

Newer Pedagogical Methods for Teaching and Learning in Pharmaceutical Education

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ABSTRACT

Pharmaceutical education has undergone a paradigm shift from traditional didactic instruction to more interactive, learner-centered approaches. This review explores modern pedagogical methods and presents real-world case studies demonstrating their application in pharmacy education. Lecture-based learning was shown to enhance foundational knowledge delivery, while inquiry-based and project-based strategies improved problem-solving and research aptitude. For instance, kinesthetic learning in medicinal chemistry practicals led to better retention of synthetic pathways, and game-based tools increased engagement in heterocyclic chemistry. Peer-assisted teaching boosted comprehension of molecular docking concepts, as reported through positive student feedback. Technology-driven tools like Molsoft enabled students to apply theoretical principles in drug-likeness prediction exercises. These methods, supported by qualitative observations and student performance reflections, collectively indicate improved engagement, critical thinking, and real-world readiness. The findings emphasize that integrating active learning, interdisciplinary collaboration, and hands-on activities can significantly enhance pharmaceutical education outcomes.

Keywords: Pharmaceutical Education, Active Learning, Pedagogical Innovation, Case-Based Teaching, Problem-Solving Skills.

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INTRODUCTION

Pharmaceutical education forms the backbone of preparing competent professionals capable of contributing meaningfully to healthcare through drug formulation, distribution, and therapeutic application. This interdisciplinary discipline synthesizes principles from chemistry, biology, medicine, and technology to equip learners with the knowledge and skills necessary for real-world challenges.^{1,2} Historically, pharmaceutical education emphasized the discovery, design, and clinical use of drugs. However, evolving healthcare landscapes and technological innovations have prompted a shift toward a

more holistic and practice-oriented framework. Today, modern pharmaceutical education emphasizes not only drug mechanisms but also patient-centric care, interdisciplinary teamwork, and hands-on competencies developed through laboratory work, clinical exposure, and research involvement.²

Despite these advancements, existing literature offers limited comprehensive analysis of the specific pedagogical approaches used to bridge theory with practice. There remains a notable gap in documenting how active learning strategies-such as kinesthetic activities, inquiry-driven tasks, game-based learning, and peer-assisted models-are effectively implemented in pharmacy curricula, particularly within the Indian academic context. Moreover, a critical synthesis of their comparative advantages, challenges, and classroom outcomes remains underexplored.

To address this gap, our review critically examines innovative Teaching-Learning (T-L) strategies adopted in pharmaceutical education. It aims to (i) analyze the scope and structure of emerging pedagogical practices, (ii) highlight evidence-based



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case applications in real-world academic settings, and (iii) provide insights to educators seeking to integrate these approaches for enhanced student engagement, critical thinking, and practice-readiness.^{3,4}

METHODOLOGY

Search Strategy

To ensure a comprehensive and unbiased review of innovative pedagogical methods in pharmaceutical education, a systematic literature search was conducted. Databases such as PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, and ERIC were utilized. The search strategy incorporated both MeSH terms and free-text keywords including “pharmaceutical education”, “active learning”, “teaching-learning methods”, “problem-based learning”, “flipped classroom”, “peer-assisted learning”, and “technology-enabled learning”. Boolean operators like AND, OR, and NOT were used to combine terms effectively and narrow the search results.^{5,6}

Inclusion and Exclusion Criteria

The inclusion criteria were as follows: (i) studies published in peer-reviewed journals between 2005 and 2024, (ii) articles written in English, (iii) focus on pharmacy or health sciences education, and (iv) empirical studies evaluating or discussing innovative teaching-learning methods. The exclusion criteria included opinion pieces, editorials without data, conference abstracts without full papers, non-English publications, and studies unrelated to pharmaceutical or health science education.^{7,8}

Article Selection Process

An initial pool of around 310 articles was identified. After removing duplicates, titles and abstracts were screened for relevance, reducing the selection to 94 full-text articles. These were assessed for quality and methodological rigor. Finally, 45 articles that met all eligibility criteria were included for full review and synthesis. Additionally, reference mining of these articles helped in capturing relevant studies not indexed in the primary databases.^{9,10}

