult.[26]

It was also found that the automatic nature of the task influenced prescription choice by overlooking or overriding patient medication history and individual factors. For instance, one of the interviewees reported prescribing statin and macrolide to a patient since everyone else was doing so. However, prescriber self-reflection helped them realize that co-administration of statins and macrolides is associated with an increase in the risk of myopathy and rhabdomyolysis. The integration of knowledge previously overlooked, and reconfiguration of the learner's prior understanding, made the prescriber self-correct the prescribing errors that had not been identified by anyone else.[26]

The European Association for Clinical Pharmacology and Therapeutics (EACPT) proposed that, as prescribing brings together or integrates most of the pharmacology knowledge and skills, graduates should be trained more thoroughly with increased attention to prescription writing, scrutinizing medication charts and taking responsibility for patient care.[22] The lens of the threshold concept framework offers an insight into the integrative and reconstitutive traits of troublesome knowledge in transition across conceptual thresholds. Contemplating these aspects of knowledge and practice can help to make an error-prone task such as prescription writing more rational, safer and more patient-centred.

C. Bounded

Threshold concepts are discipline distinct. Meyer and Land's elaboration of threshold concept as 'bounded' emphasizes the demarcation that exists between disciplinary areas. Hence, this offers a useful lens through which examine the issue of context and its relationship to the developmental aspects of threshold concepts. Thinking about the boundedness can help frame ideas of the discipline: how the discipline is similar to or different from other connected fields.[4] Since the task of prescription writing is multidisciplinary, including evaluating and analysing patient information and sorting rational therapeutic solutions that underlie intra- and transdisciplinary integration of knowledge and concepts, the respective knowledge and concepts used in making therapeutic decisions can be distinctly related and identified from the specific disciplines.

D. Transformation and liminality

Threshold concepts, once understood, bring about a substantial shift in the perception of a subject, leading to transformation of personal identity, a reconstructive step to subjectivity. This transformation may be sudden

or can be protracted over a considerable period. While transformation is likely to influence the affective component - a shift in values, feelings or attitudes - it may also include a performative element.[4] It has been observed in educational settings that learners usually struggle to achieve the new (transformed) status; as a result, they take solace in a phrase coined by Ellsworth, 'stuck places,' where their understanding is not more than a form of 'mimicry'.[29] Mimicry embodies a surface approach to understanding, troublesome understanding or limited understanding.[4]

Similarly, the development of competent prescribing skills and patient communication needs transformation not only in learner performance but also in values, feelings and attitudes. The transformation of a medical student into a prescriber begins with the formulation of the therapy for a patient in a prescription format[1]. However, the factual knowledge-driven curriculum of pharmacology restrains the process of transformation in novice learners (junior doctors), since students struggle for most of their time in dealing with information that they find short-lived and difficult to recall and recite.[30] Evidence from clinical practice signifies inadequate pharmacology knowledge as an escalating concern in the integrity of pharmacology as foundational material crucial to safe and effective clinical practice.[31]

Hence transformation often takes a protracted course over a considerable length of time. This delay can place learners in a transitional state of *liminality*, where their thought process oscillates between old and emergent understandings.[13] The extended course of a learner in the phase of liminality may confine his or her understanding as less than genuine and unauthentic. This ritualised form of learning or mimicry can aid academic progress or learning but does not transform them into genuine expert learners, leading to anxiety and loss of confidence. Studies have highlighted the gravity of the situation where the highest prescribing error rates are seen among junior doctors as they are mainly in charge of the bulk of the prescribing in NHS hospitals.[23]

The challenges associated with teaching and learning of pharmacology undermine the transformation of discipline-centred knowledge into discipline-based skills such as prescription writing or patient communication. Educational settings that foster ritualised learning as mimicry transform neither the learners' perspectives nor their performance. Moreover, students spend most of their time in liminality where their thought process swings back and forth trying to find a solution.[9]

