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Educational Theories And Their Integration, Application In Preclinical Medical Education: A Narrative Review

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Abstract
Medical education is a continuous, lifelong journey that includes both preclinical and clinical stages, aiming to prepare competent physicians. The preclinical stage builds the conceptual and cognitive skills needed for clinical practice and has shifted from traditional lecture-style teaching to more integrated, learner-focused methods. Educational theory provides a clear framework for enhancing how students learn, retain, and apply the basic sciences. Using educational theory in preclinical curricula has led to innovations such as integrated teaching, flipped classrooms, simulation-based learning, and formative assessment methods.

This narrative review examines key educational theories in preclinical medical education and their effects on curriculum design, teaching, engagement, and assessment. Literature from 2000–2026 was reviewed using major databases, including seminal works. The review covers behaviorism, cognitivism, constructivism, social learning, adult learning, experiential learning, cognitive load, and self-determination theories.

Behaviorist approaches are useful for rehearsal, feedback, and observable skill development; cognitivist and cognitive load theories support knowledge organization and the management of complexity; constructivist and experiential methods promote active, contextualized learning; and motivational and social theories explain learner engagement, professional identity formation, and collaboration. By applying principles of educational psychology in medical education, this review demonstrates how theoretical frameworks influence curriculum design, teaching strategies, and faculty development. It shows that theory-based approaches enhance learner engagement, knowledge retention, and clinical reasoning. Incorporating educational theory into curriculum planning helps create effective preclinical medical programs and improves teaching, learning, and assessment methods. Additionally, preclinical medical subjects require different educational strategies tailored to their learning demands. The literature consistently indicates that no single educational theory fully captures the complexity of preclinical medical learning. Instead, successful curricula typically combine multiple complementary theories.

This review's findings support the adoption of integrated, theory-informed educational models, primarily by differentiating between dominant and supporting theories based on curriculum and disciplinary needs. These strategies promote the development of integrated curricula grounded in active, experiential learning, enabling educators to align educational theories with both curricular objectives and the specific requirements of each discipline.

Despite these advantages, challenges persist, including gaps in faculty training, curriculum overload, limited resources, and difficulties aligning theory with institutional practices. Incorporating educational theory approaches into preclinical medical education can boost student engagement, improve understanding, and better prepare learners for clinical training. Future curriculum development should align educational strategies with evidence-based theories while addressing practical barriers to implementation to optimize learning outcomes.

Keywords: *Medical Education, Preclinical Curriculum, Educational Theory, Curriculum Design, Learning Theory*

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I. Introduction

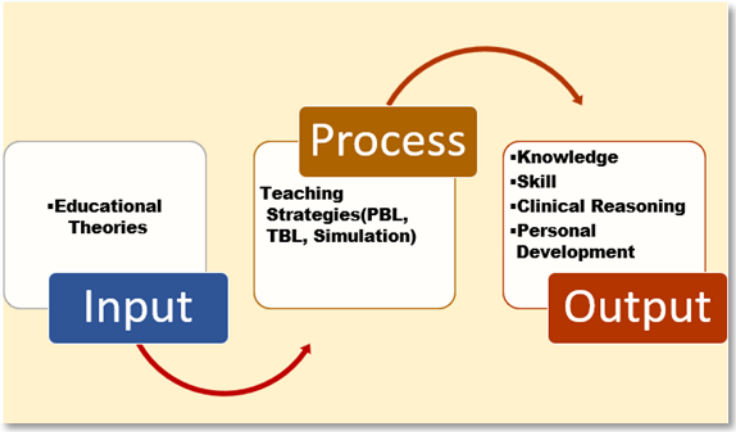
The term "education" comes from the Latin words educare, meaning "to bring up," and educere, meaning "to bring forth." The definition of education has been studied by theorists from various fields. Many agree that education is a deliberate activity aimed at achieving goals like passing on knowledge, skills, and character traits. [1,2] Education is the structured process of acquiring knowledge, skills, values, and habits, and it is a fundamental human right essential for personal development and societal progress. It encompasses formal, non-formal, and informal learning, empowering individuals to think critically, secure employment, and improve their quality of life. [3,4]

Education includes formal (structured school systems), non-formal (organized workshops and training), and informal (experiential) learning. Medical education, a specialized formal track, involves pre-clinical foundational sciences, clinical clerkships, graduate residency or specialty training, and continuing medical education (CME). Modern approaches include Problem-based learning (PBL), Team-based learning (TBL), simulation, and integrated, systems-based curricula. Medical education has evolved over the past century due to scientific advancements and changing expectations for physicians' roles. The early years of medical school once primarily focused on anatomy, physiology, biochemistry, pathology, microbiology, and pharmacology. Clinical exposure was introduced later. This structure was shaped by reforms from the early twentieth century that emphasized scientific rigor. While this approach established strong biomedical foundations, it also created a separation between theory and clinical practice. [5,6,7] Modern medical education is starting to question the strict division between preclinical and clinical stages. Educators understand that medical training needs early integration of biomedical knowledge with clinical reasoning, communication skills, and professional values. Achieving this requires more than just curriculum adjustments; it also involves a deeper understanding of how students learn. [6,8,9]

Education theory, emerging in the 1800s, is a dynamic field that analyzes teaching and learning processes, bridging pedagogical practice and philosophical foundations to improve educational outcomes. [4] Educational theory provides conceptual frameworks that explain how people learn, develop skills, and create meaning from their experiences. These frameworks offer valuable guidance for designing curricula that promote deep understanding instead of simple memorization. For example, adopting problem-based learning (PBL) draws on constructivist theory, enabling students to collaboratively solve clinical cases rather than simply memorize facts. Likewise, simulation-based exercises used in anatomy or clinical skills courses reflect experiential learning theory by allowing students to apply knowledge in realistic scenarios. In preclinical medical education, applying educational theory can support decisions about teaching methods, such as encouraging active discussion in small groups, structuring assessment systems through formative quizzes and reflective exercises, and designing learning environments that prioritize interaction and engagement. [10,11,12]

Despite the availability of numerous theoretical frameworks, their application within medical curricula remains inconsistent and uneven. Some programs continue to prioritize traditional lecture-based teaching, whereas others have implemented active learning methods such as problem-based or team-based learning. However, there is often a disconnect between educational theory and practice, as these pedagogical approaches are sometimes adopted based on tradition or institutional preference rather than a clear theoretical rationale. This gap between theory and practice can limit the effectiveness of curriculum innovations, suggesting the need for more deliberate integration of educational theories into curriculum design and instructional strategies. [13,14,15]

This narrative review aims to provide a comprehensive analysis of the major educational theories that have shaped health professions education, with a specific focus on their influence on preclinical curriculum development. By combining theoretical frameworks with practical educational strategies, this article offers a theory-based guide designed to inform and improve preclinical medical education. Applying educational theory to curriculum design helps educators effectively link theory and practice, enhancing both the quality and relevance of medical training. Instead of viewing theories as separate ideas, this review examines how they intersect, where they complement each other, and how a theory-informed approach can strengthen the design of modern preclinical curricula.