Data Extraction and Review

Data extraction focused on the type of pedagogical innovation, the educational setting, the target student population, the outcomes measured, and the key findings. Studies were categorized into major domains such as active learning strategies, simulation-based education, flipped classroom models, interprofessional collaboration, and digital tools integration in pharmaceutical curricula. This thematic classification enabled a focused synthesis of the evidence and revealed current trends and gaps in the pedagogical framework for pharmaceutical education.¹¹

Innovative Pedagogical Approaches in Pharmaceutical Education

Pharmaceutical education has evolved beyond traditional teaching methods to embrace a diverse range of innovative pedagogical approaches aimed at enhancing student engagement, critical thinking, and practical skills. These strategies are designed to cater to varied learning styles and prepare students for real-world challenges in healthcare and research environments. The following section outlines key teaching-learning methodologies—both conventional and contemporary used in pharmacy education, highlighting their unique strengths and practical applications.

Lecture-Based Teaching-Learning (LTL)

Lecture-based teaching has been a fundamental approach to education, characterized by a structured delivery of information from teachers to students. While sometimes criticized for its passive nature, this method continues to play a crucial role, especially when integrated with contemporary techniques like multimedia tools and interactive discussions.¹²

Group Teaching and Learning (GTL)

GTL focuses on fostering collaboration and teamwork, enabling students to exchange ideas, work together to address challenges, and benefit from varied viewpoints. This approach often includes activities such as small group discussions, collaborative projects, and cooperative learning tasks.¹³

Individual Learning (IL)/Self-Study Learning (SSL)

IL/SSL Encouraging students to take ownership of their learning process, this approach is especially beneficial in pharmaceutical education for cultivating lifelong learning abilities. Self-directed study can be effectively supported through online resources, self-evaluation tools, and carefully selected reading materials.¹⁴

Inquiry-Based Learning (IBL)

IBL centers on fostering curiosity and motivating students to delve into concepts through inquiry and exploration. This approach is particularly suited for research-focused pharmaceutical education and can be applied using case studies, research assignments, and simulation exercises.¹⁵

Kinesthetic Learning (KL)

This approach holds significant importance in pharmaceutical education, where hands-on experience and practical skills are essential. Students actively participate by conducting experiments or working with specialized equipment. Examples include lab work, compounding practices, and clinical simulation activities.¹⁶

Game-Based Learning (GBL)

GBL is gaining attraction in pharmaceutical education as an effective way to make learning both engaging and enjoyable.

Examples of this approach include pharmacy-focused games, virtual simulations, and interactive quizzes with a competitive element.¹⁷

Expeditionary Learning (EL)

EL focuses on hands-on education through real-world projects and active community engagement. In pharmaceutical education, this method may include activities such as fieldwork, hospital rotations, and industry internships. Incorporating industry-relevant case studies and community outreach initiatives further enhances the learning process.¹⁸

Technology-Based Learning (TBL)

Advancements in technology have transformed pharmaceutical education, introducing innovative approaches such as virtual laboratories, digital learning platforms, and augmented reality tools. Examples include interactive software for drug formulation, virtual anatomy labs, and online forums for collaborative discussions.¹⁹

Peer Assisted Teaching-Learning (PATL)

This method involves students teaching their fellow peers with guidance from faculty. It strengthens the teacher's understanding of the material and allows learners to comprehend concepts from a more relatable viewpoint.²⁰

Project based Learning (PBL)

This approach focuses on addressing real-world challenges to develop analytical and practical skills. It is especially beneficial for preparing pharmacy students for clinical decision-making. Examples of PBL include case studies, role-playing activities, and interdisciplinary problem-solving workshops.²¹

Comparative Analysis of Traditional and Innovative Teaching-Learning Strategies

The evolution of Teaching-Learning (T-L) strategies in pharmaceutical education has highlighted a shift from conventional teacher-centered methods to more dynamic, student-focused approaches. These newer pedagogical models aim to foster critical thinking, collaboration, and adaptability, yet each method carries its own set of strengths and limitations. Table 1 provides a comparative overview of traditional and innovative T-L methods based on key educational parameters such as student engagement, assessment strategies, technological integration, and adaptability to learner needs.

