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Advanced Professional Development Programme in Health Professions Education

Building the foundations of clinical reasoning: What clinical and non-clinical teachers can do

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Clinical reasoning

- 75% of diagnostic errors can be attributed to clinician diagnostic thinking failure

- Diagnostic accuracy is the core competency of medical graduates

Thammasitboon S, Cutrer WB. Curr Probl Pediatr Adolesc Health Care 2013

What clinical reasoning is

- Making sense of incomplete information
- Deciding what matters and what does not
- Linking findings to mechanisms
- Generating possible explanations
- Comparing alternatives
- Managing uncertainty

- … during the journey of making a diagnosis

What clinical reasoning is not

- Listing many possible diagnoses
- Pattern recognition alone
- A skill that students either have or lack

Clinical reasoning does not begin in the wards

- Year 1 & 2 medical students are already learning the building blocks of reasoning:
  - Normal structure and function
  - Mechanisms of disease
  - Causal explanations
  - Links between biomedical science and clinical symptoms
  - Ways of organizing knowledge

Current situation

- Clinical reasoning is rarely taught during pre-clinical years
- National survey in USA showed 84% of students enter clinical clerkship with poor to fair knowledge of CR concepts
- Early clinical year students observe the complex cognitive processes of diagnostic & management decisions in more experienced clinicians, and think:
  - “How did you get to that?”
  - “How did you process all of that information so quickly?”
  - “How did you know which questions to ask?”

Rencic J et al. J Gen Intern Med 2017

Current situation

- CR is difficult to assess
- Students develop on different time frames

- But it can be taught early in medical education by making the process explicit to students

Daniel M et al. Acad Med 2019
Rencic J et al. Teaching Clinical Reasoning (2015)

Key theoretical foundations

- Dual process theory
- Metacognition
- Illness script
- Problem representation
- Knowledge encapsulation
- Cognitive integration & apprenticeship
- 4C framework

Dual process theory

- Dual-process theory distinguishes between:

Thinking Process	Description	Relevance to early learners
System 1 (intuitive)	Fast, pattern recognition	Limited in early learners because they lack experience
System 2 (analytic)	Slow, deliberate reasoning	More accessible, but still requires knowledge

- Expert clinicians often use rapid pattern recognition
- But pre-clinical students cannot do this reliably, as they lack sufficient clinical exposure and illness scripts

Dual process theory

- Teaching should not emphasize rapid diagnosis

- Instead, teachers should model **slow, explicit reasoning**:
  - What is the key finding?
  - What system is involved?
  - What normal function has been disturbed?
  - What mechanism could explain this?
  - What other findings would we expect?
  - What does this make more or less likely?

- CR should be a complex, knowledge-dependent process, rather than a simple transferable reasoning algorithm

Eva KW. Medical Education 2005

Augmenting dual process with metacognition

- Metacognition
  - "Thinking about your own thinking"
  - Awareness of how you learn, make decisions, and solve problems
  - Monitor and control your cognitive processes
  - Feedback from system 1 & 2 processes either reinforces or alters cognitive processes
  - Synergistic enhancement in ability to reason quickly and accurately in the future