[Figure 1: Conceptual Framework Linking Educational Theories to Learning Outcomes in Preclinical Medical Education"; PBL- problem-based learning, TBL- Team-based learning**]**

Table 1: Major Phases of Medical Education

Stages of Medical Education	Core Elements	Purpose
Premedical Education	• Undergraduate prerequisite courses (e.g., Biology, Chemistry, Physics, Mathematics) • Preparation for medical entrance examinations (e.g., MCAT or equivalent)	Provides the scientific foundation and academic preparation required for admission into medical school.
Undergraduate Medical Education (UME)	• Preclinical training in basic sciences (e.g., Anatomy, Physiology, Biochemistry, Pharmacology, Pathology, Microbiology) • Early clinical exposure and skills training • Clinical clerkships in major specialties (e.g., Internal Medicine, Surgery, Pediatrics, Obstetrics & Gynecology, Psychiatry, Family Medicine)	Develops core medical knowledge, clinical reasoning, and patient care skills required to graduate as a medical doctor.
Graduate Medical Education (GME)	• Residency training in chosen specialties (e.g., Internal Medicine, Surgery, Pediatrics) • Subspecialty fellowships (e.g., Cardiology, Gastroenterology, Oncology) • Advanced clinical decision-making and supervised patient management	Provides specialized training and practical experience required for independent clinical practice in a medical specialty.
Continuing Medical Education (CME):	• Ongoing training for licensed physicians to maintain competency. • Workshops, conferences, seminars, and certification courses • Online learning modules and professional development programs • Maintenance of licensure and board certification requirements	Ensures physicians remain up to date with advances in medicine, maintain clinical competency, and improve the quality of patient care throughout their careers.

II. Methodology

This study was conducted as a narrative review to synthesize and critically interpret major educational theories and their applications in preclinical medical education. A narrative review design was selected because the purpose of the article was to integrate conceptual, theoretical, and applied literature across a broad educational field rather than to evaluate a single intervention or perform quantitative meta-analysis. The review focused on how educational theories inform curriculum design, teaching strategies, learning processes, and assessment in undergraduate preclinical medical education.

A structured literature search was conducted in PubMed/MEDLINE, Scopus, and Google Scholar to identify relevant literature published between January 2000 and February 2026. Seminal theoretical works published before 2000 and some scholarly webpages were included, where necessary, to explain the development and core principles of major learning theories. The search was limited to English-language publications. Reference lists of selected articles were also reviewed manually to identify additional relevant studies and foundational papers.

Search terms combined concepts related to medical education, educational theory, learning theory, and preclinical curriculum design. Representative terms included "medical education" AND "educational theory," "preclinical curriculum" AND "learning theory," "undergraduate medical education" AND "educational theory," "constructivism" AND "medical education," "cognitive load theory" AND "medical students," "adult learning

theory" OR "andragogy" AND "medical education," and "self-determination theory" AND "medical students." Search terms were adapted across databases according to indexing structure and search functionality.

Studies were considered eligible if they were peer-reviewed articles published in English and addressed educational or learning theories relevant to health professions education, particularly undergraduate or preclinical medical education. Conceptual papers, narrative reviews, systematic reviews, and empirical studies were included when they contributed meaningfully to understanding curriculum design, teaching, learning, motivation, or assessment. Studies were excluded if they were unrelated to medical or health professions education, lacked meaningful relevance to educational theory or curriculum design, or consisted of editorials, conference abstracts without full text, or non-scholarly web sources.

Titles and abstracts were screened for relevance, followed by a full-text review of potentially eligible papers. Because the literature was diverse in design and purpose, findings were summarized narratively and organized around major theoretical frameworks and their implications for curriculum development, instructional design, learner engagement, assessment, and implementation challenges. As a narrative review, this study is inherently interpretive and may be subject to selection bias; however, rigor was improved through structured searching, clear eligibility criteria, and careful prioritization of scholarly sources.

III. Educational Theory And The Evolution Of Preclinical Medical Curriculum

The early history of medical education primarily focused on training. Students learned medicine mainly through observation and mentorship with practicing physicians. Formal instruction in biomedical science was limited, and there were few standardized requirements for medical training.[16]

The Flexner Report is a significant, book-length study of medical education in the United States and Canada, written by Abraham Flexner and published in 1910 with support from the Carnegie Foundation. [17,18,19] Flexner not only assessed the state of medical education in North America but also provided detailed descriptions of the medical schools operating at that time. He offered both critiques and suggestions for improving medical education in the United States. The release of the Flexner Report sparked major reforms in North American medical schools. The report advocated creating university-affiliated medical schools based on the basic sciences. As a result, medical training shifted to a structure with two preclinical years followed by two clinical years. [19,20,21]

In this model, the preclinical phase focused on disciplines such as anatomy, physiology, biochemistry, pharmacology, pathology, and microbiology. Teaching mainly involved lectures, supplemented by laboratory sessions and occasional small-group discussions. While this traditional structure ensured systematic coverage of scientific content, it often led to the separation of basic science subjects from one another and from clinical practice. In contrast, later curricular models, such as problem-based and organ-system-based curricula, aimed to promote the integration of knowledge across disciplines and establish early links to clinical scenarios, addressing the limitations of the earlier approach. [22,23,24]

Founded in 1847, the American Medical Association (AMA) played a crucial role in standardizing and enhancing medical education in the United States. [25] When the Council on Medical Education (CME) was established in 1904, the AMA set minimum admission standards and a standardized curriculum that included two preclinical years followed by two clinical years. The AMA's efforts were vital in establishing clear criteria for both preclinical and clinical medical training. [26,27,28] By the late twentieth century, dissatisfaction with traditional, lecture-based medical curricula—which often separated basic sciences from clinical practice—grew, prompting educators to explore alternative problem-based and organ-system-based curricula that integrated multiple disciplines into a single course. [29] McMaster University in Canada pioneered problem-based learning, opening its medical school in 1969 with a revolutionary, student-centered, three-year program. Led by Dr. John Evans and others, this approach emphasized active learning, where small groups of students examined clinical scenarios (cases) to identify their own learning needs rather than attending traditional lectures. [30,31,32]