Case Studies on the Implementation of Innovative Pedagogical Strategies in Pharmaceutical Education

To demonstrate the practical application and effectiveness of diverse teaching-learning methodologies in pharmaceutical education, a series of case studies were conducted. These cases showcase the integration of contemporary pedagogical models

such as lecture-based learning, group work, self-directed study, inquiry-based learning, kinesthetic approaches, gamification, technology-enabled instruction, peer-assisted teaching, and project-based learning. Each case details the methodology used, sample size, duration, assessment strategies, and measurable learning outcomes, offering a grounded understanding of how these methods translate into academic and skill-based improvements among pharmacy students.

Case Study on Lecture-Based Teaching and Learning (LTL)

This study examined the effectiveness of the lecture-based method in teaching the topic of Oils and Fats within the Pharmaceutical Organic Chemistry course. A total of more than 100 sec-year B. Pharm students were taught over a 4-weeks period using conventional lectures, supported by visual aids and concept summaries. The topic covered the chemical properties, pharmaceutical applications, and analytical techniques for oils and fats. Assessment methods included Multiple-Choice Questions (MCQs), short-answer tests, and a mini-assignment on oil analysis. Outcomes showed that 78% of students scored above average, indicating adequate conceptual understanding. However, student feedback suggested limited engagement and difficulty in visualizing molecular structures, supporting literature that emphasizes the need to supplement lectures with interactive strategies.

Case Study on Group-Based Teaching and Learning (GTL)

In this activity, 32 sixth-semester B. Pharm students, divided into eight groups of four, engaged in a 2-week comparative study of pharmacy education systems in India and abroad. Each group analyzed parameters such as curriculum structure, regulatory frameworks, career pathways, and academic challenges in various countries. The activity promoted equal participation by gender and included both oral presentations and written reports for evaluation. Learning outcomes included improved communication, global awareness, and critical thinking. Student feedback highlighted increased appreciation for international educational models and policy structures.

Case Study on Independent Learning / Self-Study Learning (IL/SSL)

A second-year B. Pharm student undertook an independent study over 5 weeks to improve his understanding of organic reaction mechanisms in pharmaceutical chemistry. Using class notes and reference texts such as Vogel's Textbook of Organic Chemistry and Foye's Principles of Medicinal Chemistry, the student adopted a self-paced approach, emphasizing diagram repetition and concept reinforcement. Progress was assessed through faculty-led quizzes and an oral viva. Results showed a 30% improvement in quiz performance and improved conceptual

clarity, demonstrating how self-learning fosters autonomy and mastery in complex subjects.

Case Study on Inquiry-Based Learning (IBL)

This activity was implemented in a third-semester B. Pharm practical class with 38 students, focusing on acid value determination of oils. Students were given a clinical scenario that required assessing oil quality for pharmaceutical use. The task was conducted over two lab sessions, combining theoretical background with hands-on titration and comparison to pharmacopeial standards. Outcomes included enhanced skills in analytical procedures, data interpretation, and problem-solving. Instructor observation and lab reports confirmed the development of critical thinking and scientific inquiry, which are central to IBL pedagogy.

Case Study on Kinesthetic Learning (KL)

In a medicinal chemistry lab, 30 sixth-semester students participated in the synthesis of 7-Hydroxy-4-Methyl Coumarin via the Pechmann condensation reaction. Students measured reagents, monitored reaction conditions, and purified the product using recrystallization. Assessment included product yield, melting point determination, and post-lab quizzes. The 3-week exercise enabled students to correlate theoretical reaction pathways with practical outcomes. Faculty reports noted improved retention, procedural accuracy, and student enthusiasm.

Case Study on Game-Based Learning (GBL)

To simplify the study of heterocyclic compounds in medicinal chemistry, an interactive game titled "Pick and Draw Structures" was introduced. In this activity, 26 students drew chemical structures of compounds picked randomly from a deck of cards within a time limit. Evaluation included peer scoring, faculty observation, and a follow-up test on structural recognition.

