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Teaching Metacognitive Skills: Helping Your Physician Trainees in the Quest to 'Know What They Don't Know'

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Medical education accreditation agencies have adopted behavioral expectations for physician trainees that focus on self and practice assessment and improvement, including self-monitoring and goal setting. Considered part of the pool of "generic" or transferable skills vital to the development of self-directed, lifelong learners, these skills seem to be valued by the medical education community in many countries.[1-8] One example is the requirement for US residents to identify their own strengths and weaknesses, and then set specific learning goals as part of the practice-based learning and improvement competency[3] (**Table 1**). Yet, metacognitive skills, which enable the performance judgments and cognitive control necessary for meeting competencies such as practice-based learning and improvement, seem to be infrequently taught and assessed in medical education.[9] The purpose of this article is to provide an overview of metacognition and its importance for trainee learning and practice improvement, and to offer teaching strategies to enhance metacognitive skills of trainees.

BACKGROUND

Many medical education accreditation bodies now include language related to self-assessment, self-directed learning, lifelong learning, and practice assessment and improvement as part of their trainee competencies, roles, or standards.[3-8]

Trainee physicians in the United Kingdom are expected to "identify, document and meet their educational needs,"[4] and all physicians are expected to reflect on their own performance.[10] In Canada, residents are expected to "demonstrate insight into their own limitations of expertise via self-assessment,"[6] and US residents, as part of the practice-based learning and improvement competency, are required to continuously self-assess and use self-directed learning skills to improve patient care.[3,11]

At the same time, it has been noted that physicians seem to have limited abilities to critically examine their own performance in aggregate during unguided self-assessments.[12-17] Metacognition, which allows individuals to self-assess and regulate cognitive processes

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related to learning and performance,[18-20] has, until recently, received little attention within the medical education literature.[9]

METACOGNITION AS AN UNDERLYING CONSTRUCT

Metacognitive processes have been described and studied for decades within the fields of psychology, cognitive neuroscience, behavioral neurology, educational psychology, education, and special education. Articles published in the medical education literature have focused primarily on the role of metacognition in clinical reasoning[21-24] and career-long learning.[9]

What Is Metacognition?

In the field of education, metacognition is often referred to as thinking about one's own thinking processes. Yet, metacognition also can be understood as a range of executive system processes[19,25] that are intimately involved in self-assessment, cognitive control, and monitoring,[19,20,26-29] such as controlling the amount of time spent studying and assessing whether we understand a text. Through ongoing monitoring and control of cognition, metacognition enables us to recognize the "absence of knowledge" in a given context.[30] Metacognitive processes depend on a complex interplay of several distinct brain regions known to be responsible for attention to task, self-awareness, memory, and even individual expectations.[31] Historically, metacognition has included the concept of metacognitive knowledge, recognizing that learners must have knowledge or awareness of strategies such as rehearsal, use of mnemonics, and content organization, which can all be mobilized during learning.[25,32,33]

Metacognitive Monitoring

Metacognition as a global set of processes can be parsed into a number of subprocesses, including metacognitive monitoring and control.[26] Metacognitive monitoring refers to those processes we engage in when monitoring our own learning.[19,34] When a reader concludes she has not understood a paragraph just read, metacognitive monitoring processes are at play. The sense that we do not know enough about a particular subject is produced by the cognitive systems involved in monitoring. During metacognitive monitoring, learners judge the difficulty of material to be learned, assess ease in mastering new material, and determine whether something has been learned already.[34] Self-questioning is often used by learners as they monitor their own learning.

PERSPECTIVES VIEWPOINTS

- Residents are expected to identify strengths and weaknesses as part of the practice-based learning and improvement competency.
- Metacognition enables performance judgments and cognitive control necessary for practice-based learning and improvement, yet metacognitive skills are infrequently taught.
- There have been recent calls to highlight metacognitive skills, yet few articles discuss how metacognitive skills can be taught.
- Techniques to enhance trainees' metacognitive skills include reflection, feedback, questioning strategies, and think-aloud techniques.

