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The Double Helix Model for Epistemic Reconstruction in Contemporary TCM Education: Structured Co-Existence, AI Mediation, and a Five-Year Roadmap

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Abstract

Traditional Chinese Medicine (TCM) education increasingly faces epistemic dependence under additive curricula that translate TCM concepts through biomedical standards, producing cognitive compartmentalization and weakening theoretical autonomy. This conceptual paper proposes a Double Helix Model for structured co-existence between two epistemic strands: an A-strand grounded in classical canons and *xiang*-based pattern thinking, and a B-strand providing scientific and technological instrumentation (systems biology, data science, and AI). Instead of premature fusion, the model stabilizes interaction through explicitly designed "base-pair" mechanisms, including digital hermeneutics for classical interpretation, knowledge graphs for structuring tacit knowledge, and dual-track clinical reasoning for comparative diagnosis. A staged five-year roadmap is outlined to operationalize immersion, translation, and autonomous synthesis in curriculum design.

Keywords Traditional Chinese Medicine education; Double Helix model; Epistemic dependence; Artificial intelligence mediation; Knowledge graphs

1 Introduction: The Epistemic Challenge of Contemporary TCM Education

1.1 From Discursive Marginalization to Epistemic Dependence

Since the establishment of modern higher education institutions for Traditional Chinese Medicine (TCM) in the mid-twentieth century, university-based education has played a crucial role in the standardization, systematization, and large-scale transmission of TCM knowledge. These institutional achievements have significantly enhanced the social legitimacy and organizational capacity of TCM within China's modern healthcare system. However, beneath this apparent institutional consolidation, a deeper epistemic tension has gradually emerged within TCM education.

This tension is frequently described in the literature as a form of *discursive marginalization*, whereby TCM increasingly loses its capacity to interpret clinical phenomena, evaluate therapeutic efficacy, and justify theoretical claims using its own conceptual language. Importantly, such marginalization does not imply a decline in clinical practice per se. Rather, it reflects a structural weakening of TCM's epistemic autonomy within contemporary educational and scientific evaluation systems.

In many current curricula, TCM concepts are often interpreted, translated, or justified primarily through the analytical framework of Western biomedicine. Diagnostic categories rooted in TCM's functional and relational ontology—such as patterns of imbalance, dynamic regulation, and systemic correspondence—are frequently redefined in terms of anatomical structures, biochemical indicators, or molecular mechanisms. While this strategy may facilitate short-term communication across medical paradigms, it simultaneously risks subordinating TCM knowledge to external epistemic standards.

This phenomenon can be more precisely described as *epistemic dependence*: a condition in which one knowledge system increasingly relies on another, dominant system to validate its own concepts, methods, and outcomes. Within medical education, epistemic dependence tends to emerge not through explicit exclusion, but through curricular structures, assessment criteria, and implicit hierarchies of scientific legitimacy.

1.2 Additive Curricula and Cognitive Compartmentalization

A central institutional mechanism contributing to epistemic dependence is the widespread adoption of additive curricular models. In such models, courses in TCM and Western medicine are arranged in parallel or sequential blocks—commonly framed as "TCM courses plus biomedical courses"—without a coherent epistemological architecture governing their relationship.

Empirical studies in medical education suggest that additive curricula often lead to *cognitive compartmentalization*. Students learn to activate different explanatory frameworks in different contexts, rather than developing an integrated or reflexive understanding of multiple medical paradigms. In practice, this results in a dual cognitive structure: biomedical reasoning is mobilized in technologically intensive or acute clinical settings, while TCM reasoning is reserved for supplementary or supportive interventions.

From an educational perspective, such compartmentalization does not constitute genuine interdisciplinary competence. Instead, it encourages a form of pragmatic switching that leaves underlying epistemological conflicts unresolved. Over time, students may internalize a hierarchy of credibility in which quantitatively measurable, anatomically grounded explanations are perceived as inherently more scientific than relational or phenomenological accounts of health and illness.

The consequence is not merely pedagogical inefficiency, but a gradual erosion of TCM's theoretical integrity. When core TCM concepts are habitually explained through external biomedical analogies, they risk being reduced to illustrative metaphors rather than functioning as autonomous analytical tools.

1.3 Epistemic Reconstruction under the Framework of New Medical Sciences

In recent years, educational reforms associated with the framework of "New Medical Sciences" have emphasized interdisciplinary integration, digital transformation, and the incorporation of emerging technologies such as artificial intelligence, big data, and systems biology. These reforms provide both opportunities and risks for TCM education.

On the one hand, advanced technologies offer unprecedented tools for data analysis, visualization, and pattern recognition, potentially enhancing the empirical articulation of complex medical phenomena. On the other hand, without a clearly articulated epistemic strategy, technological integration may inadvertently reinforce existing asymmetries between knowledge systems. In such cases, digital tools become instruments for translating TCM into biomedical terms, rather than mediating between distinct epistemological logics.