The challenges of teaching prescribing skills include the provision of sufficient education of pharmacology for all prescribers early, during their undergraduate training. This expertise needs to be retained after graduation, in addition to the synthesised knowledge of disease and the ability to correctly monitor therapy. This can help minimise the incidence of medication errors, and allow sufficiently flexible prescribing practices while tailoring therapy in accordance with the needs of a particular patient.[32]

Prescription writing may possibly have linked to a few threshold concepts that are transformative in nature; the transformation can be established through the integration of experiential clinically oriented and conceptual theoretical learning. For instance, a similar attempt was made to foster students' acquisition of prescribing skills in a medical school in Gothenburg, Sweden by modification of a clinical pharmacology curriculum integrated into the internal medicine course. The precise focus of the course included a review of the practice of medication with a list of common drugs for self-completion and "how-to" instructions and discharge summaries via web-based education. The study established that the students' level of professional confidence improved in the basics within the art of prescription writing; it enabled them to carry out medication reviews and to write medication discharge summaries.[33] The integration of student experiential and conceptual learning transformed their level of confidence and reinforced their prescribing skills.

Addressing such challenges can bring about the notion of transformation as supported by the threshold concept framework. Crossing these thresholds will direct a prescriber towards a transformed way of inspection, comprehension, and interpretation required for a balanced prescription. The shift in the values, attitudes, and performance will likely improve the efficacy of prescription writing by optimizing the rational assessment of benefit and harm balance associated with pharmacotherapeutic management, thus overcoming uncertainty associated with therapeutic decisions.

E. Irreversible and discursive

The irreversible trait of threshold concepts emphasizes that a difficult concept, once troublesome to understand, may now become apparent and enduring.[34] The change of perspective that a student experiences is unlikely to be forgotten or unlearned except through considerable effort. Furthermore, as the integration includes a spectrum of prior understanding, it is most likely to be irreversible, as it holds together a learner's understanding about various phenomena.[35]

Similarly, prescribing by health professionals requires a combination of knowledge and skills, a comprehensive plan, and dosage adjustments. This facilitates the best pharmacotherapeutic management while minimizing the risk of drug-drug interactions (DDIs) and adverse drug reactions (ADRs).[36] Though students experience difficulty understanding pharmacological principles governing interactions between drugs and their target, a clear understanding of and knowledge about the most frequent potential DDI allows healthcare professionals to optimize pharmacotherapeutic management and minimise the risk of DDIs.[37,38]

Additionally, such a shift in the perspective is generally

accompanied by an extension of the learner's use of language. The elaboration of this discourse results in the advancement of new thinking that can be further expressed, reflected upon, and communicated.[4] For instance, one of the reasons for prescribing error is the lack of an individual's reflection. The critical thinking may foster transformation when experiences are linked with reflection. For instance, when reflection includes the opportunity for discussion with colleagues and clinical supervision, it essentially safeguards appropriate prescribing and minimizes the risk of antibiotic resistance.[39] The failure of health professionals to reflect on their professional practices can culminate as medical or prescribing errors. Reflection enables a learner to think critically while applying their knowledge and to reassess their clinical decision-making aptitude with a perspective of becoming better health professionals.

Within the confines of the threshold concept framework, prescribing offers an enriching platform for learner discourse that helps them to express, reflect and communicate their way of thinking and practising. Furthermore, a change of viewpoint occasioned by the integration of new knowledge and reconstitution of the cognitive schema while dealing with the troublesome aspect of prescribing is 'irreversible' since it is unlikely to be forgotten. Development of this expertise/mastery can in many ways help minimize the risk and hazard of prescription errors.

Above all, medical students have to learn to communicate, act, and think like a doctor. They need to acquire the social practices and discourses of prescribing practitioners.[40] These social practices are comprised of open communication, responsiveness and respect, and recognition of the patient's right to participate in decisions. The discourse around threshold concepts stimulates reflection on disciplinary knowledge and inspires learners' investigations into typical blocks and ways to help.[9] The alignment observed between key attributes of threshold concepts and prescription writing is shown in Table 1.