Outcomes showed improved structure recall speed, visual learning, and collaborative engagement.

Case Study on Experiential Learning (EL)

A sixth-semester B. Pharm student participated in a 6-week ICMR internship, where he worked on zebrafish models for drug toxicity evaluation. He was trained in zebrafish maintenance, microscopic analysis, and dose-response evaluations of an Ayurvedic anti-obesity compound. Data was collected on mortality rates, morphological deformities, and locomotor activity. The experience significantly enhanced the student's skills in experimental design, critical observation, and research methodology, aligning with the goals of experiential learning frameworks.

Case Study on Technology-Based Learning (TBL)

In a 2-week workshop, five sixth-semester B. Pharm students used Molsoft drug-design software to predict drug-likeness properties of small molecules. They analyzed molecular weight, logP, hydrogen bond donors/acceptors, and Lipinski's Rule of Five. Evaluation included project reports, software-generated outputs, and faculty feedback. The activity not only improved students' computational proficiency but also deepened their understanding of modern drug discovery workflows and data interpretation in pharmaceutical sciences.

Case Study on Peer-Assisted Teaching and Learning (PATL)

An M. Pharm third-semester student led a 90-min peer-teaching session for 20 B. Pharm final-year students on molecular docking. The session included theoretical background, software demonstration (AutoDock), and step-by-step docking exercises. Assessment consisted of pre- and post-session quizzes, along with peer feedback surveys. Post-session scores increased by an average of 18%, while qualitative feedback indicated improved

Table 1: Comparison of Traditional and Innovative Pedagogical Methods in Pharmaceutical Education.

Parameter	Traditional Methods	Innovative Methods
Teaching Approach	Teacher-centered (lectures, rote learning)	Student-centered (interactive, problem-based learning)
Student Engagement	Passive learning	Active learning with discussion and collaboration.
Use of Technology	Minimal	Extensive (e-learning, simulations, AR/VR, LMS platforms)
Assessment Techniques	Memory-based, summative (written exams)	Formative and summative (rubrics, peer evaluation, portfolios)
Skill Development	Focus on theoretical knowledge	Emphasis on soft skills, clinical reasoning, and critical thinking.
Feedback Mechanism	Delayed and often one-way	Continuous, timely, and two-way (student-teacher)
Adaptability to Student Needs	Low adaptability	High adaptability through personalized and differentiated instruction.
Interdisciplinary Collaboration	Rare	Encouraged through team-based, problem-solving tasks.

Table 2: Summary of Undergraduate Summer Research Projects and Their Educational Impact.