This paper argues that the core challenge facing contemporary TCM education is not the absence of integration, but the lack of an explicit epistemic architecture capable of sustaining plurality without assimilation. Addressing this challenge requires a shift from additive models of curriculum design toward a

structurally differentiated framework that preserves epistemic identity while enabling systematic interaction.

1.4 Toward a Conceptual Model of Structured Co-Existence

In response to these challenges, this study proposes a conceptual educational framework termed the *Double Helix Model*. Drawing on the biological metaphor of the DNA double helix, the model conceptualizes TCM education as comprising two analytically distinct yet dynamically interconnected epistemic strands: one grounded in the ontological and cognitive traditions of TCM, and the other oriented toward modern scientific and technological methodologies.

Unlike fusion-oriented or hybrid models, the Double Helix Model emphasizes *structured co-existence*. Each strand retains its internal coherence and evaluative standards, while interaction occurs through explicitly designed mediating mechanisms rather than implicit assimilation. The purpose of this model is not to resolve epistemological differences, but to render them pedagogically productive.

As a conceptual paper, this study does not seek to provide empirical validation of the proposed framework. Instead, it aims to clarify the epistemic conditions under which emerging technologies—particularly artificial intelligence and knowledge representation systems—may function as mediating instruments rather than epistemic arbiters. The subsequent sections elaborate the theoretical foundations, structural components, and educational implications of the Double Helix Model within the context of TCM education reform.

2 Theoretical Framework: Epistemic Divergence and the Limits of Additive Integration

2.1 Ontological Commitments in Medical Knowledge Systems

Medical knowledge systems are grounded not only in empirical observations, but also in implicit ontological commitments that shape how phenomena are perceived, classified, and explained. Western biomedicine and Traditional Chinese Medicine (TCM) represent two paradigmatic examples of such epistemically divergent systems.

Modern biomedicine is largely constructed upon a substantial ontology, in which the body is conceptualized as an assemblage of discrete anatomical structures governed by linear causal mechanisms. Disease, within this framework, is typically defined as a localized dysfunction attributable to identifiable structural, biochemical, or molecular abnormalities. Epistemic validity is closely associated with measurability, reproducibility, and reduction to constituent parts.

By contrast, TCM is rooted in a generative and relational ontology. Its core analytical units are not isolated structures, but dynamic functional states emerging from systemic interaction. Concepts such as *qi*, *yin–yang*, and the *five phases* do not denote material entities, but relational processes through which physiological balance and pathological transformation are interpreted. Knowledge production within TCM emphasizes pattern recognition, contextual interpretation, and experiential continuity rather than linear causation.

These ontological differences are not merely theoretical abstractions; they actively shape diagnostic reasoning, therapeutic decision-making, and criteria of validity within educational and clinical practice. Attempts to reconcile these systems without acknowledging their distinct ontological commitments risk producing conceptual distortion rather than genuine integration.

2.2 Epistemic Incommensurability and Educational Friction

The coexistence of multiple medical paradigms within a single educational environment inevitably generates epistemic tension. Drawing on the notion of epistemic incommensurability, such tension arises

when distinct knowledge systems employ fundamentally different criteria for explanation, justification, and evaluation.

In the context of medical education, incommensurability does not imply mutual exclusivity. Rather, it indicates that concepts, methods, and evidentiary standards cannot be seamlessly translated without loss of meaning. For example, attempts to equate TCM pattern diagnoses directly with biomedical disease categories may facilitate surface-level communication, yet obscure the functional logic through which TCM concepts operate.

When educational institutions fail to address this incommensurability explicitly, students are left to navigate competing explanatory frameworks on their own. The result is often cognitive dissonance, managed through pragmatic compartmentalization rather than reflective synthesis. Over time, this process may encourage implicit epistemic hierarchies in which biomedical explanations are perceived as primary, while TCM knowledge is relegated to a supplementary or symbolic role.

Such outcomes reflect not a failure of individual learners, but a structural limitation of educational design. Without an articulated framework that acknowledges epistemic plurality, curricular integration tends to default toward assimilation by the dominant paradigm.

2.3 Epistemic Dependence as a Structural Outcome

Within pluralistic educational settings, epistemic dependence emerges when one knowledge system increasingly relies on another to establish legitimacy. In medical education, this dependence often manifests through assessment standards, research evaluation metrics, and curricular sequencing that privilege reductionist methodologies and quantitative indicators.

For TCM education, epistemic dependence is particularly consequential. When TCM concepts are routinely validated through external biomedical mechanisms, their internal coherence and explanatory autonomy may be progressively weakened. This does not necessarily invalidate empirical research on TCM therapies; rather, it highlights a structural imbalance in how knowledge is framed and authorized.