Discussion

Prescription writing as a competency transforms a medical student into a prescribing physician through the synthesis of both required knowledge and regulatory elements.[1] The transformation depends on how a medical student integrates the basic principles/knowledge of the discipline and individual characteristic of the drugs for the benefit of the patients considering the regulatory guidelines associated with a balanced prescription. Mindfulness in all aspects of prescribing can enhance the prospect of benefits, minimize the risk of adverse reactions, and improve patient adherence to therapy.[32]

However, articulation of prescribing is not adequate as most medical students have noticed that their undergraduate coursework does not sufficiently prepare them for practical prescribing.[23] To that end, there is a need to improve pharmacology education in medical school curriculum as inadequate knowledge regarding commonly used drugs or the confidence for clinical application of this knowledge can make it difficult for future cohorts of doctors to offer safe and effective pharmacotherapeutic care.[41] In addition, safe and effective prescribing is challenging in patients with multiple long-term disorders and complex polypharmacy when various drugs are used concurrently in the same patient.[28]

This challenge is further amplified by rapidly expanding drug innovations, drugs with contemporary mechanisms of action, side effects, and drug-drug or disease-drug interactions.[28] Furthermore, the facts and information linked to pharmacological management and therapeutics are in constant evolution due to the emergence of new drugs and evidence of how to use them while taking patient safety into account.[42]

The comparison drawn between prescription writing and the threshold concepts framework through this review paper highlight the taxing nature of prescription writing as a process. The underlying knowledge component of prescription writing is likely troublesome for novice learners as most of discipline-specific, bounded, fundamental concepts remain as 'inert' or 'ritual' piece of knowledge in their mind. Furthermore, the lack of practical prescribing opportunities for junior doctors during the course of their medical education makes it difficult to proactively integrate essential components of the inert and ritual knowledge into diverse clinical scenarios.

The effective integration of disparate ideas in a more essential, coherent and meaningful manner enables the understanding of a threshold concept.[43] Failure to do so keeps the knowledge in a ritualised form or mimicry. Mimicry as a 'coping strategy' takes the learner into the suspended state of incomplete understanding known as liminality.[9] The limited and poor understanding of prescribers during the phase of liminality results in them being accountable for the majority of the prescribing errors. Therefore, a transformation is required not only in the prescriber's performance but also in values, feelings, and attitudes in order to enhance the process of prescription writing effectively.

The learners' struggles during the liminal phase help them to reconstruct an already existing cognitive schema and discard earlier misconceptions in order to accommodate a new understanding. This combination of integration and reconfiguration is known as the reconstitutive trait of the threshold concepts. It is accompanied by ontological and epistemological transformation. This transformation can help govern clinical judgement and therapeutic decision making of prescribers towards effective pharmacotherapeutic care, management and patient safety.

The transformation influences both the learning process and the learner. This transformation is irreversible and

Table 1. Key attributes of threshold concepts and alignment with prescription writing

Attributes	Conceptual definition	Alignment with Rx writing
Troublesome	Implicit knowledge or alien concept difficult for students to grasp	Requiring recollection and integration of essential but troublesome knowledge in a clinical context
Integrative	Displaying the previously obscure interrelated knowledge; understanding by clicking together disparate ideas	Pulling together the fundamental knowledge & concepts of related discipline to make critical clinical decisions
Reconstitutive	Reconfiguration of the prior cognitive schema; discarding potential misconceptions	Involves self-correction of prescribing error by integration of previously overlooked information to promote safe prescribing
Bounded	Discipline relevant	Based on the concepts from within the specified disciplines of pharmacology and therapeutics
Transformative	Transforming learner's knowledge and way of thinking and being	Mastery or expert driven integration, analysis and reconstruction of foundational and advanced level knowledge into rational therapeutic solutions
Liminality	Suspended state where the thought process and understanding drive back and forth	Prescribers are capable of making critical therapeutic decisions in complex clinical scenarios
Irreversible	Unlikely to be forgotten, permanent transformation of learner's perspective	Involves consolidation of knowledge when integrated, analysed and applied in real-time scenarios
Discursive	Characterized by extended use of natural, symbolic or artificial language; Demonstrate the discipline-specific way of reasoning	Stimulates prescriber's critical thinking while applying their knowledge and reassessing their clinical decision for safe prescribing

is characterized by a change in discourse. The changed discourse encompasses extended use of language by students to discuss, inquire, cross-examine, conform and understand their learning; it also prompts reflection on discipline-specific ways of thinking and ways to help.[9,44] The extended communication of health professionals across various disciplines in a team-based approach can help minimise the hazards associated with prescription errors. Furthermore, reflection can help to improve prescribing practice.