Other institutions, such as Western Reserve University in the 1950s and later many others, experimented with organ-system–based curricula.[33] These integrated multiple disciplines (e.g., anatomy, physiology, pharmacology, and pathology) within a single course organized by human body systems (e.g., cardiovascular, respiratory, gastrointestinal), often incorporating PBL techniques. These innovations reflected a broader shift in educational philosophy—from teacher-centered instruction toward learner-centered education. In this new paradigm, students were encouraged to take a more active role in their own learning, and educators began to consider how different teaching methods could support deeper understanding. Modern curricular reforms aim to bridge the gap between theory and practice by emphasizing interdisciplinary learning, early patient exposure, and problem-solving skills. [34,35,36]

Modern preclinical medical education is shifting from traditional, lecture-based basic science teaching to integrated, competency-focused, and digitally-enhanced methods. Driven by recent global challenges and rapid advances in medical technology, these changes aim to connect foundational knowledge with practical clinical skills earlier in training. The traditional "Flexnerian" model, with two years of science followed by two years of

clinical work, is being replaced by integrated structures such as Horizontal & Vertical Integration, a shortened preclinical phase, and Early Clinical Exposure (ECE). [37,38]

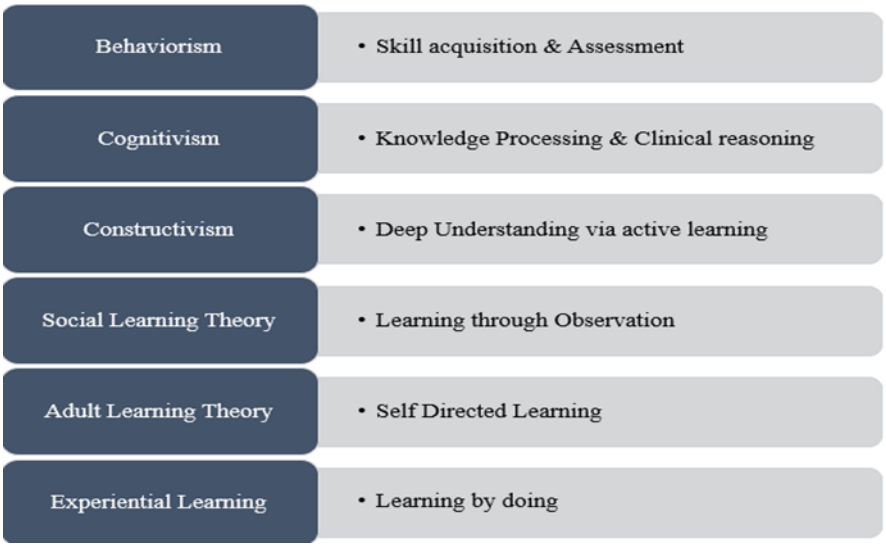
Educational focus has shifted from "time-in-seat" to measurable outcomes such as Competency-Based Medical Education (CBME), Active Learning, and Parallel Curriculum. New topics are being integrated into foundational modules to reflect modern healthcare, including Telemedicine Training, Social Determinants of Health (SDH), and Technology-Enhanced Instruction.[39] The integration of Artificial Intelligence (AI) in medical education has moved from a theoretical idea to a practical necessity, with many medical students now using AI tools for learning as of early 2026.[40,41] Overall, these ongoing reforms demonstrate an evolving approach that emphasizes integration, adaptability, and relevance. As the preclinical curriculum progresses, it aims to equip future physicians with not only strong scientific knowledge but also the practical skills and digital literacy needed in today's healthcare environment. [42,43]

IV. Foundations Of Educational Theory In Medical Education

Foundations of educational theory in medical education offer an evidence-based framework for designing curricula, teaching, and assessment. Educational theory includes many perspectives that explain how people learn. These theories primarily originate in psychology and educational research and influence professional education, including medicine. Key theories include cognitive, social, behavioral, and experiential approaches. For example, behaviorism emphasizes observable changes in behavior and uses reinforcement and feedback; in practice, it is applied through structured skill drills and immediate corrective feedback during clinical skills training. Cognitivism focuses on mental processes such as memory, problem-solving, and information processing; educators may apply cognitive theory by organizing information into meaningful chunks or using concept maps to help learning. Constructivism suggests that learners actively build knowledge through experience and reflection, as seen in problem-based learning, where students work through clinical cases, blending new knowledge with prior experiences. Social learning theory highlights the importance of learning in social contexts, such as through role modeling and communities of practice; for example, medical students often learn professional behaviors and communication by observing experienced clinicians during ward rounds. Self-determination theory (SDT) centers on personal growth and self-actualization, emphasizing learners' needs and motivations, which can be promoted by allowing learners to set personalized goals and engage in reflective practice. Experiential learning theory, such as Kolb's model, emphasizes learning through direct experience, reflection, and application in real-world settings; simulation-based resuscitation training exemplifies this approach. [10,44,45,46]

These frameworks shift education from simple transmission to student-centered learning, emphasizing cognitive processing (memory), social interaction (communities of practice), and learner self-direction. Each perspective highlights different aspects of learning and suggests various teaching and design methods. Modern medical education often integrates multiple theories rather than treating them in isolation, which has significant implications for curriculum development. For instance, an instructional session might incorporate cognitive strategies to support knowledge retention, experiential elements through simulations, and social learning through group collaboration. Blending theories allows educators to leverage each perspective's strengths and tailor teaching strategies to diverse learning contexts; however, it can also increase complexity when aligning teaching methods with clear theoretical rationales. [47,48,49] Therefore, thoughtful integration of theories is vital to ensure coherence and effectiveness in educational practice. Major educational theories in medical education are listed below.

A. Behaviorism
B. Cognitivism
C. Constructivism
D. Social learning theory
E. Adult learning theory
F. Experiential learning theory
G. Cognitive load theory
H. Self-determination theory (SDT)



[**Figure 2:** Core Educational Theories and Their Primary Contributions to Learning in Preclinical Medical Education**]**

V. Major Educational Theories And Their Implications For Preclinical Medical Education

Behaviorism

Behaviorism is one of the earliest methods for understanding learning. Developed in the early twentieth century, it emphasizes observable behaviors rather than internal thoughts. According to this approach, learning happens when responses to stimuli are reinforced through repetition and feedback. [50,51]

Early behaviorist research demonstrated that behavior can be modified through reinforcement, repetition, and feedback. These ideas remain crucial in educational environments where specific behaviors or skills must be acquired. B.F. Skinner and other behaviorist experts highlighted the importance of reinforcement in shaping behavior. Positive reinforcement promotes desired behaviors, while negative reinforcement reduces incorrect responses. In schools, behaviorist principles are often implemented via structured assessments and feedback systems. [51,52,53]

In medical education, behaviorist principles are especially helpful for learning procedural skills and clinical routines. For example, students studying pharmacology can gain from repeated exposure to drug mechanisms, indications, and side effects through organized review sessions. In preclinical labs, students practice repeatedly under supervision. When learning anatomy or lab techniques, they receive feedback that reinforces proper actions and corrects mistakes. Repeated practice with structured feedback—such as in learning physical exam maneuvers or laboratory procedures—demonstrates how reinforcement and repetition are intentionally used in teaching to build technical skills and automatic responses. Similarly, procedural skills like venipuncture or catheter placement can be strengthened through repeated practice and feedback.