Importantly, epistemic dependence differs from interdisciplinary collaboration. Collaboration presupposes reciprocal recognition of epistemic integrity, whereas dependence reflects asymmetrical validation. Educational models that conflate the two risk reinforcing the very hierarchies they seek to overcome.

2.4 Theoretical Implications for Educational Design

The theoretical analysis above suggests that the core challenge in contemporary TCM education is not a lack of integration, but an absence of epistemically informed structure. Additive curricular models, while administratively convenient, are insufficient to address ontological divergence and epistemic asymmetry.

An effective educational framework must therefore satisfy two conditions simultaneously. First, it must preserve the internal coherence of distinct medical epistemologies, allowing each to operate according to its own ontological logic. Second, it must enable systematic interaction through explicitly designed mediating mechanisms that do not presuppose conceptual reduction or hierarchical assimilation.

These requirements point toward a model of structured epistemic co-existence rather than unification. Such a model treats epistemic difference as a pedagogical resource rather than a problem to be eliminated. Within this framework, emerging technologies—particularly artificial intelligence and knowledge representation systems—can be reconceptualized not as arbiters of scientific legitimacy, but as instruments for translation, comparison, and reflexive understanding.

The following section introduces the Double Helix Model as a conceptual response to these theoretical constraints, outlining how epistemic differentiation and interaction may be simultaneously institutionalized within TCM education.

3 The Double Helix Model: Dual-Strand Co-Existence in TCM Education

The Double Helix Model conceptualizes Traditional Chinese Medicine (TCM) education as a structurally differentiated system composed of two epistemically distinct yet functionally interconnected strands. Rather than pursuing fusion or unification, the model institutionalizes epistemic plurality through structured co-existence, ensuring both autonomy and interaction. In this framework, epistemic difference is not treated as a deficiency to be resolved, but as a productive condition to be pedagogically organized.

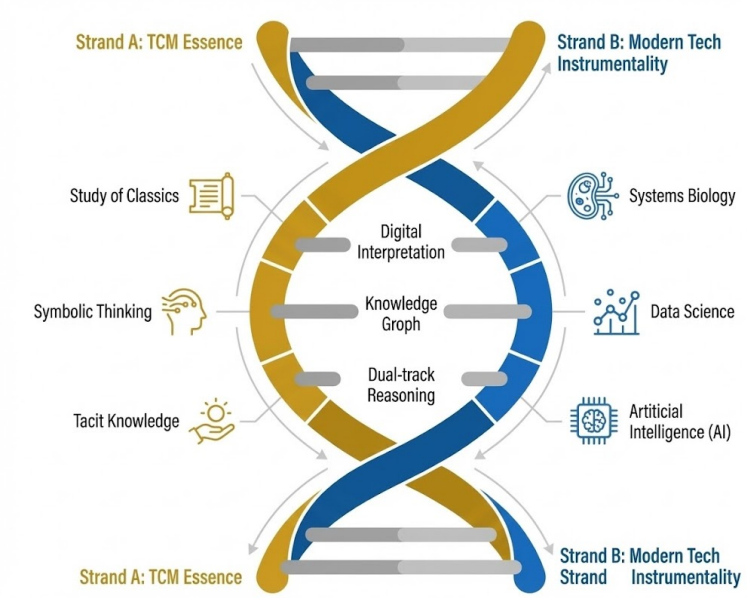

Figure 1: Conceptual diagram of the Double Helix educational model. *The golden A-strand represents the epistemic subjectivity of Traditional Chinese Medicine (TCM), encompassing classical text study and* xiang*-based thinking training. The blue B-strand represents the instrumental dimension of modern science and technology, including systems biology, data science, and artificial intelligence. The two strands are tightly connected through key mediating mechanisms—namely digital interpretation, knowledge graphs, and dual-track clinical reasoning—which together form stable epistemic linkages analogous to base pairs. Through this structured interaction, the model supports the cultivation of new medical professionals who combine epistemic autonomy with translational and technological competence.*

3.1 The A-Strand (Golden Strand): Epistemic Subjectivity and Original TCM Thinking

The A-strand represents the autonomous knowledge system of Traditional Chinese Medicine. Its central educational function is to re-establish the legitimacy and explanatory power of *xiang thinking*, a mode of reasoning grounded in holistic perception, relational interpretation, and pattern recognition. As the epistemic foundation of the curriculum, the A-strand largely determines the distinctive intellectual orientation and professional identity of TCM practitioners.

The ontological core of the A-strand is anchored in the classical canon of TCM, particularly the four foundational texts: *Huangdi Neijing*, *Shanghan Lun*, *Jingui Yaolue*, and *Wenbing Tiaobian*. Within the Double Helix Model, these texts are not treated merely as historical or philological artifacts. Instead, they are approached as repositories of living knowledge that continue to guide clinical reasoning and therapeutic judgment. Accordingly, curricular design within the A-strand emphasizes the clinical applicability of classical concepts rather than limiting instruction to textual exegesis or linguistic annotation.

