Opinion Paper

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From principles to practice: embedding clinical reasoning as a longitudinal curriculum theme in a medical school programme

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Abstract: There is consensus that clinical reasoning (CR) is crucial for increasing the value of diagnosis, medical decision-making and error reduction. These skills should be developed throughout medical education, starting with undergraduate study. International guidance provides principles for CR curricula but interventions to date, are short term in nature. In this report, we describe the creation of a longitudinal, spiral CR curriculum within a large UK medical school programme (2500 students). A working group drove systematic evidence-based reform of existing structures. We utilised recognised models for curriculum development and mapping, relating learning outcomes to competency frameworks. Application of multiple teaching methodologies, rooted in enquiry-based learning and reported in CR literature, encourage metacognition for information-processing and illness script development. Development of CR is emphasised with recurrent, progressive learning opportunities, each stage purposefully building upon previous experiences. Formative and summative assessment approaches to drive learning, encouraging students' ability to apply and articulate CR, is constructed via Miller's Prism of Clinical Competence. Implementation of pedagogy is contingent on faculty development. Whilst many clinicians practice sound CR, the ability to articulate it to students is often a novel skill. Engagement in faculty development was strengthened through cross-institutional recognition of teaching workload and flexibility of delivery. We report lessons learned from the implementation phase and plans for measuring impact.

Keywords: clinical reasoning; curriculum development; faculty development.

Background

Clinical Reasoning (CR) is defined as a process wherein clinicians observe, collect, and interpret data to diagnose and treat patients [1, 2]. It forms a crucial component of clinical practice with poor clinical reasoning leading to inaccurate diagnoses, clinical errors in treatment and management with resultant harm to patients. This has prompted many international medical organisations to call for clinical reasoning instruction throughout the spectrum of medical education. Unfortunately, most instructional interventions designed to teach clinical reasoning reported in the literature have been short term in nature and have yielded disappointing results. In this report, we describe the design, development, and implementation of a longitudinal clinical reasoning curriculum within undergraduate medical education to address this gap. We anticipate that this curriculum will improve clinical reasoning of our students and in turn improve patient care; and will be evaluating the results to determine if these aspirations can be confirmed.

Concepts in CR [3–5] and suggestions for teaching methods are well described [6–10], yet studies examining short-term interventions have yielded disappointing results [11, 12]. There is a growing international consensus

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that longitudinal integration into undergraduate medical curricula is required for learner acquisition and application of CR in clinical practice. International organisations endeavouring to embed CR into healthcare education highlight this need in the United States (Society to Improve Diagnosis in Medicine), Europe (DID-ACT) and United Kingdom (Clinical Reasoning in Medical Education Group, CReME) [13–15]. The latter summarises empirical methods for vertical curricula integration of CR through five domains (clinical reasoning concepts, history and physical examination, choosing and interpreting diagnostic tests, problem identification and management, and shared decision making) providing principles to encourage implementation. Despite such international guidance, reports on successful implementation of longitudinal CR curricula in medical schools remain limited. Undoubtedly, this relates to the challenges faced when introducing curriculum change: lack of curricular time and faculty expertise being the greatest barriers [16], with constraints due to resource limitations frequently encountered. Moving from principles to implementation requires the use of effective curriculum development models. Thomas et al.'s [17] curriculum development in medical education template provides a pragmatic six-step approach: (1) problem identification and general needs assessment; (2) targeted needs assessment; (3) goals and objectives; (4) educational strategies; (5) implementation; and (6) evaluation and feedback.

The purpose of this paper is to share an evidence-informed approach to developing and delivering a Clinical Reasoning curriculum at scale. We describe how we systematically, integrated CR competencies, teaching methods and assessments across the 5-year programme at Manchester Medical School. As the largest medical school in the UK, it supports 2400 medical students. The three clerkship years involve 4000 clinical and academic faculty teaching students through rotations of 11,610 clerkships, delivered in 14 hospitals and 500 family practices. The narrative provides practical information for policy makers, curriculum planners and faculty development leaders to enable similar adaptations to their programmes.