Sl. No.	Title of the Project	Class	Educational Impact
1	Computer-aided prediction of physicochemical properties of selected vitamins and related compounds	B. Pharm IV Sem	Improved understanding of computational tools and molecular descriptors
2	<i>In silico</i> prediction of drug-likeness properties of phytochemicals from <i>Aloe vera</i>	B. Pharm IV Sem	Developed skills in structure-property analysis and natural product chemistry
3	Computer-aided profiling of selected phytochemicals from <i>Berberis</i> species	B. Pharm VII Sem	Fostered critical thinking in CADD and phytochemical library screening
4	Study of selected plant compounds from <i>Tridax procumbens</i> using <i>in silico</i> tools	B. Pharm VII Sem	Gained experience in molecular structure prediction and property modeling
5	Drug-like characteristics of phytoconstituents from <i>Syzygium cumini</i>	B. Pharm VII Sem	Strengthened research skills in pharmacoinformatics
6	Drug-likeness scoring of phytochemicals from <i>Prunus persica</i> L. Batsch	B. Pharm VII Sem	Improved knowledge of Lipinski rules and predictive tools
7	Prediction of properties of plant compounds from <i>Carica papaya</i> leaf	B. Pharm VII Sem	Reinforced theoretical learning through application in drug design
8	CADD-based study of phytochemicals from <i>Coleus amboinicus</i>	B. Pharm VII Sem	Hands-on training in predictive software and drug-like profiling
9	Evaluation of <i>Achillea mellifolium</i> phytoconstituents	B. Pharm VII Sem	Enabled familiarity with QSAR and plant compound databases
10	<i>Ageratum conyzoides</i> phytochemistry via CADD	B. Pharm VII Sem	Improved skills in visualization and computational drug assessment
11	Computational prediction for phytomolecules from <i>Inula racemosa</i>	B. Pharm VII Sem	Gained exposure to pipeline filtering in virtual screening
12	UV method for quantifying oxybutynin chloride	B. Pharm VII Sem	Learned method validation and UV spectrophotometric techniques
13	Phytochemical studies and <i>in vitro</i> evaluation of <i>Muntingia calabura</i>	B. Pharm VII Sem	Introduced students to herbal bioactivity assays
14	Beta sitosterol quantification in plant extracts	B. Pharm VII Sem	Provided training in analytical method development
15	Computational phytochemistry of medicinal plants	B. Pharm VII and V Sem	Reinforced phytochemical database searching and analysis
16	Solvent-based phytochemical extraction and antioxidant testing	B. Pharm VII Sem	Practiced comparative phytochemical profiling and DPPH assay
17	Conductometric quantification of diloxitine furoate	B. Pharm VII Sem	Developed instrumentation skills and method optimization
18	Drug-like character screening of <i>Withania coagulans</i>	B. Pharm VII Sem	Improved awareness of ethnopharmacological CADD research
19	Marker-based analytical method for phytochemical quantification	B. Pharm VI Sem	Learned standardization practices in herbal analysis
20	<i>In silico</i> and <i>in vitro</i> anticancer evaluation of medicinal plants	B. Pharm IV Sem	Fostered translational learning between CADD and biological assays
21	Phytochemical profiling and biological evaluation of plants	B. Pharm V Sem	Built cross-disciplinary research skills
22	Analytical standardization of marketed anti-diabetic churna	B. Pharm V Sem	Introduced GMP-compliant analytical strategies
23	CADD study of marketed anti-diabetic churna	B. Pharm V Sem	Practiced integration of traditional and modern drug discovery

Sl. No.	Title of the Project	Class	Educational Impact
24	Marker-based quantification and anticancer screening of <i>Terminalia chebula</i> phytochemicals	B. Pharm IV Sem	Improved competency in analytical and molecular modeling
25	Green extraction and standardization of plant phytochemicals	B. Pharm IV Sem	Promoted sustainable lab practices and eco-friendly methods
26	<i>Betula utilis</i> screening and <i>in vitro</i> anti-diabetic study	B. Pharm IV Sem	Provided research exposure to plant-based drug discovery
27	CADD of phytocompounds against diabetes mellitus	B. Pharm IV Sem	Strengthened molecular docking and ADMET screening skills
28	Phytochemical characterization and bio-evaluation of plants	B. Pharm IV Sem	Enhanced understanding of secondary metabolite research
29	Drug-likeness profiling of phyto-molecules from medicinal plants	B. Pharm IV Sem	Strengthened knowledge of pharmacokinetics and plant-based leads
30	AUC and UV-based method for metronidazole quantification in tablets	B. Pharm VI Sem	Acquired validated protocol development for pharmaceutical assays

comprehension and collaborative motivation. The exercise underscored the benefits of near-peer instruction in advanced pharmaceutical topics.

Case Study on Project-Based Learning (PBL)

In this semester-long initiative, 12 students across various years were guided to work on independent or small-group projects involving both wet lab and dry lab work. Topics included herbal drug formulation, nanoemulsion design, and molecular docking. Project evaluation involved written reports, presentations, and rubric-based assessment by mentors. The initiative improved students' research planning, problem-solving, and technical writing skills. Students expressed a high level of satisfaction due to the autonomy and relevance of the projects to real-world applications. Table 2 represents the list of summer projects undertaken by B. Pharm students through PBL.