At the epistemological level, the A-strand affirms the primacy of TCM as a self-sufficient interpretive system. Educationally, this entails cultivating learners' capacity to initiate TCM-based pattern recognition

instinctively when encountering clinical phenomena. For example, a diagnosis such as "kidney deficiency" is first understood as a functional constellation encompassing growth, reproduction, and fluid metabolism, rather than being immediately reduced to anatomical or pathological abnormalities of the renal organ. This approach reinforces epistemic confidence and protects against unconscious assimilation into biomedical explanatory frameworks.

Pedagogically, the A-strand revitalizes and adapts traditional modes of instruction, including recitation, embodied practice, and apprenticeship-based clinical learning. Through sustained engagement with classical language and guided clinical observation, students internalize the linguistic logic and perceptual sensitivity central to TCM practice. A significant portion of this learning involves the acquisition of tacit knowledge, such as pulse differentiation and embodied diagnostic calibration. Such knowledge cannot be fully articulated through formal instruction and must instead be cultivated through bodily immersion and experiential continuity.

3.2 The B-Strand (Blue Strand): Scientific Objectivity and Translational Capacity

The B-strand reflects the contemporary orientation of New Medical Sciences and provides methodological resources for validation, interpretation, and epistemic expansion. Importantly, this strand is not designed to replace or dominate the A-strand, but to enhance its explanatory reach and communicative capacity within modern scientific and clinical contexts.

In terms of curricular content, the B-strand extends beyond conventional biomedical subjects such as anatomy, physiology, and pathology. It incorporates systems biology, bioinformatics, data science—including programming in Python and R—and complexity science. These disciplines are particularly suited to the analysis of non-linear, multi-level biological systems and therefore exhibit a natural conceptual affinity with the holistic orientation of TCM.

The epistemological stance of the B-strand may be characterized as a form of critical realism combined with scientific translation. Students are encouraged to investigate the material and biological correlates underlying TCM clinical efficacy without presuming reductionist equivalence. For instance, metabolomic approaches may be employed to characterize biochemical signatures associated with a TCM pattern such as "spleen deficiency," thereby rendering previously invisible functional states accessible to empirical observation. This process does not negate the conceptual integrity of TCM; rather, it expands its interpretive visibility and facilitates dialogue with contemporary biomedical research.

A defining principle of the B-strand is the explicit positioning of modern science and technology as epistemic instruments rather than arbiters of legitimacy. Within this framework, technologies function as microscopes and telescopes that extend perceptual range, rather than as judicial authorities that determine theoretical validity. Educational design within the B-strand therefore emphasizes methodological reflexivity and actively resists forms of technological determinism or metric absolutism.

3.3 Interaction Mechanisms (Base Pairs): Structured Non-Fusion

The stability of the Double Helix Model depends on the presence of clearly defined interaction mechanisms analogous to base pairs in a biological double helix. Complete separation between epistemic strands results in fragmentation, while unregulated integration risks assimilation. The model therefore introduces structured mediating practices that enable interaction without fusion.

One such mechanism is digital hermeneutics, through which artificial intelligence techniques are applied to the analysis of classical TCM texts. By establishing systematic mappings between classical terminology and contemporary semantic structures, digital hermeneutics supports interpretive translation while preserving conceptual nuance.

A second mechanism is dual-track clinical reasoning. In clinical education, students are trained to apply both TCM pattern differentiation and biomedical disease classification to the same case. Rather than forcing premature reconciliation, this approach encourages explicit comparison, enabling learners to identify points of convergence and divergence between paradigms without privileging one a priori.

A third mechanism involves translational medicine seminars, which provide structured forums for transforming clinical insights derived from TCM practice into empirically testable hypotheses. These seminars cultivate bidirectional translation between experiential knowledge and scientific investigation, reinforcing epistemic reciprocity rather than hierarchical validation.

Together, these interaction mechanisms function as epistemic connectors that stabilize the Double Helix Model. They enable sustained dialogue between autonomous knowledge systems while preserving the internal coherence and evaluative integrity of each strand.

