Quantum Thinking in Graduate Medical Education: Transforming Minds, Methods, and Possibilities

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Consider a resident at a large academic medical center. Midway through their residency, the trainee begins to receive negative feedback regarding communication with colleagues and is reluctant to engage in feedback sessions. Despite strong clinical knowledge and previously high performance, the shift in behavior prompts concern among faculty. A remediation plan is initiated that focusses on structured supervision, direct observation, and professionalism modules. Now, let us pause and reflect. Why are we attributing the problems to the resident's attitude or compliance alone? How might we resolve these issues if we adopt a different lens?

Graduate medical education (GME) exists within the intricacies of structured training and unpredictable realities of clinical practice. The learning environment we experience today is no longer static but rather shaped by diverse learners, advances in technology, complex patient encounters, and unforeseen global health challenges.[1] In our roles as educators or residents we find ourselves at a critical juncture, where conventional models of teaching and learning struggle to keep pace with modern education and practices.[2]

Learning in medicine has never been merely about accumulating knowledge; it is about cultivating the ability to analyze, question, and apply information in complex and unpredictable contexts. Residents must move beyond passive learning to become active managers of their own intellectual and clinical development. Similarly, GME faculty must shift from being transmitters of knowledge to facilitators of deeper inquiry. Faculty must create environments where uncertainty is not seen as a gap in training but as an essential part of learning.[3] In GME, an overemphasis on rigid curricular structures at the expense of adaptability and intellectual flexibility may create learning environments that neglect essential context-sensitive factors (FIGURE 1).[4]

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Introducing the Quantum Thinking Approach

In physics, quantum mechanics is recognized as the science of uncertainty, commonly referred to as the Heisenberg Uncertainty Principle.[5] This principle demonstrates that certain properties, like position and momentum, cannot be precisely known at once. This is not a flaw, but rather a fundamental feature of reality. Within this uncertainty paradigm lies an intriguing cognitive model, the "quantum thinking" model, which invites us to embrace ambiguity, question absolutes, and remain open to complexity.[6,7]

The quantum thinking approach challenges traditional perspectives and invites us to consider multiple possibilities simultaneously.[8] At the core, quantum thinking is not about problem-solving; it is about problem-framing. A powerful example of this mindset is seen in forward-thinking business organizations that foster innovation in uncertain environments.[9] Their leadership frameworks emphasize comfort with ambiguity, systems thinking, and experimentation over rigid planning. Instead of asking, "What is the best idea?" teams are encouraged to explore a broad range of possibilities and reframe problems from multiple perspectives before converging on a solution.

Adopting a Quantum Thinking Approach

Adopting a quantum thinking model of cognition in GME requires a foundational mindset shift from one that resists complexity to one that embraces it.[10,11] Questions to guide quantum thinking resonate with principles found across established educational theories, such as complexity theory, systems theory, constructivist learning, and situated cognition, which advocate for deeper inquiry, contextual responsiveness, and dynamic framing of learning processes.[12-14] A quantum thinking framework also reinforces a key theme: that residency experiences and educational elements are not individually discrete but deeply entangled in how we are teaching and learning. Therefore, meaningful change must account for this interdependence (FIGURE 2).