Longitudinal CR curriculum development

Five components were adapted from the curriculum development for medical education model to implement large-scale CR learning across the breadth of our course and will be described in turn:

(1) Problem identification and needs assessment
(2) Goals and objectives
(3) Educational strategies
(4) Implementation
(5) Evaluation and feedback

Problem Identification and needs assessment

Realising the significance of clinical reasoning to medical student learning our school recognised a notable gap. A working group was established and given responsibility for developing a longitudinal theme in CR. Members of the working group were purposefully selected to encompass relevant stakeholders. The group constituted individuals with programme leadership roles, knowledge of curriculum development, assessment, and CR, medical students and resident doctors.

The working group under took a targeted needs assessment by identifying CR-relevant curriculum design principles [18]. This was followed by a mapping exercise aligning our formal, informal and hidden curriculum to core elements required to produce a longitudinal CR syllabus [18, 19].

1. Formal
   i. Developing domains and learning outcomes with defined and progressive competency levels
   ii. Identifying structured activities for teaching and learning CR
   iii. Adapting current materials and developing CR learning resources
   iv. Developing CR assessments to support and evaluate learning
   v. Designing a systematic faculty development programme
2. Informal
   i. Identifying opportunistic activities for teaching and learning CR
   ii. Identifying opportunistic activities for assessing CR
3. Hidden
   i. Emphasising relevance of CR theme to clinical practice to both learners and faculty

Goals and objectives for a longitudinal CR curriculum

Defining clinical reasoning

Agreement on a precise definition of CR and the full scope of what it entails remains the subject of academic debate [2].

This challenge must be weighed against the importance of providing visibility for curriculum development initiatives to succeed. CR learning can only be visible in curricula, if programmes make a commitment to a definition. This provides a common ground for effective learner-preceptor interactions. It also addresses the need to ensure they appreciate the relevance of the topic to their clinical practice, supporting a positive milieu for the hidden curriculum. Consensus opinion from working group members resulted in adoption of the concept that CR is a process by which clinicians:

- Collect cues, process information, understand the patient's problems
- Plan and implement appropriate action plans
- Evaluate the outcomes and learn from the entire process [1]

Next, we determined that the CR syllabus would concentrate on the student's ability to understand and translate CR theory into the workplace rather than focus on team and healthcare system influences on CR practice [20]. This mirrors regulatory guidelines for medical student education in the UK [21]. Utilising the definition of CR by Ball and Balogh [1] alongside wider literature [5, 22, 23] we created four domains: theoretical concepts; patient assessment; diagnosis, investigation and management; and shared decision-making. The domains were translated using Miller's Prism of Clinical Competence [24] into seven core CR Intended Learning Objectives (ILOs) as shown in Figure 1. The ILOs facilitated mapping of educational strategies that would integrate into pre-existing teaching and assessment methods or identify gaps necessitating additional ones. The result was a CR curriculum map depicting learners' development and application of CR skills in a structured, scaffolded and progressive manner (Table 1).

Educational strategies

Teaching methods

Enquiry-based learning (EBL) methodology underpins our curriculum, focusing on active and collaborative learning [25]. A range of blended learning strategies are used to provide students with multiple opportunities to discuss, apply and reflect on their learning including: online interactive case-based resources; flipped classroom small group sessions; small group debrief sessions, written reflection and workplace-based patient encounters [26]. To implement this longitudinal CR curriculum, we drew upon recognised conceptual frameworks that integrate CR in their teaching approaches [5, 27, 28]. We selected two that simplify metacognitive processes into bitesize chunks workable in both