However, behaviorism alone does not address complex tasks like diagnostic reasoning or ethical decision-making. For example, interpreting conflicting clinical findings to make a diagnosis or balancing patient autonomy with beneficence requires analysis, synthesis, and judgment—not rote learning. In contrast, cognitive theories highlight mental processes such as understanding, memory, and problem-solving, recognizing that learners actively process and organize information. Constructivist theories further suggest that learners build meaning through experience, reflection, and engagement with context. Therefore, cognitive and constructivist approaches provide essential frameworks for understanding how individuals interpret, adapt to, and resolve new or ambiguous problems. These theories overcome the limitations of behaviorism by emphasizing internal processes like motivation, prior knowledge, and the ability to transfer learning to new situations, which are especially important for complex reasoning and ethical decision-making in medicine. [56,57,58]

Cognitivism

Cognitivism emerged in the mid-twentieth century as researchers explored the mental processes involved in learning to address the shortcomings of behaviorism. Instead of focusing solely on behavior, cognitive theorists examined how we process, organize, and store information in memory. These theorists investigate mental processes such as perception, memory, attention, and problem-solving. From a cognitive perspective, learning occurs when new information is organized into meaningful structures within the learner's memory. An important concept in cognitivism is schema development. Schemas are mental frameworks that help individuals organize and interpret information. For example, when a student encounters a patient with chest pain, schemas related to

cardiovascular physiology and pathology, learned earlier, guide diagnostic reasoning. A key insight from cognitive psychology is that working memory has limitations. When students face complex information, their learning depends on how teachers organize and present ideas. [59,60,61,62]

Within medical education, this insight has important implications. Biomedical sciences involve complex systems and mechanisms that can easily overwhelm new learners. Effective teaching, therefore, requires careful organization of information to enhance understanding.

Cognitive theory provides various instructional strategies to enhance learning and retention in medical education. It recommends several methods: organizing material into meaningful frameworks, utilizing diagrams and visual tools, encouraging students to connect topics, and promoting active recall and knowledge application. Medical students should develop comprehensive knowledge networks that link basic science concepts to clinical manifestations. Teaching strategies based on this theory focus on improving memory, understanding, and clinical reasoning. Key techniques include managing cognitive load during simulations, chunking complex information, creating concept maps, practicing retrieval through quizzes or multiple-choice questions, and employing case-based learning to connect new knowledge with existing schemas. Techniques like cognitive scaffolding gradually reduce instructional support as learners become more proficient. Overall, these methods help students organize knowledge effectively and develop expert-level diagnostic reasoning instead of merely memorizing facts. [62,63,64,65]

These strategies help students build organized knowledge networks that support retention and clinical reasoning.

Constructivism

Constructivist theory states that learners build knowledge through interaction with their environment. Instead of merely absorbing information, students make sense of new content by applying their prior knowledge and experiences. Constructivism emphasizes active participation in learning. When students solve problems, discuss, and explain ideas, they develop a deeper understanding. Constructivism has significantly influenced modern approaches to medical education. Instructional strategies such as problem-based learning and case-based learning are based on constructivist principles. These methods encourage students to analyze clinical scenarios, identify knowledge gaps, and collaborate to develop explanations. [66,67,68]

Problem-based learning, which was first introduced at McMaster University in the late 1960s, continues to be a key example of applying constructivist theory in medical education. During PBL sessions, small groups of students work through clinical cases under the guidance of a facilitator. The facilitator's role is not to deliver lectures but to guide discussion and encourage inquiry. [31,32,69] In medical education, constructivism has shaped the development of problem-based and case-based learning. Typically, in a problem-based learning curriculum, students are presented with a patient case and collaborate to analyze clinical scenarios, identify knowledge gaps, research relevant information, and use biomedical knowledge to inform clinical reasoning. [70,71]

Constructivist learning environments incorporate discussion, inquiry, and reflection. Faculty serve as facilitators, guiding students to understand complex concepts. Research indicates that such methods foster a deeper grasp of scientific ideas and enhance students' ability to apply knowledge to clinical cases. Furthermore, constructivist environments promote self-directed learning, which is vital for physicians who must continually update their knowledge. [66,72,73]

Social learning theory

Social learning theory states that individuals gain knowledge, skills, and behaviors not only through direct instruction but also by observing and interacting with others in social settings. This model highlights the importance of modeling and imitation in learning. In professional education, especially in fields such as medicine and nursing, students closely observe the behaviors, attitudes, and decision-making styles of experienced practitioners. These observational learning experiences help shape their professional identity and internalize workplace norms. [74,75,76]

Within medical education, social learning is crucial for developing professional identity. Even in the preclinical stage, students observe faculty and senior learners, forming implicit ideas about professional norms and expectations. Relying solely on informal observation to learn these norms can also expose students to unexamined or poor practices. For example, without structured opportunities for critical reflection, students might inadvertently adopt outdated attitudes or negative behaviors modeled by others, thereby perpetuating undesirable aspects of professional culture. To address this, curriculum design should incorporate explicit strategies that encourage students to critically reflect on and analyze negative role models, such as prompting discussion of challenging observations during guided debriefings or reflective writing assignments. This approach helps educators assist students in recognizing, questioning, and resisting inappropriate behaviors or attitudes. Educational strategies such as structured mentorship programs and explicit instruction in professional values help students differentiate between positive and negative role models, diminish the impact of negative modeling, and foster professional growth. [77,78,79]

Collaborative learning environments enhance these processes. Small-group discussions and peer-teaching activities motivate students to share perspectives and to assist one another in learning. By incorporating these collaborative methods, professional education can more effectively promote meaningful social learning experiences that help develop competent and reflective practitioners. [80,81]

Adult learning theory (andragogy)

Research suggests that the adult brain begins to slow down around age 25. [82] Of course, that doesn't mean adult brains aren't capable of learning new concepts. It just means they need to participate in activities that keep the brain active and promote learning. By understanding how adults learn best, educators can design courses, programs, and training sessions that connect with learners' real-world experiences. This isn't just about transferring knowledge; it's about equipping adults with skills they can immediately use in their careers, hobbies, and daily lives. A focused framework for understanding these processes is Adult Learning Theory, which explains how educators can adapt teaching methods to meet the unique characteristics and motivations of adult learners. [83,84]