Prescription writing is reflective of a student's way of thinking and practising in the discipline of pharmacology. The way of thinking and writing a balanced prescription requires meticulous contemplation on diagnosis, specific needs of the patients dictated by the nature of the disease, associated co-morbidities, other therapies, and the patient's choices and abilities.[32] Adopting a pedagogical tool based on the threshold concepts framework can help revamp the multifaceted task of prescription writing for undergraduate medical students. This review offers an aerial view of challenges and troublesome knowledge associated with prescription writing. Building on the troublesome disciplinary knowledge of pharmacology and therapeutics underlying prescription writing, the threshold concept framework can help to redesign the curricula in order to endorse a more transformative ways of thinking and practising prescription writing at an earlier level of medical education.

Threshold concepts of prescription writing: food for thought

There remains the possibility of a few threshold concepts underlying the facets of prescription writing. Identifying these can help students transform their thinking and open a new way to understanding. Therefore, a balanced approach to prescribing not only entails a critical and proactive way of thinking and practising but also requires mastery of formerly-unidentified threshold concepts. Mastery of a threshold concept often permits a learner to develop connections across discrete aspects of knowledge that were previously hidden from view.[13] For instance, an integral component of prescription writing is formulation of dosage regimen. The purpose is to optimize the balance of benefit to harm ratio. The important principles of dosage regimen include[32]:

a) Understanding and correlating disease pathophysiology with the mechanism of action of the relevant drugs and
b) Though challenging, evaluating the benefits to harm balance of therapy.

In order to formulate an appropriate dosage regimen, a prescriber needs to refer to evidence regarding the appropriateness, effectiveness, and interaction of drugs. Furthermore, the regimen should be tailored according to the nature of the disease, individual characteristics of the patient, such as predispositions to ADRs and interactions as they confer different susceptibilities, and benefit and harm balance of pharmacotherapeutic management. In addition, drugs with a narrow therapeutic index are more prone to provoke adverse reactions when given in dosages that are within or slightly above the accepted therapeutic index.[32]

Prescribers often find it troublesome to assess the benefits to harm balance of a therapeutic dosage regimen in an individual case.[32] The dosage regimen as a key or core concept of pharmacology or therapeutic medicine functions as a building block for students to structure their knowledge of prescribing using intuition and common

sense. However, the very concept might take learners across a zone of troublesome knowledge or 'cognitive portal' where a counter-intuitive way of thinking offers a more sophisticated understanding of phenomena such as optimization of drug dosage regimen keeping the patient's condition and safety in mind. Unlocking such troublesome ideas helps the learner to transform knowledge into a transformed way of thinking and practising.[45]

Conclusion

This paper is an attempt to draw a comparison between the multifaceted task of prescription writing and the threshold concepts framework, with alignment of these concepts supported by examples. The threshold concepts framework has proven instrumental in identification of concepts that radically transform students' understanding and offers them avenues to use the counterintuitive way of thinking. Bringing elements of threshold concepts framework in revamping the prescribing process in medical education can ensure a more rational and safe approach to prescription writing. The comparison between different facets of prescribing and threshold concepts can offer the threshold concepts framework as a pedagogical utility in addressing challenges associated with teaching, learning, and assessment of prescription writing at the undergraduate medical educational level. Furthermore, it also offers food for thought to identify the potential threshold concepts inherent in the process of prescription writing.

Ethical approval

Not applicable.

Competing interests

The authors declare that there is no conflict of interest.

Authors' Contribution

FK conceived the idea and prepared the manuscript, SB offered subject specific insights and BN contributed in content organization. All authors reviewed the final manuscript.

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