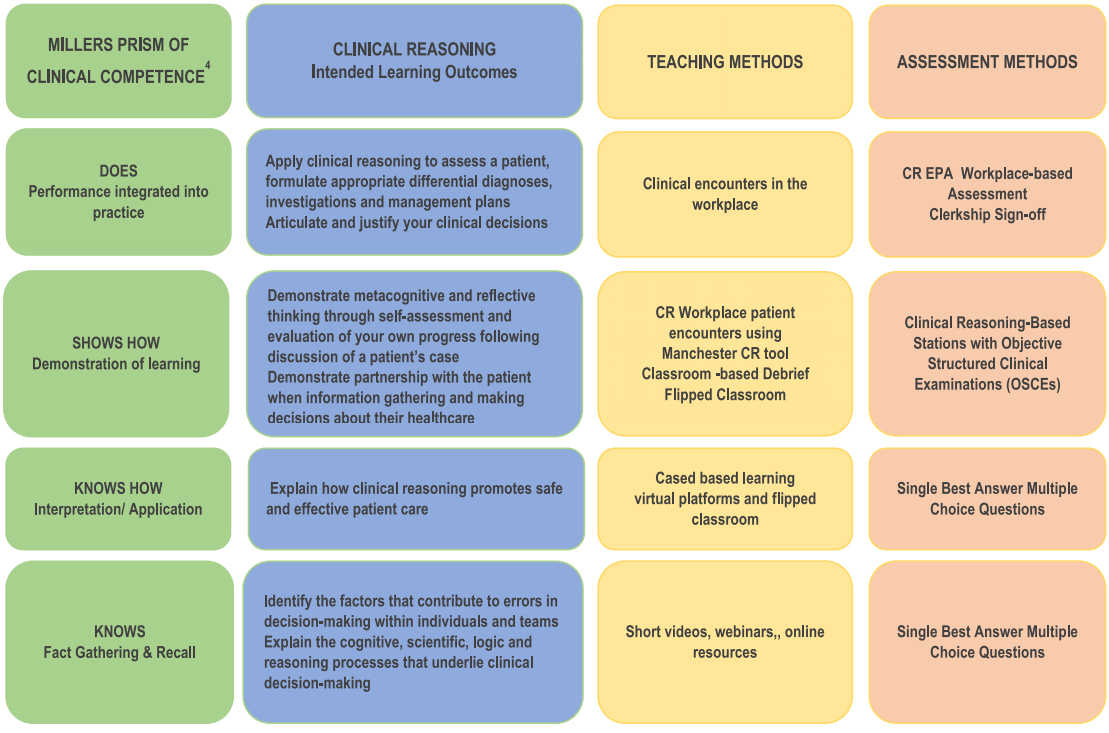

Figure 1: Applying Miller's Prism of clinical competence to construct learning outcomes and map teaching and assessment methods in clinical reasoning.

Table 1: Clinical reasoning curriculum map: domains, intended learning outcomes and teaching methods.

Clinical reasoning domain	Intended learning objectives and teaching methods				
	Pre-clerkship		Clerkship		
	Year 1	Year 2	Year 3	Year 4	Year 5
Theoretical concepts	Explain the cognitive, scientific, logic and reasoning processes that underlie clinical decision-making		Apply cognitive, scientific, logic and reasoning processes to patient encounters to complete an assessment (history and physical examination)		
	Webinar Short videos Small group discussion		Clerkship experience		
	Identify the factors that contribute to errors in decision-making within individuals and teams		Evaluate factors that contribute to errors in your decision-making following completion of a patient assessment	Evaluate factors that contribute to errors in the team's decision-making during patient care	
	Webinar Short videos Case-based classroom discussion		Clinical debrief Clinical reasoning EPA	Clinical reasoning EPA	
	Explain how clinical reasoning promotes safe and effective patient care		Illustrate how clinical reasoning promotes safe and effective patient care		
	Webinar Short videos Case-based classroom discussion		Clinical debrief Personal and professional portfolio written reflection		
Patient assessment	Use purposeful interviewing to gather data from simulated patient encounters	Apply clinical reasoning to assess a patient through purposeful history taking and hypothesis-driven physical examination in simulated patient encounters	Apply clinical reasoning to assess a patient through purposeful history taking and hypothesis-driven physical examination in real patient encounters		
	Simulated patient encounters Case-based classroom discussion		Clerkship experience Clinical reasoning EPA		
	Demonstrate metacognitive and reflective thinking through self-assessment and evaluation of your own progress following discussion of a patient's case				
	Simulated patient encounters Case-based classroom discussion		Clerkship experience Clinical debrief Clinical reasoning EPA		
Diagnoses, investigation and management			Formulate appropriate differential diagnoses or problem lists for the patients you assess	Formulate appropriate differential diagnoses or problem lists, investigations and management plans	
			Articulate and justify your clinical decisions using reasoning skills when: – presenting a summary using sematic qualifiers and precise medical terms – choosing and interpreting investigations – recommending plans for managing your patient's care		