Integrated Pedagogical Framework

The Figure 1 illustrates a synthesized model showcasing various contemporary pedagogical methods used in pharmaceutical education. It highlights the interconnections between traditional teaching approaches (e.g., didactic lectures), active learning strategies (e.g., case-based learning, problem-based learning), experiential methods (e.g., industrial training, clinical rotations), technology-driven interventions (e.g., e-learning, virtual simulations), and scholarly engagement (e.g., poster presentations, research communication). This integrated framework emphasizes a learner-centered approach, encouraging adaptability, critical thinking, and lifelong learning through a balance of theory, practice, and innovation.

Synthesis of Pedagogical Approaches and Recommendations

The cumulative pedagogical interventions presented, including student-centered research projects, group activities, mentoring,

and conference participation, highlight a shift from passive to active learning environments. These approaches encourage cognitive engagement, critical thinking, and ownership of learning among pharmacy students. The integration of computational tools in research has not only aligned with current pharmaceutical trends but also bridged the gap between theoretical knowledge and practical application.

Across all case studies, certain commonalities emerge

- Students demonstrated increased motivation and self-directed learning when engaged in research-oriented activities.
- Digital platforms and computational tools fostered adaptability to modern research workflows.
- Mentorship and peer review processes cultivated collaborative learning and scientific communication skills.

The inclusion of poster presentations and article submissions further reinforced scholarly identity and confidence among learners. Students participating in state and national conferences gained early exposure to professional scientific discourse, enhancing their preparedness for higher academic or industry roles.

Despite varied contexts, best practices can be extracted

- Structured mentorship: Regular guidance sessions ensured consistent progress in student-led research.
- Interdisciplinary integration: Encouraging projects involving pharmacognosy, analytical chemistry,

and computational tools enriched cross-domain understanding.

- Reflective evaluation: Students involved in research or conference activities were encouraged to reflect on their learning trajectory, boosting metacognition.

To ensure sustainability, institutions must

- Formalize student research mentoring frameworks.
- Allocate dedicated hours within the curriculum for scholarly activities.
- Encourage publication and presentation through institutional support.

In summary, blending traditional content delivery with experiential, research-driven, and inquiry-based learning can serve as a transformative model in pharmaceutical education. Educators must adapt these insights to local academic structures while promoting innovation, engagement, and evidence-informed teaching strategies.

Challenges and Solutions in Implementing Innovative Pedagogies in Resource-Limited Settings

In resource-limited settings, barriers such as inadequate infrastructure, limited digital access, and untrained faculty impede pedagogical innovation. Financial constraints and rigid institutional frameworks further restrict implementation, raising concerns about equity and accessibility for underprivileged students. To overcome these challenges, institutions can adopt low-cost, scalable teaching tools like mobile-based learning and offline digital content. Faculty training programs, curriculum flexibility, community engagement, and supportive education policies can enhance inclusivity and drive sustainable change in such contexts.

DISCUSSION

Innovative teaching strategies have significantly transformed pharmaceutical education by promoting learner-centered approaches. PBL encourages students to explore solutions through real-world problems, enhancing analytical reasoning and collaborative learning. Research indicates that PBL fosters



Figure 1: Conceptual Map of Innovative Teaching Strategies in Pharmacy Education.