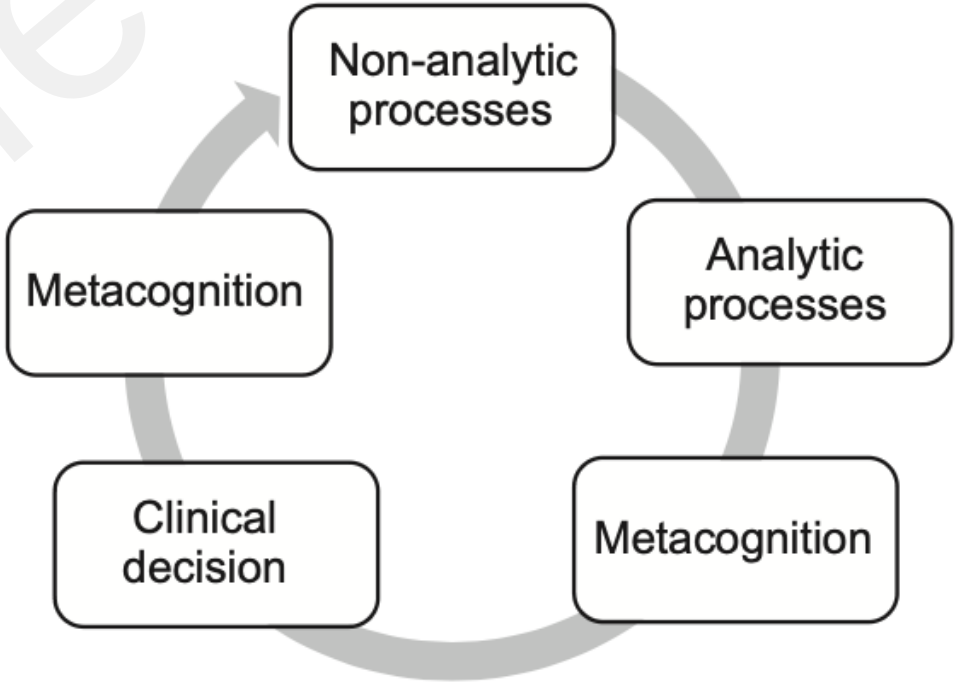


Figure 2 Continuous cyclical or spiral model of analytic and non-analytic processes, along with metacognition, for clinical reasoning and decision making.

Marcum JA. J Eval Clin Pract 2012

Metacognition

- Monitoring system for cognitive processes of practicing clinician
  - Reinforcing sound CR that leads to correct diagnosis
  - OR remedying faulty CR that leads to incorrect diagnosis

- Teachers can promote metacognitive skills similarly through immediate and effective feedback
- Knowing how clinicians make decisions is important for early clinical learners

Example: shortness of breath

- Before causes or diagnoses
  - What is the very first mental step you personally take when you hear “shortness of breath”?

Why shortness of breath feels obvious to experts

- Experts reason with organized frameworks
  - Problems with respiratory or cardiovascular system
  - And could also be secondary to renal or hematological system
  - Questions that would help with diagnosis would immediately appear in their minds

- This inference feels effortless, but a lot of reasoning has already happened before diagnosis enters the picture

Clinical reasoning depends on organized knowledge

- CR performance is strongly linked to the organization and accessibility of knowledge

- Experts do not simply know more facts. They organize knowledge around:
  - Mechanisms
  - Patient problems
  - Discriminating features
  - Illness scripts
  - Meaningful patterns

- We need to help students organize knowledge, not just accumulate it

How students vs experts think differently

- Preclinical students often hold fragmented facts:
  - “Aldosterone increases sodium reabsorption.”
  - “Oedema is swelling.”
  - “Heart failure causes breathlessness.”

- A teacher’s role is to help them connect these facts into causal chains:
  - “Reduced cardiac output activates RAAS, causing sodium and water retention, increasing venous pressure and contributing to peripheral oedema and pulmonary congestion.”

Why it is not obvious to early learners

- For many early learners
  - Symptoms are experienced as isolated complaints
  - Organ-system framing is still fragile
  - Mechanisms may be remembered as separate facts
  - Clinical language may not yet connect with biomedical knowledge

- Before diagnosis, they often need to ask:
  - Which system is failing?
  - What function is disturbed?
  - What consequence would that produce?

What early learners often lack

- System-level organization
- Sufficient illness scripts
- Clinical vocabulary
- Experience with real patients
- Ability to prioritize data
- Understanding of discriminating features

So they may default to

- Memorizing lists
- Pattern guessing
- Using buzzwords
- Jumping to diagnoses
- Treating all facts as equally important

Illness script

- Organized knowledge / mental representations of disease

Component	Meaning	Early learner version
Fault	Pathophysiology	What has gone wrong biologically?
Enabling conditions	Risk factor / context / epidemiology	Who is likely to get this, and why?
Consequences	Symptoms, signs, tests	What would this mechanism produce / lead to?