Table 1: (continued)

Clinical reasoning domain	Intended learning objectives and teaching methods				
	Pre-clerkship		Clerkship		
	Year 1	Year 2	Year 3	Year 4	Year 5
			Case-based learning: Virtual and flipped classroom discussions Clerkship experience Clinical reasoning EPA		
Shared decision-making	Explain how partnership with the patient is central to information gathering and decision-making about their care		Demonstrate how partnership with the patient is central to information gathering and decision-making about their care		
	Simulated patient encounters		Clinical communication skills simulated patient encounter discussion: low to high complexity cases Clerkship experience Clinical reasoning EPA		

EPA, entrustable professional activities.

classroom and ill-structured settings, such as the clinical workplace. Croskerry's Dual Process Theory [5] was adopted to offer an orienting framework and vocabulary for clinical educators to make implicit behaviours explicit and to facilitate students' understanding of how experts make clinical decisions. Secondly, the Clinical Reasoning Cycle [28] was used to afford medical students the opportunity to learn like experts: offering cues, patterns and strategies to apply during simulated and workplace encounters to develop reasoned decisions. The concept of a cycle of CR aligns with the definition of this as a process. Furthermore, the clarity offered by this model facilitates progression from low-complexity case discussions, with high levels of support and scaffolding in classrooms (early clerkship years), to cultivation of self-directed learning and subsequent development of complex and transferable skills in the workplace (senior clerkship years).

Classroom teaching

In pre-clerkship years, online case-based materials provide scaffolding for live webinars. The materials describe CR theory, introduce a common language and signpost relevance to future clinical practice. They close with a review of core CR concepts and a discussion about application in the first clerkship year. Between these weekly case-based materials, students work through clinical scenarios starting with symptom presentations leading to diagnostic hypotheses generation, clinical investigations, and management decision making. Each scenario is augmented by a short 5-min video that highlights a different aspect of the CR cycle. In clerkship years, instruction involves a blended, flipped classroom model to support workplace experiences. Students work through interactive online cases prior to weekly small group *themed-case discussions* where they are challenged with unseen exemplar clinical vignettes that require application of CR processes to complete set tasks. This not only provides equivalent learning across a geographically distributed programme but supports more experienced students in developing their CR skills [29].

Techniques that promote reasoning were woven into both online material and live case discussions with use of stop-start methods, what if and Socratic questioning (Figure 2): supported by contrastive learning, development of illness scripts and serial cue technique drawing on further examples of reasoning-based approaches [6, 11, 22, 23, 29].

Simulated and real patient encounters

CR integration into experiential clinical learning has been purposeful and recurrent, with each stage of the syllabus building upon the previous: revisiting, reinforcing and increasing complexity. In pre-clerkship years, our learners work with simulated patients supported by facilitators to apply CR learning in safe environments. In later years, immersion in clerkships provides extensive opportunities for repeated deliberate practice with both simulated and real patients; a key requirement for the development of CR [30]. Early clerkships focus on students developing purposeful interviewing and hypothesis-driven examination skills with later clerkships emphasising students' development of problem identification, investigative and management planning and shared decision-making skills.