American educator Malcolm Knowles introduced this concept in 1968. Today, it is more widely recognized as Adult Learning Theory. Adult learning theory, or andragogy, claims that adults learn differently from children, emphasizing self-direction, experience-based learning, and practical, problem-centered methods. [85,86] Adult Learning Theory is a framework that moves beyond a one-size-fits-all approach. It examines the diverse needs of adults, considering factors like prior experience, responsibilities, and personal motivations. By acknowledging these differences, educators can create tailored strategies that make learning not only effective but also engaging and meaningful. [87,88]

Medical students, although early in their professional development, are typically adult learners who bring prior educational experiences and career goals to their studies. Instructional approaches that focus on real-world application, therefore, tend to be especially effective for them. When students see the relevance of a topic to their future professional duties, they are more likely to engage deeply with the material. Medical students also often benefit from opportunities to pursue independent study or research projects that match their interests. [88,90,91]

Adult learning theory also highlights the importance of autonomy in learning. Effective teaching, therefore, recognizes learners' independence and emphasizes its relevance to future clinical practice. Team-Based Learning (TBL) is a highly effective, structured form of collaborative, active learning that closely aligns with adult learning theory (andragogy). TBL involves stable, diverse teams working through a cycle of preparation, application, and peer feedback to solve complex, real-world problems. This approach shifts instructors from the role of lecturer to facilitator, fostering critical thinking, interdependence, and the immediate application of knowledge—key drivers for adult learners. [86,88] Instructional strategies aligned with adult learning principles include, for example, clinical case discussions in medical education. In these sessions, students analyze patient scenarios, collaborate to determine diagnoses, and propose treatment plans, thereby directly applying theoretical knowledge to practical situations. [91,92] Self-directed learning (SDL) activities, Team-Based Learning (TBL), problem-centered instruction, and the flipped classroom are further examples of adult learning theory.

In summary, by applying adult learning theory and evidence-based instructional methods, educators can enhance student engagement and facilitate the practical application of knowledge. This approach not only meets the immediate educational needs of medical students but also equips them with essential skills and perspectives for their future medical careers. [86,88,93,94]

Experiential learning theory

David A. Kolb introduced his experiential learning theory (ELT) in 1984, drawing inspiration from the work of Gestalt psychologist Kurt Lewin, as well as John Dewey and Jean Piaget. Kolb's theory provides a holistic view that includes experience, perception, cognition, and behavior. [95] It describes a method where a person's skills and job requirements are assessed using the same language, making their comparability measurable. Experiential learning theory views learning as a cyclical process in which knowledge is developed by transforming experience. This cycle generally involves four interconnected stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Learners start by engaging in an experience, then reflect critically on it, develop conceptual understanding, and finally apply this knowledge in new situations. Repeating this cycle gradually deepens and expands learning. [95,96,97]

In medical education, experiential learning is most prominently integrated into clinical training; however, its importance extends well into the preclinical phase. Early use of experiential strategies helps connect the traditional gap between basic sciences and clinical practice. Structured lab sessions, simulation activities, and early patient interactions are effective ways to incorporate experiential learning into preclinical curricula. [98,99,100]

Simulation-based education demonstrates this framework in practice. High-fidelity mannequins, standardized patients, and virtual simulation platforms allow students to practice clinical scenarios—such as

managing acute asthma, performing basic life support, or conducting patient interviews—in a safe, controlled environment. For example, a preclinical student involved in a simulated anaphylaxis case must apply pharmacological knowledge (e.g., epinephrine dosing and mechanism of action) while also honing clinical decision-making skills. After the simulation, structured debriefing sessions help learners reflect on their actions, identify gaps in understanding, and connect observed outcomes with underlying physiological and pharmacological principles. Similarly, anatomy dissection labs and physiology practical can be viewed from an experiential standpoint. Instead of passively observing structures, students actively explore anatomical relationships and then relate these findings to clinical conditions, such as nerve injuries or vascular compromise. Reflective activities—such as guided questions or brief reflection writings—further strengthen the integration of theory and practice.

These methods promote deeper learning by integrating complex biomedical concepts into meaningful clinical contexts. As a result, students can better retain knowledge, apply it to problem-solving, and develop early clinical reasoning skills. By incorporating experiential learning techniques into preclinical education, curricula can transition from rote memorization to active, context-based knowledge development that supports long-term professional skills. [103,104,105]

Cognitive load theory

Cognitive load theory is a crucial concept in medical education. It states that the human working memory has limited capacity. When instructional materials present too much information at once, learners can experience cognitive overload, which hinders learning. Therefore, effective teaching strategies focus on managing cognitive load by breaking down information into smaller, manageable parts. Using visual aids, concept maps, and structured outlines helps students organize complex material more effectively. For example, in pharmacology education, grouping drugs by their mechanism of action can enhance understanding and retention. Cognitive load theory offers valuable insights into how instructional materials should be designed. Because working memory has limited capacity, instructional strategies must reduce unnecessary cognitive demands while supporting meaningful learning. [106-109] To better understand how instruction can be optimized, it is helpful to examine the three types of cognitive load that are commonly described.

I. Intrinsic load
II. Extraneous load
III. Germane load

Intrinsic load:

Intrinsic load refers to the inherent difficulty or complexity of the material being learned within Cognitive Load Theory (CLT). For example, in medical education, understanding the physiological mechanisms behind cardiac function involves processing multiple interacting components, such as the electrical conduction system and cardiac cycle dynamics. Intrinsic load reflects the mental effort required to understand new information and is determined by the number of interacting elements in the content, not by how the material is presented. [106,110]

Extraneous load:

Extraneous load refers to the unnecessary mental effort needed to process information, caused by poor instructional design or distracting, irrelevant, or complicated presentation methods. It drains working memory capacity that should be used for learning, and it can be reduced by simplifying materials, eliminating distractions, and using clear, direct communication. [106,111]

Germane load:

Germane load is the constructive mental effort used to process information, develop schemas, and store knowledge in long-term memory, representing the "good" mental effort in learning. It enhances learning by connecting new information to existing knowledge. It is part of Cognitive Load Theory, along with intrinsic (difficulty) and extraneous (presentation) loads. [112,113]

