Blending Active, Digital, and Simulation-Based Strategies to Teach Therapeutics in Undergraduate Medical Education: An Integrative Review

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Abstract

Modern therapeutics education increasingly relies on active and technology-enhanced methods to prepare undergraduates for safe, rational prescribing and complex treatment decisions. This narrative review synthesizes contemporary evidence on five trending instructional strategies in undergraduate medical therapeutics: problem-based learning, team-based learning, flipped classrooms, simulation-based and virtual patient learning, and structured rational-prescribing curricula such as those inspired by the WHO Guide to Good Prescribing. Recent reviews and pilot studies suggest that active formats, especially flipped and simulation-based designs, outperform traditional lectures in knowledge gains, clinical reasoning, and learner satisfaction, while virtual reality environments appear particularly promising for communication and decision making in therapeutic encounters. Integration of these methods with updated clinical pharmacology and prescribing curricula can close persistent gaps in prescribing competence. Based on current data, we propose a hybrid "Therapeutics Decision-Making Pathway" that sequences case-based, team-based, flipped, and simulation components around a longitudinal prescribing framework to achieve more reliable transfer of therapeutic knowledge to practice.

Keywords: therapeutics education, prescribing, flipped-classroom, simulation, virtual-patient, problem-based-learning, team-based-learning, pharmacology-curriculum

Introduction

Preparing undergraduate medical students to deliver safe, effective therapy remains a central yet challenging goal, as suboptimal prescribing continues to contribute to preventable morbidity and health system costs worldwide. Traditional lecture-based pharmacology often emphasizes drug facts rather than the complex, context-sensitive reasoning needed for rational therapeutic decision making at the bedside. Multiple curriculum evaluations and competency frameworks now emphasize that undergraduate programs must explicitly develop prescribing skills, risk–benefit appraisal, and interprofessional communication across the continuum from preclinical learning to clinical clerkships.[2][4][6][7]

In response, educators have introduced a range of active and technology-enhanced approaches, including problem-based learning (PBL), team-based learning (TBL), case-based learning, flipped classrooms, and simulation-based or virtual patient

learning. Systematic reviews indicate that flipped classrooms and simulation-rich designs can yield superior knowledge acquisition and learner satisfaction compared with traditional didactic formats, particularly when embedded in well-structured, outcome-aligned curricula. At the same time, the WHO Guide to Good Prescribing and updated national pharmacology curricula provide detailed frameworks for rational prescribing instruction, yet their optimal integration with novel methods remains underexplored.[8][9][10][3][11][4][5][6][12][7][1][2]

Against this backdrop, the present article focuses specifically on education in therapy, understood as the design, personalization, and communication of pharmacological and non-pharmacological treatment plans for common clinical problems. We aim to synthesize current evidence on trending methods used to teach therapeutics to undergraduate medical students, compare their strengths and limitations, and propose a pragmatic integrated model for curriculum design. By aligning contemporary pedagogies with robust prescribing frameworks, we seek to support educators in constructing therapeutics courses that move beyond drug memorization toward clinically relevant, patient-centered decision making.

Methods

This narrative review targeted recent literature on undergraduate medical education methods explicitly applied to therapeutics, pharmacotherapy, or prescribing. We focused on five categories of educational strategies that are prominently discussed in recent reviews or protocols: problem-based learning and related case-based formats, team-based learning, flipped classroom designs, simulation-based and virtual patient learning (including virtual reality), and structured prescribing curricula epitomized by the WHO Guide to Good Prescribing and updated national clinical pharmacology frameworks.[9][10][3][11][4][5][6][12][7][1][2]

We drew on recent systematic reviews, network meta-analysis protocols, curriculum descriptions, and pilot intervention studies published mainly from 2019 onwards. Key sources included reviews of flipped classrooms in medical education, comparative evaluations of active learning strategies, reports of integrated PBL–flipped–multidisciplinary teaching on acute coronary syndrome, virtual patient and virtual reality simulation studies, and updated national prescribing curricula. Given heterogeneity in populations, outcomes, and designs, we did not attempt quantitative synthesis but instead organized findings thematically around educational design, learning outcomes, and relevance to therapeutics instruction. The primary outcomes of interest were knowledge and skills in therapeutics, rational prescribing performance, clinical reasoning, and learner satisfaction.[10][3][11][13][5][12][7][1][8][2]