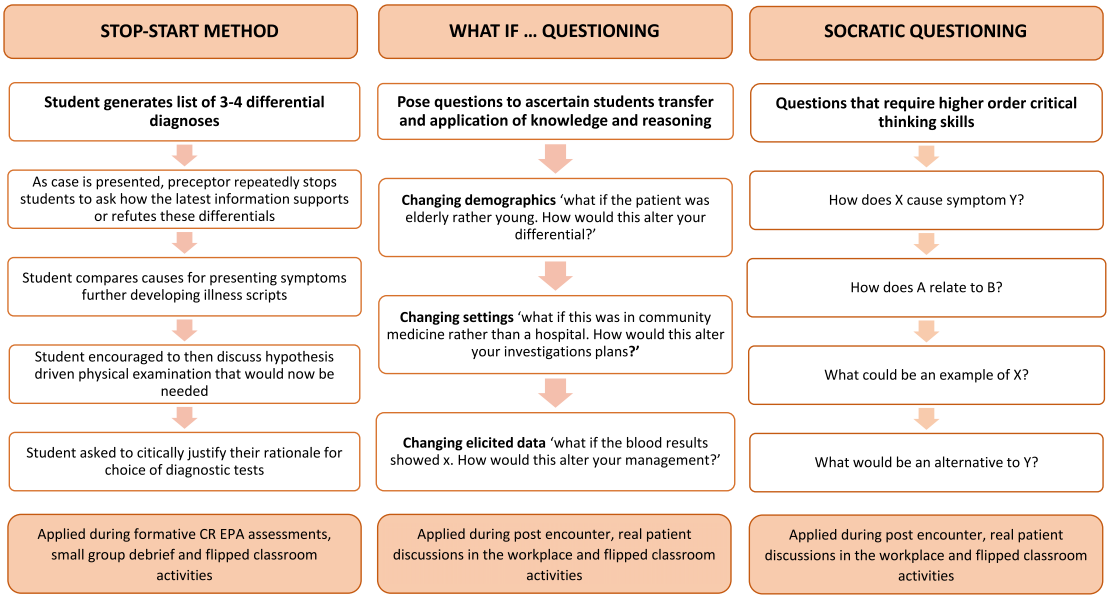

Figure 2: Techniques used to make CR explicit during in-person teaching [6].

During all clerkships, students are required to complete and present multiple patient assessments (history taking and physical examination) on a weekly basis. They record these activities in an electronic logbook. Students are asked to reflect upon all patient encounters, including those not formally presented to preceptors. In their interactions with both patients and teachers, students are encouraged to not only develop their CR processes but to also demonstrate their growing ability to seek and receive formative feedback to ensure learning is effective. To achieve this, we developed the Manchester Clinical Reasoning Tool (MCRT) (Figure 3) as a Workplace-Based Assessment (WBA). This tool was created by translating the Clinical Reasoning Cycle steps through a learner-centric lens. The MCRT was developed to prompt consideration of not only *what* is asked during a patient encounter, but also *why* it is asked. This encourages students to focus on their metacognition: to move from unstructured information gathering to purposeful interviewing and thereafter, hypotheses driven physical examinations [6]. Preceptors provide feedback and encourage learners to evaluate their ability for each stage of the clinical reasoning process in the MCRT. Recognising that CR is a core skill of clinical practice, we looked to the Entrustable Professional Activities (EPA) literature [31] to facilitate formative discussions (Figure 3B). This scaffolding supports students to develop CR skills with increasing complexity. Feedback and feed-forward on students' metacognitive approach is provided to inform their future practice. This aligns with evidence that corrective feedback helps develop competence and illness scripts [30, 32].