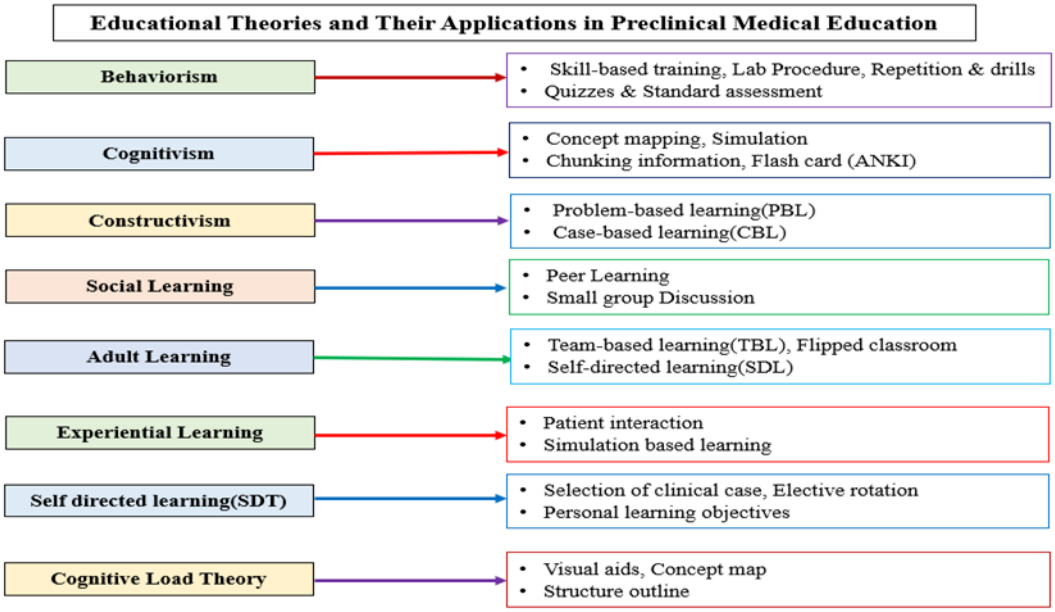
Intrinsic load pertains to the difficulty of the material, extraneous load comes from poorly designed instructional resources, and germane load relates to effective learning processes. Good instructional design strives to reduce extraneous load while encouraging learners to allocate their cognitive efforts to grasping key concepts. In preclinical education, this may include simplifying visual aids, presenting information in logical order, and providing worked examples that demonstrate complex procedures. [106,113,114,115]

Self-determination theory (SDT)

Motivation is essential for effective learning, and self-determination theory (SDT) provides a clear framework for understanding how to enhance learner motivation. According to SDT, fulfilling three basic

psychological needs—autonomy (choice), competence (mastery), and relatedness (connection)—is crucial for promoting intrinsic motivation, high-quality performance, and mental health. When educational environments support these needs, learners tend to engage more deeply and stay motivated; conversely, environments that suppress these needs can cause alienation and reduce well-being. This will examine how the principles of SDT can be intentionally applied to improve motivation and learning outcomes, especially in medical education. [116,117]

In medical education, autonomy-supportive teaching might involve letting students choose clinical cases to study, pick among elective rotations, or set personal learning goals, thereby encouraging them to lead their own educational experiences. Promoting independent exploration can include encouraging learners to pursue research projects or engage in self-directed study in response to clinical questions they encounter. Providing constructive feedback that highlights strengths and offers clear steps for improvement can boost students' confidence and sense of competence. Collaborative learning settings, such as small-group case discussions or team-based simulation exercises, also improve motivation by fostering relationships and effective communication between learners and instructors. The need for competence is met by offering students chances to achieve mastery through skills workshops, supervised clinical practice, and formative assessments that help them feel effective in their roles. The need for relatedness is supported by structured mentorship programs, regular group reflection sessions, and peer collaboration, all of which nurture a sense of belonging and connection within the medical learning community. [118,119]



[Figure 3: Application of Educational Theories to Instructional Strategies in Preclinical Medical Education**]**

VI. Challenges In Implementing Educational Theories In Preclinical Curriculum

Educational theories have significantly influenced the development of modern preclinical curricula. Several teaching methods based on these theories are now widely used. While educational theory provides valuable guidance, applying theory- based curricula can be challenging. [10, 44] Traditional medical curricula often separate basic sciences from clinical training. Modern curricula increasingly emphasize integrating across disciplines and stages of training. Integrated curricula organize instruction around organ systems rather than individual disciplines. For example, a cardiovascular module may combine anatomy, physiology, pathology, and pharmacology. This approach improves knowledge integration and helps students understand the clinical relevance of basic science concepts. Horizontal integration links related subjects within the same educational phase. For instance, physiology and biochemistry might be taught together within organ- system modules. Vertical integration connects basic sciences with clinical applications throughout the curriculum. Early exposure to clinical scenarios helps students see how foundational knowledge supports patient care. The spiral curriculum is another key organizational model. In this approach, core concepts are revisited repeatedly with increasing complexity, reinforcing learning and encouraging deeper understanding over time. Despite progress in curriculum reform, several challenges still remain. Poorly designed integrated curricula can overwhelm preclinical students, exceeding their working memory capacity and hindering learning. The rapid growth of biomedical knowledge makes it difficult to determine which content should be prioritized. Balancing the depth of basic sciences with clinical relevance also poses ongoing challenges for educators. Time constraints in the curriculum force educators

to prioritize coverage over depth, often leading them to skim material rather than foster in- depth understanding. Pressure to complete the curriculum increases stress for both teachers and students. [122-126,134]

Furthermore, adopting innovative teaching methods requires faculty development and institutional support. Common obstacles include limited faculty time and competing curricular priorities. Even with recommended strategies like structured faculty development programs and institutional support mechanisms that have proven to enhance reform and encourage faculty involvement, changes can still fail if underlying cultural or background factors are ignored. Educators who rely on rote memorization may hesitate to embrace problem- or case-based learning. Developing and implementing new educational models (such as PBL or TBL) demands significant planning and evaluation time, which conflicts with professional duties and research commitments. There is often a lack of recognition, rewards, or financial incentives for faculty who invest time in curriculum redesign, which can lead to low motivation. [127-129]

Implementing curricula based on educational theories such as Competency-Based Medical Education (CBME), Problem-Based Learning (PBL), Team-Based Learning (TBL), or integrated models during the preclinical years faces numerous challenges, including faculty resistance and resource constraints. For instance, efforts to introduce problem-based learning (PBL) in some medical schools failed due to a lack of faculty support, inadequate training, and ongoing institutional resistance. These issues did not merely lead to superficial implementation; they hindered PBL's transformative potential, as insufficient faculty engagement and poor preparation resulted in sessions that resembled traditional teaching methods and failed to effectively promote critical thinking or self-directed learning. This demonstrates that the success of curricular reform depends not only on adopting new pedagogical approaches but also on ensuring that faculty are equipped and motivated to facilitate them effectively. Adopting new methods requires substantial investments in technology, IT infrastructure, and learning resources, which may not be available, especially in low- and middle-income countries. Increased group teaching also requires more physical space, small-group rooms, and coordinated scheduling, all of which can be difficult to manage. The high teacher-student ratio remains a significant barrier to implementing active, student-centered learning and personalized assessment. [130-134]