Results

Overview of trending methods in therapeutics education

Recent work characterizes six broad families of active strategies as central to modern medical education: case-based learning, PBL, TBL, flipped classrooms, simulation-based education, and composite “bridge-in–objective–preassessment–

participatory–postassessment–summary" models. In therapeutics contexts, PBL and case-based learning are often used to anchor decisions about drug choice, dosing, and monitoring within authentic clinical scenarios such as acute coronary syndromes or chronic disease management. TBL structures similar content into pre-class preparation followed by in-class readiness tests and team problem solving, with growing adoption in pharmacology and therapeutics blocks.[11][4][5][7][9][10]

Flipped classrooms are increasingly popular, relocating initial content acquisition to pre-class videos or readings and using classroom time for higher-order analysis of treatment options, guideline application, and prescribing exercises. Simulation-based education, including standardized patients, high-fidelity mannequins, and computer-based virtual patients, offers risk-free environments in which students can practice complex therapeutic decisions, order sets, and patient counseling. Finally, updated clinical pharmacology and prescribing curricula structure learning objectives across domains such as principles of pharmacology, therapeutic areas, and practical prescribing skills, offering a scaffold into which these active methods can be embedded.[3][4][13][5][6][12][7][1][8][10][2]

Comparative features of key teaching methods

The first table summarizes core characteristics of four widely used methods in undergraduate therapeutics education: PBL, TBL, flipped classrooms, and simulation/virtual patients. Descriptions and relative strengths are synthesized from recent systematic reviews, protocols, and exemplar interventions.[13][5][12][7][1][9][10][3][11]

Table 1.

Pedagogical characteristics of major teaching methods for undergraduate therapeutics

Method	Core structure in therapy teaching	Primary pedagogical focus	Typical strengths for therapeutics education	Main limitations in undergraduate settings
Problem-based learning (PBL)	Small groups work through therapeutic cases from presentation to management decisions, guided by facilitators [9][10][4][7]	Student-driven inquiry, integration of basic pharmacology with clinical reasoning	Fosters deep understanding of indication, mechanism, and alternatives; supports transfer from pathophysiology to rational treatment choices [9][10][4][7]	Resource-intensive; variable facilitator expertise; may lack explicit prescribing practice unless deliberately built in [9][10][4][7]
Team-based learning (TBL)	Pre-class preparation, individual and team readiness tests, followed by team application of	Accountability, peer teaching, structured application exercises	Efficient for large cohorts; promotes guideline use, comparative drug evaluation, and consensus building	Requires careful question design; may underemphasize individualized prescribing unless

	therapeutic problems [9][10][11][5]		on treatment plans [9][10][11][5]	assessment targets it [9][10][11][5]
Flipped classroom	Online or asynchronous content on pharmacology and guidelines precedes in-class case discussions, prescribing tasks, and feedback [1][8][10][5]	Shift of class time from content delivery to active problem solving	Meta-analyses show higher knowledge scores and satisfaction than traditional lectures; maximizes time for nuanced therapeutic decision making [1][8][10][5]	Demands robust pre-class engagement and faculty capacity to design interactive sessions [1][8][10][5]
Simulation / virtual patients	Standardized patients, mannequins, or digital/VR cases simulate consultations, acute events, and chronic care where students select and communicate therapy [10][3][13][5][12]	Experiential learning, deliberate practice in a safe environment	Enhances clinical reasoning, decision-making, and communication; VR simulations show gains in confidence for therapeutic communication in diverse settings [10][3][13][5][12]	High setup cost; limited exposure if curriculum time and equipment are constrained [10][3][13][5][12]

Evidence for learning outcomes in therapeutics

Several recent analyses demonstrate that innovative methods generally outperform traditional lectures in key learning outcomes relevant to therapeutics. A recent review and meta-analysis of flipped classrooms in medical education reported that this approach is associated with significantly better knowledge achievement and higher student satisfaction compared to traditional didactic teaching, particularly when active in-class problem solving is emphasized. A separate synthesis of innovative methods similarly found that simulation-based, flipped, and blended formats produce the largest performance gains in written and practical assessments, suggesting that frequent, structured engagement with realistic therapeutic problems enhances both conceptual mastery and skills.[5][1][8][10][11]

In cardiovascular therapeutics, an integrated model combining PBL, flipped classroom sessions, and multidisciplinary team (MDT) teaching on acute coronary syndrome yielded substantial improvements in students' clinical reasoning, decision-making, and satisfaction relative to a traditional teaching control. Within this model, PBL cases prompted students to analyze pathophysiology and pharmacological options, flipped pre-work freed classroom time for high-level discussions, and MDT discussions added perspectives from multiple specialties, thereby enriching understanding of complex therapeutic trade-offs. These findings support the idea that combining complementary

active strategies can create synergistic gains in therapeutic competence beyond any single method alone.[10]