The MCRT was designed to be adaptable to all learning environments and stages of student experience during clerkship years. In this way it provides an integrative approach to CR learning, enabling practice, reflection and assessment in the workplace for large cohorts of geographically dispersed clerkship students (approximately 1500).

Assessment methods

A range of assessments are used to evaluate students' CR ability at all levels of Miller's pyramid (Figure 1). These approaches are formative, driving learning and deliberate practice, and summative, informing onward progression. In essence, each assessment approach requires students to apply and articulate their clinical reasoning.

Knows/knows how

Single Best Answer (SBA) questions form the mainstay of our applied knowledge assessments. This format involves a short context-rich clinical vignette. The learner selects the most likely option from a series of five plausible options relating to diagnosis, investigations or management. SBAs have been shown to draw upon knowledge acquisition and higher-order thinking processes [33].

Shows how

Objective structured clinical examinations (OSCEs) are used across the whole programme. They are widely accepted as generating reliable and valid evaluations of

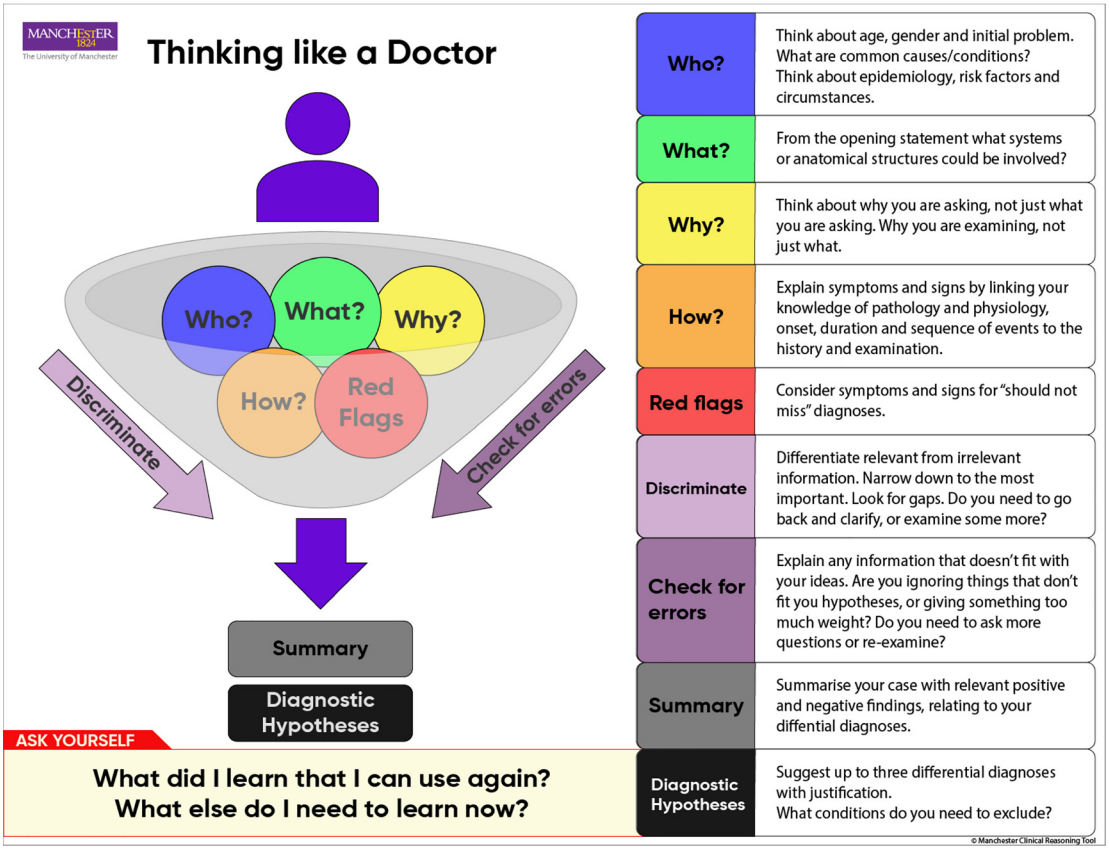

Figure 3: The Manchester CR Tool (MCRT): Workplace based assessment for Clerkship Year 1 medical students. (A) Patient encounter framework. (B) Clinical reasoning entrustable professional activity (EPA) assessment framework.