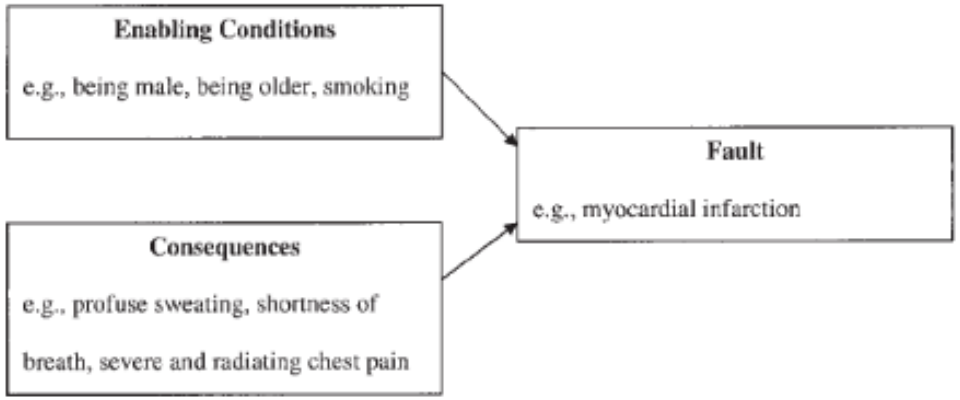


Figure 1. The use of illness script components in diagnostic situations.

van Schaik P et al. Journal of Experimental Psychology 2005

Illness script

- A pre-clinical learner's illness script is usually (appropriately) incomplete and heavily mechanism-based
- Early-year teaching should therefore emphasize **script precursors** rather than complete clinical scripts

- Pre-clinical case-based CR training can support script development

Si J. Korean J Med Educ 2022
Keemink Y et al. Int J Med Educ 2018

Two students in PBL

- Student A:
  - Highly motivated, passionate about biomedical details
  - Quickly dives into mechanisms with lots of details
  - Suggests rare or niche diagnoses

- Student B:
  - Overwhelmed by details
  - Feels they have nothing to add
  - Becomes quiet or disengaged

Two students in PBL

- Student A:
  - Curiosity outruns organization
  - Mechanisms lack system anchoring
  - Jumps to rare possibilities

- Student B:
  - No safe entry point into discussion
  - Partial understanding feels unusable
  - Cannot see where to begin

- In both cases, reasoning is occurring without a stable organizing structure

PBL is an excellent setting to teach CR

- Need to acknowledge the developmental stage of pre-clinical medical students
- Beginning with teaching the foundational concepts (“language”) of CR
- Gradually advancing in difficulty, using clinical cases
- Timed with the teaching of biomedical content to promote application of knowledge

Clinical & non-clinical PBL tutors

- Both need to face the challenge of maintaining a mechanism-rich, clinically-situated teaching

Error	Description	Consequence
Over-clinicalization	Using complex cases requiring mature diagnostic scripts	Students guess diagnoses or memorize associations
Mechanisms introduced before system-level context is clear	Detailed pathways are introduced before students have a clear picture of how a system works and consequences of its failure.	Students fail to transfer knowledge to patient problems

Going back to shortness of breath

- Case:
  - “A 65-year-old man has shortness of breath when lying flat, swollen ankles, and tiredness.”

- More developed problem representation:
  - “An older man with features of fluid overload and reduced exercise tolerance, suggesting impaired cardiovascular function.”

- Goal is to move from **surface details** to **meaningful abstractions**

Problem representation

- A concise summary of a case using meaningful clinical and biomedical abstractions