Table 1: Structural Components and Epistemic Functions of the Double Helix Model

Structural Component	**Symbolic Metaphor**	**Core Courses / Activities**	**Epistemic Function**	**Educational Objective**
A-Strand (Subject Strand)	Golden Helix	Classical TCM texts, classical Chinese, TCM philosophy, case-based learning from renowned physicians, traditional practices	Ontological grounding: establishing a worldview based on *qi*, yin–yang, and the five phases; cultivating intuitive and holistic perception	Cultural confidence: consolidating the metacognitive status of TCM thinking and preventing unconscious assimilation into biomedical logic
B-Strand (Instrumental Strand)	Blue Helix	Systems biology, bioinformatics, Python-based data analysis, evidence-based medicine, modern anatomy and physiology	Methodological empowerment: providing objective and quantitative tools to link micro-level mechanisms with macro-level clinical phenomena	Scientific literacy: acquiring a shared language for dialogue with contemporary medicine and developing translational research capacity
Interaction Mechanisms (Base Pairs)	Hydrogen Bonds	AI-assisted TCM analysis, dual-track clinical rounds, integrative narrative medicine	Epistemic translation: enabling commensurability between heterogeneous knowledge systems without altering the conceptual integrity of TCM	Cross-paradigmatic innovation: cultivating the ability to navigate between TCM and biomedical paradigms and generate insights from epistemic tension

4 The Epistemic Role of Technology: Artificial Intelligence as a Mediating Medium

Within the Double Helix Model, artificial intelligence (AI) and digital technologies are no longer conceptualized merely as instruments for improving efficiency or accuracy. Instead, they are positioned as epistemological media that mediate between heterogeneous knowledge systems. In the context of Traditional Chinese Medicine (TCM) education, such technologies function as bridges between the inherent ambiguity of pattern-based reasoning and the precision-oriented logic of modern biomedicine. By doing so, they address long-standing educational challenges associated with invisibility, non-quantifiability, and limited intersubjective accessibility.

Rather than resolving epistemic differences through reduction or substitution, AI-enabled technologies enable controlled translation across paradigms. Their epistemic value lies not in adjudicating the validity of competing medical theories, but in rendering distinct modes of reasoning mutually intelligible within pedagogical and clinical contexts.

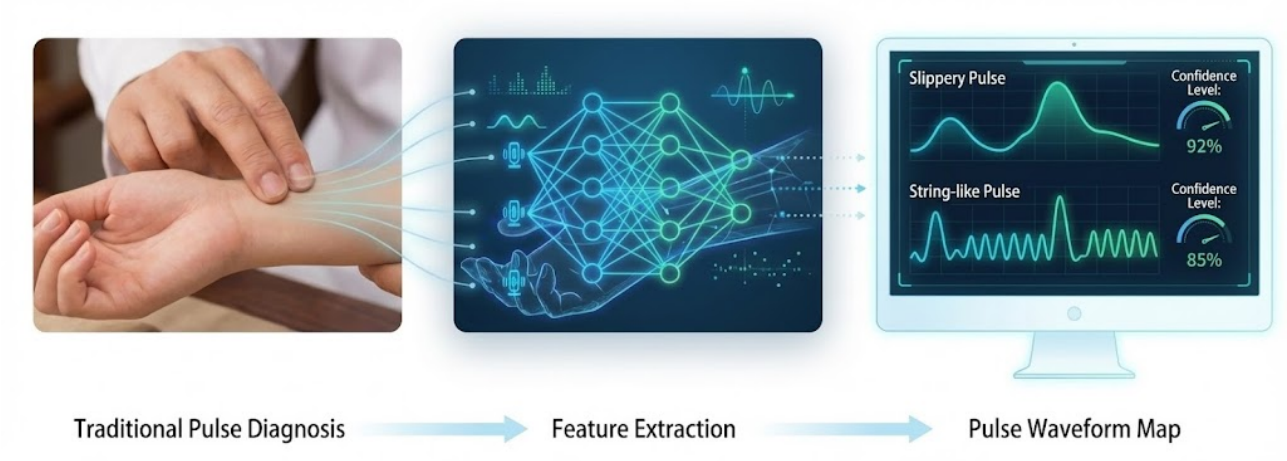

Figure 2: AI-based Pulse Diagnosis Digitization Process. *The left side depicts a traditional Traditional Chinese Medicine (TCM) pulse-taking scene (a subjective experience). The middle section shows the extraction of features through sensors and deep learning algorithms. The right side generates a visualized "pulse waveform map" (inter-subjective data), transforming the implicit "slippery pulse" into quantifiable waveform parameters, which provides a common language for teaching and research.*

4.1 From Subjectivity to Intersubjectivity: Digital Phenomenology and the TCM Digital Twin

Historically, one of the most persistent critiques directed at TCM concerns the perceived subjectivity of its diagnostic practices. Techniques such as pulse diagnosis have often been described as highly individualized and resistant to standardization, encapsulated in the classical expression that insight may be clear in the practitioner's mind yet elusive at the fingertips. This characteristic has limited the scalability and reproducibility of TCM pedagogy within institutional settings.