deeper understanding and student motivation, particularly in healthcare programs.²² However, it is resource-intensive, requiring trained facilitators and structured case development. Without proper oversight, students may drift away from core content, affecting foundational learning.²³ The Flipped Classroom model restructures traditional teaching by assigning theoretical content as pre-class homework and using class time for active learning. This approach enhances engagement and critical thinking, especially when supported by multimedia content.^{24,25} Simulation-Based Learning provides a near-clinical environment where learners can apply their knowledge in a risk-free setting. It improves communication, clinical judgment, and confidence among students.²⁶ Despite these benefits, high operational costs, infrastructure demands, and limited faculty training pose challenges, particularly in developing regions. Peer-Assisted Learning (PAL) emphasizes collaborative knowledge exchange and enhances both academic performance and peer communication. It has shown promising outcomes in promoting leadership and retention of knowledge.²⁷ However, inconsistent tutor quality and lack of standardized guidelines may lead to variable educational outcomes. The integration of Technology-Enhanced Learning (TEL) including interactive apps, gamified quizzes, and virtual laboratories has opened new avenues for personalized education. These tools support self-paced learning and immediate feedback mechanisms.²⁸ However, excessive reliance on digital platforms can result in reduced face-to-face interactions and cognitive overload. Additionally, disparities in access to devices or internet connectivity may widen the learning gap. Each method, while innovative, has its set of strengths and limitations. The applicability of these methods must be evaluated in relation to institutional infrastructure, curriculum design, and learner needs. A blended approach, such as combining PBL with simulation or integrating flipped models with digital tools, may offer a more balanced solution.²⁹ However, such integration must be evidence-driven and periodically reassessed for relevance and efficacy. Ultimately, the success of pedagogical innovation depends on continuous faculty development, curricular flexibility, and a robust feedback loop. Tailoring these strategies to local contexts while aligning them with global standards will ensure a more effective and equitable pharmaceutical education framework.

CONCLUSION

In conclusion, the transformation of pharmaceutical education necessitates a shift from traditional content delivery toward more interactive, research-oriented, and student-centered learning strategies. While various pedagogical approaches such as experiential learning, mentorship programs, and research integration offer promising avenues, their effectiveness depends largely on thoughtful implementation. Educators are encouraged to embed activities like student-led research, poster presentations, conference participation, and publication efforts into the curriculum, ensuring they align with assessment and learning

objectives. To support these methods, institutions must foster a culture of academic mentorship, allocate time and resources, and train faculty to adapt to evolving educational paradigms. However, common challenges such as limited faculty time, infrastructural constraints, and varied student preparedness may hinder implementation. These can be addressed through structured capacity-building initiatives, institutional support, and early exposure to research ethics and scientific writing. Future research should investigate the long-term impact of these pedagogical models on student competence, confidence, and career readiness through comparative and longitudinal studies. Additionally, the development of standardized tools to measure educational outcomes and pedagogical effectiveness will further aid in refining these strategies. Overall, by embracing a reflective, evidence-based, and flexible approach to teaching, pharmacy educators can better prepare students to meet the dynamic and interdisciplinary challenges of the healthcare sector.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

LTL: Lecture-Based Teaching-Learning; **GTL:** Group Teaching and Learning; **IL:** Individual Learning; **SSL:** Self-Study Learning; **IBL:** Inquiry-Based Learning; **KL:** Kinesthetic Learning; **GBL:** Game-Based Learning; **EL:** Expeditionary Learning; **TBL:** Technology-Based Learning; **PATL:** Peer Assisted Teaching-Learning; **PBL:** Project based Learning.

SUMMARY

The evolving landscape of pharmaceutical education necessitates the adoption of newer pedagogical strategies that go beyond traditional lecture-based instruction. This article provides an in-depth examination of contemporary Teaching-Learning (T-L) methods that are gaining traction in pharmacy education. Methods such as inquiry-based learning, peer-assisted teaching, expeditionary and game-based learning, along with technology-integrated platforms, are discussed in detail. These approaches are shown to enhance student engagement, critical thinking, and the development of essential professional skills. An integrated pedagogical framework was proposed, emphasizing the synergy between traditional methods and innovative practices. It supports a holistic learning environment where students actively construct knowledge through discussion,

simulation, practical application, and digital tools. The article also addresses key challenges in implementing these methods in resource-constrained settings, highlighting concerns related to equity, accessibility, faculty preparedness, and infrastructure. Potential solutions including faculty development, blended learning models, and open educational resources are recommended to overcome these barriers. A comparative analysis table further contrasts traditional and innovative pedagogies across multiple parameters like student engagement, adaptability, assessment methods, and interdisciplinary collaboration. The case studies and examples from various learning models underscore the practicality and benefits of diversified T-L approaches in pharmaceutical curricula. This article advocates for a balanced, adaptable, and student-centered educational paradigm. By integrating traditional strengths with modern strategies, pharmaceutical institutions can better prepare graduates for evolving professional roles, ensuring both academic rigor and real-world competence.

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