Addressing these challenges requires strong institutional leadership to establish a clear vision and allocate necessary resources, along with active faculty participation to keep the curriculum responsive to educational needs. Continuous review of the curriculum is essential for identifying emerging issues and adapting to changes in medical knowledge and practice. Studies indicate that targeted faculty training enhances pedagogical skills and openness to innovative teaching strategies, while a step-by-step implementation plan can support gradual change and reduce resistance. Strong leadership support is essential for creating a supportive environment and guiding reform efforts. Better logistical coordination ensures that physical space, scheduling, and technological infrastructure meet the needs of new teaching methods, while early faculty skill development prepares educators for active learning modalities and integrated curricula. Ultimately, the successful implementation of educational theories in preclinical medical curricula depends not only on structural reforms and faculty training but also on a sustained commitment to collaboration and adaptability as educational needs evolve. [135-138]

VII. Integrating Educational Theories Into Preclinical Curriculum Design

Preclinical medical education is inherently complex, requiring students to acquire foundational scientific knowledge, develop cognitive frameworks for clinical reasoning, and start forming professional development. While traditional methods may help cover content, they often lack alignment with established educational theories that explain how students learn, remember, and apply knowledge. Modern medical education increasingly emphasizes the importance of theory-informed curriculum design to foster deep learning, enhance clinical reasoning, and support long-term retention. Different preclinical subjects demand unique cognitive and practical skills. Therefore, applying educational theories should be tailored to the specific context rather than used uniformly. [139,140]

Anatomy relies on experiential learning through dissection, supplemented by repetition and peer-assisted learning. Physiology and biochemistry are mainly cognitive, requiring structured mental models; case-based methods enhance clinical integration and help prevent rote memorization. Microbiology combines behaviorist repetition with cognitive organization, while clinical vignettes support practical application. Pharmacology is largely cognitive, focusing on mechanism-based schemas, with case-based prescribing and repeated exposure to improve retention. Pathology is primarily constructivist, integrating disease mechanisms with morphology and clinical features, supported by visual and experiential tools. Behavioral sciences emphasize social and experiential learning through observation and simulation, whereas biostatistics employs cognitive frameworks with applied problem-solving centered on interpretation. Preclinical medical education incorporates multiple learning theories across various disciplines. Overall, no single theory is sufficient; effective preclinical education requires the deliberate integration of experiential, cognitive, constructivist, and social approaches aligned with subject-specific learning needs.

Educational theory underpins curriculum design in medical education by explicitly linking pedagogical approaches to learning outcomes. Looking ahead, integrated educational theory will remain crucial for assessing and improving technological and pedagogical advances in medical education. Its continuous use offers a foundation for evaluating the effectiveness, scalability, and ethical aspects of new practices. As personalized learning, advanced simulation, and competency-based models become more common, applying different educational theories will be essential to ensure these updates support both professional development and patient-centered care. [44,101,141,142] Notably, grounding curricular innovations in integrated educational theory can lead to better patient outcomes, as students trained through evidence-based methods are more capable of applying clinical reasoning, communicating effectively with patients, and adapting to complex healthcare settings. Keeping a strong connection between theory and practice is therefore vital not only to creating curricula that are adaptable and relevant to current healthcare needs but also to ensuring future physicians are ready to provide high-quality, safe, and compassionate patient care. [105,143,144]

Table 2: Comparative Overview of Educational Theories: Core Elements and Implications for Medical Education

Educational Theory	Core Element	Implication in Education
Behaviorism	Stimulus–response learning, reinforcement, repetition, measurable behavioral change, feedback-driven learning	Used to develop observable clinical skills through practice, assessments, simulations, and structured skill training.
Cognitivism	Mental processing of information, memory organization, schema formation, problem-solving, and knowledge structuring	Enhances understanding, diagnostic reasoning, and organization of complex medical knowledge.
Constructivism	Active knowledge construction, learner-centered learning, reflection, contextual learning, prior knowledge integration	Encourages deep learning through problem-based learning (PBL), case discussions, and active participation.
Social learning theory	Learning through observation, imitation, role modeling, social interaction, and the development of self-efficacy	Promotes learning through mentorship, peer learning, faculty role modeling, and collaborative clinical environments.
Adult learning theory (Andragogy)	Self-directed learning, relevance to real-life problems, use of prior experience, internal motivation	Guides curriculum design for adult learners, including medical students, residents, and physicians, by emphasizing practical, problem-oriented learning.
Experiential learning theory	Learning cycle: experience → reflection → conceptualization → experimentation	Supports learning through clinical rotations, simulation training, bedside teaching, and reflective practice.
Cognitive load theory	Limited working memory capacity, intrinsic/extraneous/germane cognitive load, structured instructional design	Improves learning efficiency by simplifying teaching materials and preventing information overload.
Self-determination theory	Motivation based on autonomy, competence, and relatedness; intrinsic motivation enhances engagement	Encourages learner motivation, autonomy in learning, and the development of lifelong learning behaviors.

VIII. Discussion

The key insight from this review is that educational theory should not be seen as just background justification added after curriculum decisions are made. Instead, it should serve as a guiding framework for those decisions. Preclinical medical education now aims to support knowledge integration, clinical reasoning, motivation, early professional development, and adaptability in rapidly changing healthcare settings. Each subject also requires a tailored teaching approach aligned with its specific learning needs; using a one-size-fits-all method is pedagogically ineffective. No single educational theory sufficiently addresses the diverse learning needs involved in preclinical training. Instead, an integrated approach that draws on behaviorism, cognitivism, constructivism, social learning theory, experiential learning, and adult learning principles is necessary. The success of such integration depends not only on including multiple theories but on carefully aligning them with the particular learning goals and instructional strategies for each subject.

A significant weakness in preclinical education is that learning theories are often mentioned but not applied in practice. Teaching remains traditional, creating a gap between educational philosophy and actual practice. Effective curricula require purposeful alignment between each subject and the best methods for learning it. Different disciplines within medical education impose distinct cognitive and experiential demands and therefore require different primary learning theories, each supported by complementary approaches. The proposed framework addresses this gap by linking each preclinical subject to a dominant educational theory, supported by additional theories that enhance learning without diluting the core approach. In this way, every subject is guided by a dominant learning theory that influences teaching methods and assessments, such as experiential learning in anatomy or cognitivism in physiology. Without this, instruction becomes fragmented and less effective. Supporting theories should be used strategically to improve learning, such as behaviorist repetition for retention or social learning for teamwork. The goal is not to apply all theories equally but to integrate them intentionally.