Advances in sensor technologies and machine learning provide a pathway beyond this limitation through what may be described as digital phenomenology. High-resolution sensors and wearable devices enable the digitization of traditionally qualitative diagnostic signals, such as pulse waveforms and tongue coloration, transforming them into high-dimensional data streams. Importantly, this process does not replace clinical intuition. Instead, it establishes a repeatable and quantifiable digital baseline that supports shared reference and comparative learning among practitioners.

The epistemic affinity between artificial intelligence and TCM reasoning further reinforces this mediating role. Deep learning systems, often characterized as "black boxes," operate primarily through pattern recognition rather than explicit linear causation. This mode of inference parallels the logic of TCM, in which diagnostic conclusions emerge from holistic configurations of symptoms rather than isolated causal chains. Such structural similarity renders AI a particularly compatible partner for TCM, often more so than reductionist biomedical models that privilege singular mechanisms.

Building upon these developments, the concept of the digital twin offers an additional layer of pedagogical and clinical significance. By constructing virtual representations of patients that integrate multi-omic data with TCM pattern differentiation, digital twins allow simulation of therapeutic interventions within a controlled environment. For educational purposes, this enables students to experiment with treatment strategies, observe dynamic changes in functional states, and gain an intuitive understanding of systemic regulation. In this setting, simulation serves not as a substitute for clinical experience, but as a reflective extension that accelerates experiential learning.

4.2 Knowledge Graphs and the Structuring of Tacit Knowledge

TCM knowledge is characterized by its breadth, historical depth, and reliance on experiential transmission. Much of this knowledge is distributed across classical texts, clinical case records, and the embodied expertise of senior practitioners, resulting in a highly unstructured knowledge landscape. Knowledge graph technologies play a crucial role in addressing this challenge by serving as epistemic connectors between the A-strand and the B-strand of the Double Helix Model.

Through formalized ontologies and relational structures, knowledge graphs make implicit conceptual linkages explicit. They enable the visualization of relationships among symptoms, syndromes, prescriptions, medicinal substances, bioactive compounds, and therapeutic targets. By organizing these elements into multi-layered networks, knowledge graphs reveal the internal logic of TCM pattern differentiation and treatment strategies without imposing reductive equivalence.

Beyond visualization, knowledge graphs support heterogeneous knowledge fusion. Classical textual data, chemical databases, and real-world clinical records can be linked through shared ontological frameworks. This allows biomedical diagnostic categories and TCM pattern classifications to coexist within a single representational system while maintaining their respective conceptual boundaries. In doing so, knowledge graphs facilitate comparison and translation without conceptual erosion.

Equally important is the pedagogical function of knowledge graph construction. Within the Double Helix educational framework, students are encouraged not only to consult existing graphs but to participate in their development. Defining entities and relationships requires careful reflection on conceptual scope, causal assumptions, and relational meaning. This process constitutes an intensive form of epistemic training, prompting learners to distinguish between correlation and causation, overlap and parallelism, and translation and reduction. As such, knowledge graph construction cultivates analytical rigor, logical reasoning, and epistemic reflexivity.

Taken together, digital phenomenology, artificial intelligence, digital twins, and knowledge graphs function as mediating infrastructures rather than dominant epistemic authorities. They stabilize intersubjective understanding, enhance translational capacity, and preserve epistemic plurality. Within the Double Helix Model, technology thus assumes a generative yet disciplined role, enabling dialogue between distinct medical paradigms while safeguarding the autonomy of each.

5 Curricular Implementation: A Five-Year Double Helix Roadmap (Conceptual Framework)

To translate the Double Helix Model from theory into educational practice, this study proposes a conceptual five-year curricular roadmap for TCM education. The roadmap draws inspiration from immersion-based bilingual education, emphasizing staged differentiation and gradual interaction between epistemic systems. Its primary objective is to avoid premature integration, which often results in superficial hybridization and epistemic dilution.

Rather than enforcing early synthesis, the roadmap is designed to cultivate parallel epistemic competencies before introducing structured interaction and, ultimately, autonomous synthesis. Table 2 summarizes the developmental stages, strategic focus, and corresponding educational activities.

5.1 Foundation Stage (Years 1–2): Immersion and Separation

The foundation stage is designed to prevent premature epistemic fusion. Early integration of TCM and biomedicine often leads to the subsumption of TCM reasoning under biomedical explanatory frameworks. To avoid this outcome, the Double Helix roadmap requires the A-strand and B-strand to develop in parallel but remain epistemically distinct during the initial phase.