Immersive simulation and virtual patients also show promise for enhancing therapeutic communication and decision making. A recent pilot study using a VR-based virtual patient platform with undergraduate students demonstrated improved confidence in clinical communication and decision-making skills after two blocks of structured VR sessions that integrated pre-briefing, role-play, virtual encounters, and debriefing. The authors argued that VR supports deliberate practice and provides linguistically and culturally tailored scenarios that are particularly useful when access to diverse real patients is limited. Broader work on virtual patients corroborates that computer-based clinical scenarios can foster data gathering and clinical reasoning, while simulation environments support safe trial-and-error learning in complex therapeutic situations.[12][3][13][5]

Structured prescribing curricula and rational therapeutics

While active methods specify how students learn, structured prescribing curricula define what they should be able to do. The WHO Guide to Good Prescribing offers a six-step model for rational prescribing that has been widely used in undergraduate courses and problem-based pharmacotherapy teaching, helping students move from problem identification to personalized treatment selection and monitoring. Evaluations of courses based on this guide indicate improved prescribing performance and increased student awareness of the principles of rational pharmacotherapy, highlighting its utility as a scaffold for therapeutics education.[4][6]

More recently, national societies have updated clinical pharmacology and prescribing curricula to align with contemporary practice and regulatory expectations. For example, the British Pharmacological Society's updated curriculum organizes learning outcomes into principles of clinical pharmacology, drugs, therapeutics, and prescribing skills, with a streamlined set of outcomes and a stable core drug list. The authors emphasize that such curricula support program-level design, mapping, and quality assurance, and aim to enhance safe, effective, and responsible prescribing among new graduates. Parallel analyses of pharmacology education stress that content must track evolving treatment guidelines for major chronic diseases, underlining the dynamic nature of therapeutics knowledge that curricula must capture.[7][2]

Comparative strengths for therapeutic competencies

The second table synthesizes how different methods support specific therapeutic competencies, including knowledge acquisition, clinical reasoning, communication, and prescribing practice. This comparison aggregates findings from reviews and exemplar studies, acknowledging that direct head-to-head data are limited and that effects depend on detailed implementation.[6][1][9][2][3][11][4][13][5][12][7][10]

Table 2.

Relative support of methods for key therapeutic competencies

Method / framework	Therapeutic knowledge (guidelines, drugs)	Clinical reasoning in therapy choices	Communication about therapy (risk–benefit, adherence)	Explicit prescribing skills (writing, safety checks)
Problem-based learning	Strong: repeated exposure to therapeutic cases consolidates core drug and guideline knowledge [9][10][4][7]	Strong: encourages hypothesis generation, comparison of alternatives, and justification of treatment plans [9][10][4][7]	Moderate: depends on inclusion of role-play or patient perspectives in cases [9][10]	Variable: often implicit unless cases include prescription writing and error analysis [9][4][6]
Team-based learning	Strong: pre-class readings and readiness tests drive acquisition of guideline-based knowledge [9][10][11][5]	Moderate–strong: team application tasks can target nuanced therapeutic choices [9][10][11][5]	Moderate: can be enhanced via structured discussion prompts about patient preferences [9][10]	Moderate: feasible to integrate prescribing questions but not inherent to the format [9][10][11]
Flipped classroom	Strong: meta-analyses show improved knowledge versus lectures when pre-class content is aligned to clear outcomes [1][8][10][5]	Strong: in-class time can focus on complex therapeutic reasoning and management algorithms [1][8][10][5]	Moderate–strong: interactive sessions can explicitly train counseling and shared decision making [1][8][10]	Moderate: prescribing tasks can be integrated into in-class exercises and assessments [1][8][10]
Simulation / virtual patients / VR	Moderate: focuses more on application than breadth of factual content [10][3][13][5][12]	Strong: immersive scenarios require prioritization, risk assessment, and dynamic treatment adjustment [10][3][13][5][12]	Strong: VR and standardized patients are particularly effective for clinical communication and counseling practice [3][13][5][12]	Moderate–strong: electronic prescribing and order entry can be practiced in simulated environments [10][5][12]
WHO Guide / structured prescribing curricula	Moderate: emphasizes core drugs and indications but not exhaustive content [2][4][6]	Strong: six-step prescribing model and updated curricula scaffold rational choice and monitoring [2][4][6]	Moderate: frameworks encourage explanation of choices but often need complementary communication training [4][6]	Strong: targets practical skills, including prescription writing, error reduction, and safety principles [2][4][6]