learners' clinical competencies [34]. In line with our CR strategy, we have developed OSCE stations to better assess reasoning abilities. Key changes are described below:

- History-taking stations: avoiding 'textbox description' presentations reliant on pattern-recognition to arrive at a single diagnosis, and instead creating real-world patient scenarios requiring purposeful interviewing to generate, justify and prioritise plausible differential diagnoses.
- Physical examination stations: adding to conventional system-based examination sequences, by introducing hypothesis-driven examinations. These utilise a short clinical vignette, from which a targeted examination is required, and avoid the de-contextualisation that occurs in systematic examinations [35]. This helps students better identify signs when they are present [36].
- Data interpretation: using clinical data (test results, images), presented all-at-once or in a more sequential fashion, assesses the candidate's data *reporting* ability and their *interpretation* ability in light of the clinical context [37].

Does

The patient assessments students present throughout clerkships are included in a portfolio of WBAs that informs overall clerkship sign-off. The WBA patient presentations involve detailed feedback from preceptors, using evaluative domains in the MCRT. Preceptors give each WBA a global rating, through the Entrustable Professional Activities model [31] (Figure 3B). A student's longitudinal development in clinical reasoning is cumulatively displayed in virtual dashboards, highlighting to learner and preceptor strengths and areas for development. The WBAs thus provide an opportunity for CR-based teaching, formative assessment of CR skills, and feedback into summative assessment decisions at clerkship completion.

Implementation

The formation of a working group was critical to success: providing a guiding coalition, with vision and strategy to

FORMATIVE FEEDBACK ON CLINICAL REASONING SKILLS	
WHO - the student considered WHO the patient is (demographics, risk factors, social situation) when analyzing the patient's complaint/ concerns	○ Little or no evidence ○ Evidence of this but inconsistent or only with prompting ○ Consistent evidence of this
WHAT - the student considers what systems or anatomical structures could be involved from the opening statement	○ Little or no evidence ○ Evidence of this but inconsistent or only with prompting ○ Consistent evidence of this
HOW - the student was able to associate the patient's symptoms (history) and signs (examination) to credible pathophysiological processes linking onset, duration and sequence of events	○ Little or no evidence ○ Evidence of this but inconsistent or only with prompting ○ Consistent evidence of this
RED FLAGS – the student considers symptoms and signs for *must not miss* diagnoses	○ Little or no evidence ○ Evidence of this but inconsistent or only with prompting ○ Consistent evidence of this
DISCRIMINATE - the student is able to discriminate between relevant and irrelevant information when presenting a patient assessment	○ Little or no evidence ○ Evidence of this but inconsistent or only with prompting ○ Consistent evidence of this
CHECK FOR ERRORS – the student is able to discuss any information that does not fit with their ideas and provides evidence that they clarified information or checked for errors in their thinking	○ Little or no evidence ○ Evidence of this but inconsistent or only with prompting ○ Consistent evidence of this
SUMMARY – the student is able to present a concise summary of the presentation with sematic qualifiers and appropriate positive and negative findings	○ Little or no evidence ○ Evidence of this but inconsistent or only with prompting ○ Consistent evidence of this
DIAGNOSES – the student suggests 2-3 diagnoses consisting of the most likely and *must not miss* diagnoses AND justifies the likelihood of each in relation to the information elicited from the patient	○ Little or no evidence ○ Evidence of this but inconsistent or only with prompting ○ Consistent evidence of this
OVERALL PERFORMANCE Assessed against expected performance at completion of medical school	
○ Could not perform a patient assessment even with direct supervision ○ Could perform a patient assessment with pro-active supervision and guidance ○ Could perform a patient assessment with reactive supervision (on request and quickly available) ○ Could perform a patient assessment independently with some supervision after the event ○ Could perform a patient assessment with mastery such that they would be able to supervise peers and juniors	