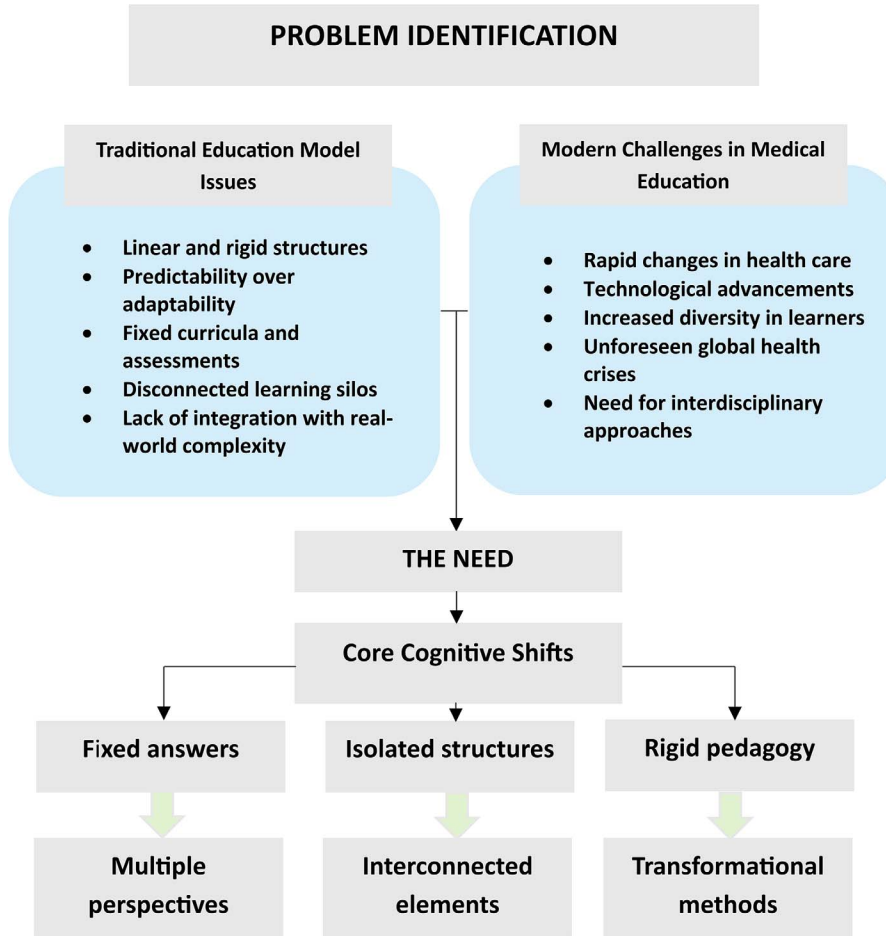

FIGURE 1
Current Challenges and Need for a Cognitive Shift in Problem Solving

To guide this shift, we must continuously engage with 3 critical questions: *Why is this happening? What if… ? If not this, then what?*

Question 1: Why Is This Happening?

The first question, *Why is this happening?* invites us to pause, reflect, and go beyond surface-level explanations to critically examine the underlying causes of a problem. This aligns with the quantum principle, "the observer effect," which refers to how the act of observing a phenomenon influences its behavior.[15] In GME, structured assessments, hierarchical supervision, fragmented rotations, and time-constrained feedback often shape how resident performance is interpreted.[16] This question enables clinicians and educators to critically examine whether observed difficulties stem from systemic features rather than individual deficits. The question can be posed during milestones evaluations, remediation planning, or end-of-rotation reviews to identify misalignments between curricular intent and clinical experience. In a context where pressures to meet competencies are high and learning environments are inconsistent, this question helps educators pause, reframe assumptions, and trace challenges to their educational roots, rather than responding only to their outward expressions.

In the example introduced earlier, the question shifts from "Why isn't the resident responding to remediation?" to "Why does the remediation process assume individual resident pathology in the first place?" On closer examination, the observed issue involves unspoken expectations about assertiveness, which are shaped by institutional culture and a hidden curriculum that conflates confidence with competence.

Question 2: What If… ?

The second question, *What if… ?* takes us to the very essence of quantum thinking, which is to contradict our initial opinions and expand our views. This question aligns with the principle of "entanglement": once