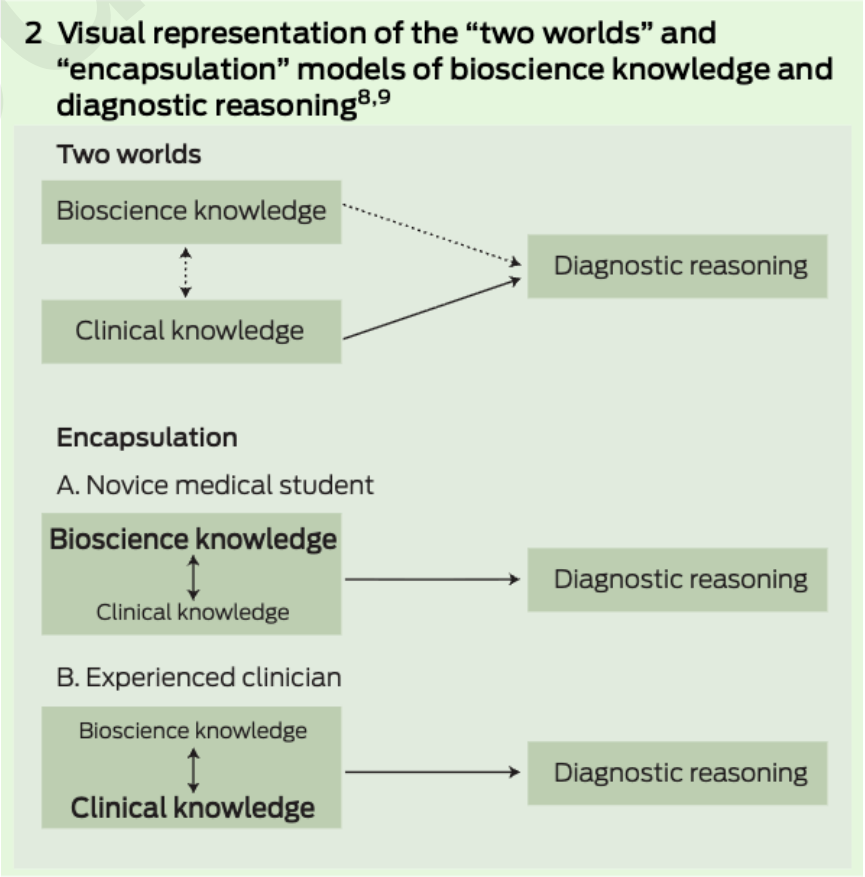
Surface feature	**More meaningful abstraction**
“Can’t breathe when lying down”	Orthopnoea / positional breathlessness
“Swollen ankles”	Peripheral oedema / fluid accumulation
“Tired on exertion”	Reduced exercise tolerance
“High creatinine”	Reduced renal filtration

Bowen JL. N Engl J Med 2006

Knowledge encapsulation

- As learners progress, biomedical knowledge become “encapsulated” into more clinically usable concepts

- Early explanation:
  - “Left ventricular systolic dysfunction reduces forward flow, activates sympathetic and RAAS pathways, increases preload and afterload, and causes pulmonary venous congestion.”
- Later encapsulated clinical concept:
  - “Heart failure causing pulmonary oedema.”



McColl G et al. Med J Aust 2012

Why students sometimes find PBL difficult

- Students face the cognitive challenge of knowledge transfer:
  - Applying biomedical knowledge learned in one context (preclinical classroom)
  - To solving clinical problems in a different context (case scenario)

Cognitive integration

- Deliberately linking biomedical science and clinical science by using causal mechanisms to explain symptoms, signs, and test abnormalities

- A pedagogical strategy that connects biomedical and clinical concepts

Clinical teachers

- Clinical expertise in a specialty does not necessarily constitute expertise in teaching clinical reasoning
- Experienced clinicians can find it difficult to explain their deeper, nonlinear reasoning processes to students as they work through a case

- Lack of curricular time (88%) and faculty expertise in teaching CR concepts (69%) were identified as barriers in a national survey in the USA

Rencic J et al. J Gen Intern Med 2017

Cognitive apprenticeship

- Avoid expert shortcuts

- Instead of “This is obviously heart failure”, try:
  - “Let's slow down. Which findings suggest fluid overload?”
  - “What mechanism could connect the heart to the lungs and ankles?”
  - “What else could cause breathlessness, and how would it differ?”

Make thinking visible

- Model reasoning aloud
- Ask structured questions
- Scaffold cases
- Give feedback on reasoning process
- Reduce complexity
- Show how uncertainty is handled

Cognitive apprenticeship

- For pre-clinical students, the teacher should not simply ask, “What is the diagnosis?”

- Instead, the teacher can ask:
  - “What normal process is being disrupted?”
  - “Which system could explain these findings?”
  - “What mechanism links the abnormality to the symptom?”
  - “What finding would you expect next?”
  - “What would make this explanation less plausible?”