Table 2: A Conceptual Five-Year Roadmap for the Double Helix Curriculum

Stage	Years	Core Strategy	A-Strand Focus (TCM)	B-Strand Focus (Science / Biomedicine)	Interaction Mechanisms
Foundation	1–2	Immersion and Separation	Classical text memorization, classical Chinese, traditional culture, foundational TCM theory (pure TCM epistemic context)	Advanced mathematics, Python programming, introduction to data science, basic chemistry and biology	Comparative history of Chinese and Western medicine: understanding epistemic divergence from historical origins
Interaction	3–4	Translation and Dialogue	Clinical theory across TCM specialties, analysis of classical and contemporary medical cases	Systems biology, bioinformatics, modern diagnostics, pathology	Dual-track clinical rounds, digital TCM laboratories, case-based and BOPPPS-oriented pedagogy
Synthesis	5	Autonomy and Innovation	Apprenticeship-based clinical training emphasizing tacit knowledge acquisition	Evidence-based research design, statistical analysis	Double Helix capstone project based on knowledge graphs or AI-assisted clinical inquiry

Within the A-strand, instruction emphasizes intensive engagement with classical texts such as the *Huangdi Neijing* and the *Nan Jing*, supplemented by courses in classical Chinese philosophy and traditional culture. Students are encouraged to develop a sensorial and intuitive understanding of concepts such as *qi* and *dao*. Assessment during this stage prioritizes memorization, interpretive reasoning, and traditional modes of argumentation. Importantly, students are discouraged from explaining TCM concepts using biomedical terminology, thereby reinforcing an independent TCM cognitive circuit.

Concurrently, the B-strand focuses on foundational scientific literacy. In addition to standard natural science courses, students receive early training in programming and data science. These skills are presented as a neutral methodological toolkit rather than as interpretive authorities, preparing students for later translational work without influencing their primary epistemic orientation.

A key bridging element during this stage is the comparative history of medicine. By examining the historical trajectories through which Chinese and Western medical systems diverged, students develop epistemic self-awareness and an explicit understanding of paradigm formation.

5.2 Interaction Stage (Years 3–4): Translation and Dialogue

Once students have established parallel epistemic foundations, the curriculum shifts toward structured interaction and translation. The central pedagogical challenge at this stage is to enable dialogue without collapsing conceptual distinctions.

Instructional methods during this phase emphasize case-based learning and structured pedagogical frameworks such as BOPPPS. Dual-track clinical rounds are introduced, requiring students to generate both TCM pattern diagnoses and biomedical disease classifications for the same clinical scenario. Rather than reconciling these diagnoses immediately, students are guided to analyze their respective explanatory scopes and limitations.

Integrative tasks further deepen this process. For example, in cases where biomedical indicators appear controlled yet symptoms persist, students are encouraged to explore how TCM interpretations account for unresolved functional imbalance. Digital TCM laboratories support this inquiry by allowing students

to compare sensor-based diagnostic outputs with their own embodied assessments. Through iterative human–machine feedback loops, learners refine both perceptual sensitivity and analytical judgment.

5.3 Synthesis Stage (Year 5): Autonomy and Innovation

The final stage emphasizes epistemic autonomy and integrative innovation. Clinical training is organized around a dual-mentorship system, with students rotating between TCM-specialized wards and integrative clinical settings. In TCM-focused environments, attention is placed on refining diagnostic micro-skills such as observation, listening, inquiry, and palpation. In integrative settings, students focus on strategic decision-making and treatment optimization across paradigms.

The capstone requirement of this stage is a Double Helix graduation project. Students select a clinical problem and analyze it through both epistemic strands, employing tools such as knowledge graphs or AI-assisted modeling where appropriate. An illustrative topic might involve extracting treatment patterns from classical texts and examining their correspondence with contemporary neurobiological mechanisms. Such projects require competence in textual interpretation, biomedical reasoning, and data-driven analysis, thereby demonstrating genuine epistemic synthesis rather than superficial integration.

6 Discussion: Challenges, Responses, and Policy Implications

6.1 Reconstructing the Epistemic Subject of TCM: From Inferiority to Cultural Confidence

The ultimate objective of the Double Helix Model is not merely curricular optimization, but the cultivation of a new generation of scholars endowed with epistemic subjectivity and cultural confidence. For an extended period, students in TCM institutions have often internalized a sense of professional inferiority, perceiving TCM as less "scientific" or less legitimate than biomedicine. This psychological condition has manifested as both epistemic insecurity and legitimacy anxiety within educational and clinical practice.

The Double Helix Model addresses this condition through a dual pathway. Mastery of the B-strand enables students to engage confidently with modern science and technology without fear or blind reverence. Concurrently, deep immersion in the A-strand roots learners in the internal coherence, philosophical depth, and clinical sophistication of TCM. The resulting epistemic posture is neither defensive nor oppositional. Instead, it produces scholars who employ scientific tools to elucidate TCM concepts, rather than to adjudicate or invalidate them. In doing so, the model directly confronts the long-standing inferiority complex and restores epistemic self-confidence within TCM education.