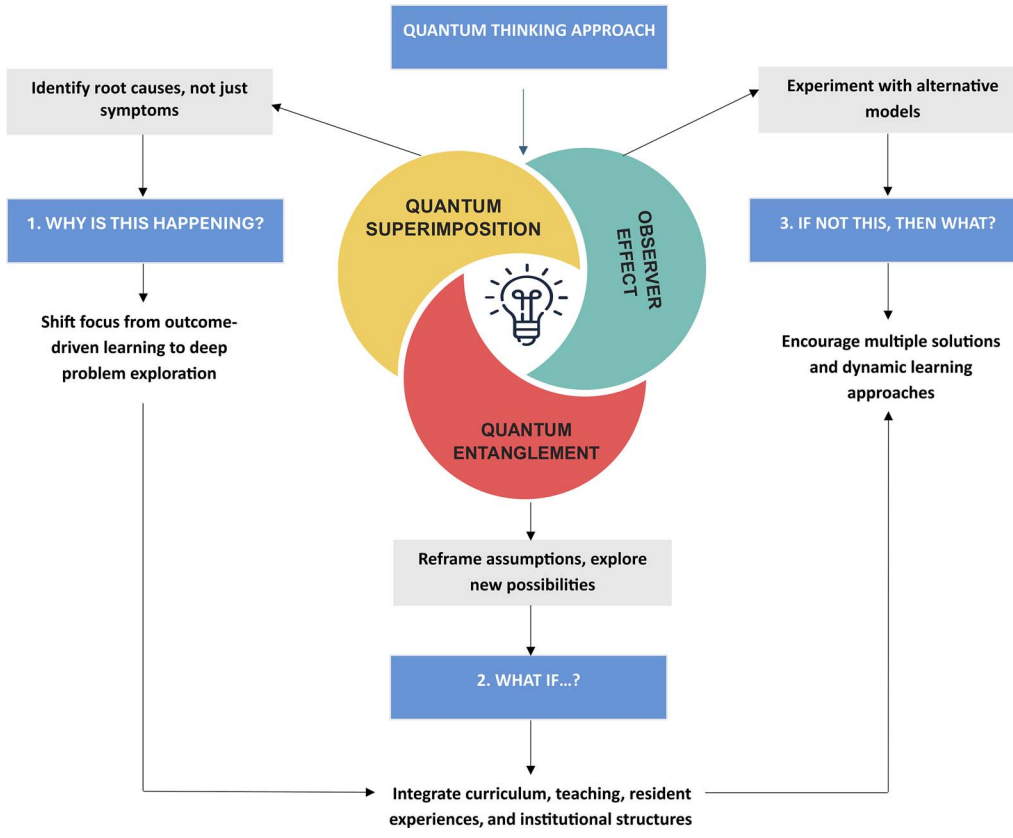

FIGURE 2
Conceptual Framework for Quantum Thinking Approach in Medical Education

particles interact, they remain connected, no matter how far apart they are.[17] GME is shaped by rotating teams, variable supervision, multiple assessment systems, and an intense clinical workload.[18] These layers often interact in unexpected ways, making it difficult to trace a single cause when problems arise. A shift in one domain, such as assessment or feedback, can ripple across curriculum design, learner identity, or institutional culture, often in subtle and unpredictable ways. Entanglement calls for careful mind-changing, which is grounded in awareness of interdependence rather than looking to solve isolated problems. For example, what other factors may be entangled, or in play, when a resident appears disengaged despite performing well, when assessment data feels inconsistent, or when feedback from different faculty members seems contradictory.

Applied to this resident, what if the resistance noted by faculty was not resistance at all, but a form of professional identity conflict? What if the structure of provided feedback created more anxiety than insight? What if other residents felt similarly, but the issue had not yet emerged? These questions may reframe the case from an individual remediation task to a systems-level blind spot.

Question 3: If Not This, Then What?

The third question, *If not this, then what?* pushes us to identify alternative approaches when existing methods appear to fail. This aligns with the quantum principle, "superimposition," that states multiple possibilities can exist at the same time. This encourages us to think beyond rigid, cause-and-effect approaches.[19] This question is fundamentally disruptive: It forces us to recognize alternate ideas and prompts a deeper interrogation of preexisting assumptions. GME is shaped by constant decision-making, such as what to prioritize in limited time, how to support residents across different rotations, and when to intervene in moments of concern. Superimposition thinking opens space to imagine alternatives that may not follow precedent but may better reflect current realities of clinical training and learning.

After considering the 3 questions, rather than implementing their usual knee-reflex remediation plan, the faculty team brainstorms about other plans to address the noted problems. Possibilities include a narrative feedback model, engaging the resident in guided reflective writing, or inviting cross-cultural conversations about professionalism expectations. This discussion

acknowledges complexity and opens new paths, while maintaining resident accountability.

The apparently paradoxical thinking of the quantum approach resists the premature closure of opinions and encourages a mindset where education and practice evolve alongside complexity rather than stagnating in past, more fixed models.[20,21] This mindset aligns with emerging ideas of medical training such as the "physicianeer" concept, which blends clinical education with engineering as well as design-thinking approaches, which emphasize adaptability, systems thinking, and interdisciplinary problem-solving.[22]

Thus, the key realization is that quantum thinking offers a meaningful reimagining of how we engage with complexities, particularly in education. It does not replace root cause analysis but invites us to look beyond linear causality and to consider the broader patterns, relationships, and unseen variables that shape the GME learning experience.[23-25] This orientation helps us move from reactive problem-solving to reflective sense-making. In doing so, we begin to see uncertainty not as a threat to be managed but as a space where insight and innovation can emerge. By asking deeper, more expansive questions, we open the door to new ways of designing, facilitating, and sustaining learning. Quantum thinking does not offer immediate answers; it reshapes the questions. And in that shift lies its transformative potential for educators, learners, and the future of GME.

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