Non-clinical teachers

- You do not need to teach full diagnosis
- You are central to building the biological frame

- What is the normal process?
- What has changed?
- What follows from that change?
- What would the patient experience?
- What lab or functional abnormality might appear?
- What similar mechanism should we compare this with?

- E.g. “If albumin falls, what happens to oncotic pressure and fluid movement?”

4C Framework

Step	Teacher question	Purpose
Context	What simple patient situation makes this concept meaningful?	Avoid decontextualised facts
Cause	What normal mechanism is disturbed?	Build biomedical reasoning
Consequence	What symptom, sign, or test abnormality follows?	Link mechanism to clinical manifestation
Compare	What similar condition or mechanism could be confused with this?	Build discrimination

Example: nephrotic syndrome

Step	Example
Context	A patient develops swollen ankles and frothy urine
Cause	Glomerular barrier damage causes protein loss
Consequence	Low albumin reduces oncotic pressure, causing oedema
Compare	Nephrotic oedema vs heart failure oedema

Building CR foundations beyond PBL

Setting	Common pattern	Helpful shift
PBL	Students jump to pathways or diagnoses	Start with system and function
Practicals	Completing the task becomes the goal	Ask what system / function is being tested
Lectures	Organizing logic is obvious to experts, but invisible to early learners	Focus on structure, not content volume
Case discussions	Clinical complexity arrives too early	Use mechanism-level questions

Common forms of misalignment

In pre-clinical teaching	**Possible unintended effect**
Basic science taught as isolated facts	Students struggle to transfer knowledge
Clinical cases pitched too high	Students guess diagnoses without reasoning
Non-clinical teachers unsure of their role	Missed opportunities to build foundations
Clinical teachers use expert shortcuts	Early learners cannot follow the reasoning
Practical sessions focus only on task completion	System-level meaning remains implicit

What to avoid with pre-clinical students

- Asking for full differentials too early
- Rewarding only the correct diagnosis
- Prioritizing rare diagnoses
- Expecting expert-level pattern recognition
- Hiding the reasoning process
- Assuming students can integrate basic and clinical science unaided
- Using clinical jargon without translation
- Treating mechanisms as separate from patient care

A developmental assessment of clinical reasoning in preclinical medical education

Alice A. Min Simpkins[a], Bryna Koch[b], Karen Spear-Ellinwood[c] and Paul St. John[d]

Table 1. First version of assessment rubric items.

Medical Knowledge
Identifies the pertinent facts of a clinical case (MK 1)
Collects and records information about a clinical case in a manner that supports the development of a differential diagnosis (MK 2)
Develops multiple working Hypotheses (i.e., differential diagnosis) related to clinical diagnosis (MK 3)
Interpersonal and Communication Skills
Provides a rationale for each hypothesis (ICS4)
Provides constructive feedback to peers (ICS 5)
Participates in the problem solving process (ICS 6)
Problem-Based Learning and Improvement
Asks relevant questions about the case in order to identify gaps in knowledge necessary to resolve the problem (PBLI 7)
Identifies and cites appropriate sources of research (PBLI 8)
Reflects on case and process, including identifying cognitive errors when they arise (PBLI 9)
Demonstrates awareness or insight into own weakness and limitations (PBLI 10)
Professionalism
Acknowledges differences of opinion and perspective among group members (PRO 11)
Appropriately documents work; research; or contributions to the group process (PRO 12)
0 = Pre-Emergent, 1-Emerging, 2 = Acquiring, 3 = Mastery

Med Educ Online 2019

Take home message

- Building clinical reasoning starts early
  - Early learners need frameworks, not full clinical complexity
  - Basic science becomes powerful when linked to clinical consequences

- Clinical teachers: slow down and make reasoning visible
- Non-clinical teachers: building the biological frame & causal relationship

Take home message

- When reasoning looks weak, it’s often the foundations that are thin, not the thinking

- System-level framing and structure doesn’t slow strong students
  - It allows more students to think

- For pre-clinical students:
  - Mechanism before diagnosis
  - Structure before speed
  - Explanation before pattern recognition