Overall, curriculum design must move beyond merely referencing theories to actively using them to shape teaching and learning.

This review's findings support adopting integrated, theory-informed educational models, primarily by distinguishing between dominant and supporting theories based on curriculum and discipline requirements. This dominant and supportive model encourages structured, theory-driven curriculum design rather than random or disconnected approaches implementation.

Anatomy is fundamentally a spatial and tactile subject, requiring students to interact with three-dimensional structures and their relationships. Therefore, experiential learning theory is the primary approach. Behaviorism contributes through repetitive exercises such as spotters, while social learning theory enhances comprehension through group dissection and peer teaching. Both physiology and biochemistry require a strong focus on conceptual understanding and mental organization, as they involve complex mechanisms, pathways, and regulatory systems that must be effectively processed, stored, and recalled. Consequently, cognitivism is the main theory, emphasizing schema development, information processing, and logical reasoning, with Constructivism supporting it by enabling students to apply these ideas in clinical situations, such as interpreting lab abnormalities or metabolic disorders. This combination helps students move beyond simple memorization toward deeper understanding and clinical reasoning. Microbiology poses a unique challenge because it demands both extensive memorization and conceptual clarity. Students need to recall many organisms, classifications, and treatments (behaviorist approach), while also understanding pathogenic mechanisms and host responses (cognitivist approach). A dual approach combining behaviorism and cognitivism is ideal for teaching microbiology, with Constructivism aiding by integrating knowledge into clinical case discussions. Pharmacology is primarily a mechanism-based discipline, requiring understanding of drug actions, interactions, and therapeutic decision-making. Therefore, cognitivism is the dominant theory, as students must organize and synthesize knowledge of pharmacodynamics and pharmacokinetics. However, pharmacology also involves a large volume of factual details, such as drug names and side effects, where behaviorism supports learning through repetition and reinforcement. Constructivism also plays an important role by applying pharmacological principles in clinical scenarios, like choosing the right therapy based on the patient's condition. Pathology acts as a bridge between basic sciences and clinical medicine, requiring students to integrate anatomy, physiology, and biochemistry to comprehend disease processes. Constructivism is the main approach here, emphasizing active knowledge construction through case-based and problem-based learning. Students deepen their understanding by connecting pathophysiological mechanisms with clinical signs, lab results, and patient outcomes. Cognitivism supports this by providing the conceptual foundation needed to understand disease mechanisms. Behavioral science centers on communication, ethics, professionalism, and interpersonal skills, which are best learned through observation and interaction. As a result, social learning theory is the key approach, highlighting role modeling, mentorship, and peer interactions. Students develop professional behaviors by observing faculty and peers, participating in discussions, and reflecting on their experiences. Experiential learning further supports this with role-play, simulations, and OSCE training, allowing students to practice and hone these skills in realistic settings.

Aligning preclinical subjects with appropriate educational theories provides a clear, evidence-based framework for designing curricula. Recognizing each discipline's unique cognitive and experiential needs allows for more targeted and effective teaching strategies. This careful integration of primary and supporting theories is essential for enhancing learning outcomes in medical education. The framework emphasizes that no single educational theory suffices for all aspects of preclinical education. Instead, successful curricula are naturally multi-theoretical but must be structured and intentional. Each subject should be grounded in a dominant theory fitting its learning requirements, while supporting theories add depth and practical application.

This review has multiple strengths. It offers a comprehensive synthesis of various educational theories and places them within the context of preclinical medical education. By integrating both conceptual and practical perspectives, the review provides valuable guidance for educators and curriculum developers. Additionally, including both foundational and recent literature improves its relevance and depth. However, some limitations should be recognized. As a narrative review, it is inherently prone to selection bias and lacks the methodological rigor of systematic reviews or meta-analyses. Relying only on English-language publications may have excluded relevant studies from other regions. Furthermore, the review does not include a quantitative evaluation of the effectiveness of specific educational interventions, which limits the ability to draw causal conclusions. Future research should focus on empirically validating integrated, theory-based curricula through long-term and experimental studies. There is also a need for strong evidence on how particular educational strategies affect learning outcomes, clinical skills, and long-term retention. Lastly, investigating the role of emerging technologies, such as artificial intelligence and digital learning platforms, within theoretical frameworks is an important area for future research.

Table 3: Stage-wise Alignment of Educational Theories with Instructional Strategies in Preclinical Medical Education

Stage	Dominant Theory Applied	Instructional Strategy
Basic Knowledge	Cognitivism	Lecture + Concept mapping
Skill Building	Behaviorism	Lab training, OSCE
Clinical Integration	Constructivism	PBL, CBL
Professional Growth	Social learning	Mentorship
Motivation	Adult Learning	Self-directed learning
Real World Practice	Experiential	Simulation

OSCE-Objective Structured Clinical Examination, PBL-Problem-based learning, TBL-Team-based learning

Table 4: Proposed Alignment of Preclinical Subjects with Dominant and Supporting Educational Theories

Subject	Dominant Theory	Supporting Theory
Anatomy	Experiential	Behaviorism, Social
Physiology	Cognitivism	Constructivism
Biochemistry	Cognitivism	Constructivism
Microbiology	Behaviorism+ Cognitivism	Constructivism
Pharmacology	Cognitivism	Behaviorism, Constructivism
Pathology	Constructivism	Cognitivism
Behavioral Science	Social learning	Experiential

IX. Conclusion

In conclusion, educational theories are not just abstract ideas; they are practical tools that directly influence how medical students think, perform, and develop as clinicians. They provide a crucial foundation for effective preclinical medical education. Combining multiple theoretical perspectives allows for a more comprehensive and adaptable approach to teaching and learning. By aligning curriculum design with established educational principles, medical educators can increase student engagement, improve learning outcomes, and better equip future physicians for clinical practice. Incorporating insights from behaviorism, cognitivism, constructivism, experiential learning, and motivational theories helps educators create curricula that integrate learning with practical application. As medical education evolves, theory-based curriculum design will remain vital for preparing future doctors to address the complex challenges of modern healthcare. The application of these theories enhances knowledge retention, clinical skills, and lifelong learning abilities. Adopting integrated, theory-informed educational models, primarily as dominant and supportive theories, will reduce the gap in the application of educational theories within preclinical curricula.

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