6.2 Faculty Constraints and the Necessity of Epistemic Re-Education

The most significant practical challenge in implementing the Double Helix Model lies in faculty structure. Many current instructors are themselves products of additive educational systems and consequently lack cross-strand teaching capacity. It is common for TCM specialists to be unfamiliar with artificial intelligence and data science, while biomedical instructors often lack meaningful engagement with TCM theory and practice.

A feasible response to this constraint is the adoption of co-teaching strategies. Pairing senior TCM clinicians with data scientists or systems biologists in the delivery of bridging courses enables complementary expertise to be mobilized within a single instructional context. For example, in teaching pulse diagnosis, a senior practitioner may demonstrate tactile techniques while a data specialist explains waveform analysis. Such collaborative arrangements not only enhance student learning, but also facilitate faculty-level epistemic renewal through sustained interdisciplinary interaction.

6.3 Policy Implications: Precision Allocation under the Framework of New Medical Sciences

At the policy level, the findings of this study suggest that initiatives under the banner of New Medical Sciences should not be equated with unidirectional biomedicalization. Resource allocation strategies that focus exclusively on reductionist research, such as the isolation of active compounds, risk further marginalizing holistic medical knowledge systems.

Instead, policy frameworks should prioritize the development of digital TCM laboratories and epistemology-oriented training platforms. Evaluation systems likewise require recalibration. In addition to conventional bibliometric indicators associated with the B-strand, assessment mechanisms should recognize clinical efficacy, classical theory innovation, and translational outputs that bridge epistemic systems. Under such a pluralistic evaluation regime, the construction of a high-quality TCM knowledge graph may be regarded as comparable in scholarly value to publication in high-impact scientific journals.

7 Conclusion

The epistemic reconstruction of Traditional Chinese Medicine (TCM) education should not be misunderstood as a return to nostalgic traditionalism, nor as resistance to scientific modernity. Rather, it reflects a pragmatic response to the pressing challenges of sustainability, legitimacy, and innovation facing plural medical knowledge systems in the contemporary world. The central question addressed by this study is not whether TCM should modernize, but how modernization can proceed without eroding epistemic identity.

The Double Helix Model proposed in this paper offers a conceptual solution to this dilemma by reconfiguring the relationship between inheritance and innovation. Instead of forcing premature integration or hierarchical unification, the model institutionalizes epistemic differentiation while enabling structured interaction. By treating TCM ontology and modern scientific methodology as two autonomous yet interconnected strands, the model resolves a century-long tension that has shaped medical education reform debates in China and beyond.

At the theoretical level, this study advances understanding of how additive educational models generate epistemic dependence. It demonstrates that the persistent marginalization of TCM within modern institutions is not primarily the result of empirical inadequacy, but of structural asymmetry embedded in curricular design, evaluation systems, and implicit hierarchies of scientific legitimacy. The Double Helix Model addresses this asymmetry by reframing epistemic plurality as a productive condition rather than a transitional problem to be eliminated.

At the technological level, the paper redefines the role of artificial intelligence and digital technologies in medical education. Rather than positioning AI as an external judge or efficiency-enhancing instrument, it conceptualizes technology as an epistemological medium capable of mediating between heterogeneous modes of reasoning. Through digital phenomenology, digital twins, and knowledge graphs, previously tacit, experiential, and pattern-based knowledge becomes intersubjectively accessible without being reduced to mechanistic explanation. In this sense, technology does not replace human judgment, but extends the conditions under which understanding can be shared, examined, and refined.

At the practical level, the proposed five-year curricular roadmap illustrates how epistemic reconstruction can be operationalized without sacrificing conceptual rigor. By sequencing immersion, interaction, and autonomous synthesis, the roadmap avoids the risks of superficial hybridization and cognitive fragmentation. It demonstrates that genuine integration is an outcome of epistemic maturity rather than its prerequisite, and that educational design must respect the temporal dynamics of knowledge formation.

Beyond the specific context of TCM education, the implications of this study extend to broader debates on knowledge governance in an era of rapid technological transformation. As artificial intelligence

increasingly reshapes scientific practice, education, and healthcare, the challenge of preserving epistemic diversity while enabling interoperability becomes ever more urgent. The Double Helix Model contributes to this discourse by offering a transferable framework for organizing plural knowledge systems without resorting to reductionism or relativism.

Ultimately, the model points toward the possibility of constructing a genuinely autonomous knowledge system—one that neither rejects modern science nor dissolves indigenous epistemologies into dominant paradigms. Within such a system, future physicians are not positioned as imperfect imitators of biomedicine, but as epistemically bilingual practitioners. Fluent in both the poetic language of holistic medicine and the computational language of contemporary science, they are equipped to navigate complexity, embrace uncertainty, and contribute to a more integrative and humane understanding of life and health.

In this sense, the Double Helix Model is not merely a proposal for curricular reform, but an invitation to rethink how knowledge itself is organized, transmitted, and legitimized in the age of intelligent technologies.

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