Figure 3: Continued.

empower action; enabling a sense of urgency and generating short term wins [38, 39]. The latter achieved through cross-organisational collaboration between academic and clinical practice clinicians also addressed common curriculum innovation barriers such as delivery of an intensive faculty development programme in CR [40, 41]. Delivery deadlines necessitated a four-month period for this activity. Success required strategic planning at the highest organisational level with early buy-in to ensure the medical school's *Teaching Clinical Reasoning* workshops were prioritised within academic and clinician preceptors' workloads. Continuing Medical Education (CME) accreditation, further enticed preceptors to prioritise this activity. While preceptors may apply sound clinical reasoning skills, they are often challenged to explain to a novice, their deeper, non-linear reasoning processes [40]. Our faculty development programme offered the following:

- Background on CR theory using the student-facing frameworks and language.
- Demonstration and practice using the MCRT through video and role play.
- Teaching techniques that highlight CR aspects of patient encounters for opportunistic workplace learning and classroom activities (Figure 2).

The workshops emphasise that CR learning should be visible and integrated into all teaching, from brief exchanges during opportunistic, experiential learning episodes to more formal dedicated discussions away from the clinical workplace. We utilised the COM-B model to design activities that improve behaviour change in preceptors [42]. COM-B describes the capabilities, opportunities and motivation required in individuals to successfully change behaviour. Applying this methodology purposefully to the design of faculty development programmes encourages preceptors to critique their own teaching styles and commit to behaviours that promote CR teaching. Since inception three years ago, 570 individuals have completed educator development sessions in CR.

Evaluation

Evaluation of student learning and faculty teaching has been incorporated into the design of the CR curriculum from the outset. The programme is tracking learner performance by gathering individual and cohort data across the three clerkship years. This consists of collating outcomes from our CR WBAs with analysis of individual CR elements, global EPA ratings for competency in patient assessments, clinical summative assessment outcomes sensitive to CR performance and qualitative data through learner audio diaries and focus groups to explore attitudes and barriers to learning CR. All preceptors are completing evaluation of the impact of faculty development in terms of its usefulness and changes they make in teaching behaviours. These evaluative strategies are ongoing and will be reported subsequently.

Summary and outlook

This paper describes the development and implementation of a longitudinal, spiral CR curriculum in an undergraduate medical programme. Implementation, at scale, was achieved by identifying solutions to previously described barriers [15, 16] through an established curriculum development model; identifying goals, objectives and evolving vertically integrated, evidenced-informed educational strategies in CR teaching, learning and assessment; investing in comprehensive faculty development; and designing measurements of impact from the outset.

Reframing teaching materials (virtual and classroom) and assessments (workplace and summative) through a CR lens enabled integration with the existing medical school programme. Given the size of the undertaking, our initial learning outcomes focussed mostly on individual and some teamwork competencies, outlined in The Society to Improve Diagnosis in Medicine Framework [14]. We are considering opportunities for further revisions, with a view to integrating system-based competencies via interprofessional education models.

The biggest enabler to achieving our goal was developing preceptors' skills in teaching CR. The buy-in of healthcare service providers was critical to this achievement. On reflection, we would have preferred a longer lead-in time (at least 12 months) rather than the four we were required to work within and increased flexibility in access to staff development events. We recently moved to both in-person and virtual modes of delivery in recognition of the competing clinical commitments that constrain preceptors' access to educator development opportunities.

Going forward, we anticipate extending the programme into residency training. Developing and implementing a longitudinal curriculum in CR in medical school on its own is insufficient. Inculcating clinical reasoning processes at individual, team and system levels needs systematic, progressive and comprehensive learning activities integrated across the spectrum of healthcare education.

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