Toward an integrated therapeutics decision-making pathway

Drawing on these findings, a hybrid model that sequences several methods within a coherent prescribing framework appears most promising. For example, a "Therapeutics Decision-Making Pathway" for an undergraduate internal medicine block might begin with short flipped modules that introduce pharmacology and guideline fundamentals for a disease such as hypertension or heart failure, ensuring baseline knowledge before class. Subsequent small-group PBL or TBL sessions could then confront students with varied patient profiles that require adjusting therapy for comorbidities, contraindications, and socioeconomic factors, making explicit use of the WHO six-step prescribing model to guide decisions.[1][8][9][11][4][6][7][10]

Later in the block, students could participate in high-fidelity simulation or virtual patient encounters where they must explain their therapeutic plan to a patient, negotiate adherence, and respond to acute changes such as adverse reactions or decompensation, all within a supervised environment that supports immediate feedback. Prescribing competencies would be assessed through structured clinical examinations, written prescriptions or order sets, and reflective assignments that require students to justify their decisions using the rational prescribing steps. Such a pathway would harness the complementary strengths of each method—knowledge consolidation via flipped content, deep reasoning via PBL/TBL, communication via simulation, and safety via structured prescribing frameworks—to address the full range of therapeutic competencies needed by new graduates.[3][13][5][12][10]

Discussion

This review highlights that contemporary undergraduate therapeutics education is moving away from isolated lectures toward blended, active designs that integrate flipped classrooms, case-based learning, TBL, and simulation within a structured prescribing framework. Meta-analytic evidence suggests that flipped and simulation-rich methods produce greater knowledge gains and learner satisfaction than traditional approaches, implying that reallocating teaching time from content delivery to high-level therapeutic reasoning is beneficial. The success of integrated PBL–flipped–MDT interventions in domains such as acute coronary syndrome further indicates that combining problem-based inquiry with multidisciplinary perspectives can enhance clinical reasoning and confidence in managing complex therapeutic scenarios.[8][11][5][1][10]

Virtual patients and emerging VR platforms add another dimension by providing immersive, low-risk environments where students can rehearse therapeutic communication and decision making, particularly valuable in settings with limited patient diversity or constrained clinical placements. These tools appear especially powerful for developing non-technical but critical aspects of therapy, such as explaining risk–benefit trade-offs, addressing language barriers, and tailoring plans to patient values. However, their implementation is resource-intensive and requires faculty training, curricular integration, and reliable infrastructure, which may limit adoption in some contexts.[13][5][12][3]

Structured prescribing curricula, including the WHO Guide to Good Prescribing and updated national frameworks, provide the essential backbone for these innovative methods by clearly defining outcomes in pharmacology knowledge, therapeutics, and practical prescribing skills. Without such scaffolding, active methods risk becoming engaging but unfocused experiences. When aligned with competency-based assessments and national examinations, these curricula can help ensure that active learning translates into measurable improvements in prescribing safety and effectiveness. Future research should explore how to best map active methods onto specific outcome domains, and which sequences or combinations yield the most durable gains in therapeutic competence across diverse educational systems.[2][11][4][5][6][7]

For educators designing or reforming therapeutics courses, several implications emerge. First, investing in well-crafted pre-class materials and in-class application activities is likely to pay off in knowledge and reasoning gains, particularly when guided by established prescribing frameworks. Second, simulation and virtual patients should be used strategically to target complex skills such as communication, interprofessional coordination, and real-time decision making, rather than as generic add-ons. Third, assessments must be aligned not only with factual knowledge but also with rational prescribing processes, error recognition, and patient-centered counseling, to signal the importance of these competencies to students. Finally, implementation studies in different cultural and resource settings, including those in Asia, are needed to adapt and validate these approaches under varying constraints.[11][4][5][6][12][1][8][10][2][3][13]

Conclusion

Active, technology-enhanced methods such as flipped classrooms, PBL, TBL, and simulation—when anchored in robust prescribing frameworks—offer a powerful toolkit to transform undergraduate therapeutics education from drug-centered memorization into patient-centered decision making. The evidence synthesized here suggests that no single method is sufficient; instead, a thoughtfully sequenced hybrid "Therapeutics Decision-Making Pathway" can exploit their complementary strengths to build knowledge, reasoning, communication, and prescribing safety in an integrated fashion. As treatment guidelines evolve and therapeutic options expand, educators who combine structured curricula with engaging, practice-oriented learning environments will be best positioned to graduate doctors capable of safe, rational, and personalized therapy.

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