Metacognitive Control

Metacognitive control, in contrast, refers to the ways in which we control our own cognitive processes during learning,[19] akin to a cognitive manager role. We use judgments of our own knowledge base, previous performance, and expected future performance to regulate our own cognitive processes. Regulating the amount of time spent studying, the pace of studying, and what we study; minimizing off-task behavior; and selecting optimal strategies for studying are examples of metacognitive control over learning.[19,32,34] At times, our trainees may be labeled with medical knowledge deficits, when in reality they may have deficits in metacognitive skills, which can affect their ability to organize and retain new knowledge.[35]

IMPLICATIONS FOR TRAINEE LEARNING

Metacognition helps us plan task completion, monitor progress toward goal attainment, and check for understanding, and is thus considered to be a critical element of the learning process.[18] Metacognitive strategies have been shown to have a direct impact on learning and performance within nonmedical educational contexts (mathematics, reading, writing), especially during problem-solving tasks.[32,36] Within nursing education, researchers noted that metacognitive processes have been linked to the development of clinical reasoning in nurses.[37] In a pharmacy education pilot study, researchers found that learners used metacognitive strategies (visualizing structures or processes) to aid in the retention of newly learned concepts.[35] Burman et al,[9] on the basis of a study of metacognitive skills of pediatric subspecialty fellows, have called for an increased emphasis on the teaching and assessment of metacognitive skills.

IMPLICATIONS FOR PRACTICE

When physician trainees are unaware of their knowledge gaps, they may be unable to critically examine

Table 1 Accreditation Council for Graduate Medical Education Practice-based Learning and Improvement Competency

Residents must demonstrate the ability to investigate and evaluate their care of patients, to appraise and assimilate scientific evidence, and to continuously improve patient care based on constant self-evaluation and lifelong learning.

Residents are expected to develop skills and habits to be able to meet the following goals:

(1) identify strengths, deficiencies, and limits in one's knowledge and expertise;
(2) set learning and improvement goals;
(3) identify and perform appropriate learning activities;
(4) systematically analyze practice using quality improvement methods and implement changes with the goal of practice improvement;
(5) incorporate formative evaluation feedback into daily practice;
(6) locate, appraise, and assimilate evidence from scientific studies related to their patients' health problems;
(7) use information technology to optimize learning; and,
(8) participate in the education of patients, families, students, residents, and other health professionals.

Source: http://www.acgme.org/acgmeweb/Portals/0/PFAssets/ProgramRequirements/CPRs2013.pdf. The practice-based learning and improvement competency is included in the ACGME's Common Program Requirements. This article explores the relationship between metacognition and competencies such as practice-based learning and improvement, which focus, in part, on individuals' assessments of their own knowledge, performance, and goal attainment.

practice patterns, evaluate past mistakes, or prevent errors due to cognitive biases, such as settling on a diagnosis that is recalled more easily than others.[13,22,38] They also cannot successfully set learning objectives based on their own gaps in knowledge or skills. This has real-world implications for the quality of care delivered. Therefore, metacognition is considered to be especially critical to clinical reasoning and decision-making[38-40] because of its fundamental role in monitoring and controlling cognitive processes. Mamede et al,[22] in a study focusing on cognitive errors in clinical decision-making by internal medicine residents, found that the use of diagnostic reflection (a metacognitive skill), when compared with nonanalytic reasoning strategies, seemed to counter cognitive biases and was associated with a statistically significant improvement in diagnostic accuracy scores. Dunphy et al[40] found that those obstetrics-gynecology physicians who scored higher on need for cognition, an aspect of metacognition,[41] had better clinical outcomes (maternal and fetal) during delivery than those with lower scores. The relationship between cognitive biases and diagnostic errors[39,40] has prompted some to call for the early introduction of metacognitive skills in medical education curricula.[21]

TECHNIQUES TO ENHANCE METACOGNITIVE SKILLS

What follows are a number of techniques that may help trainees enhance metacognitive skills and by extension their ability to meet competencies, such as practice-based learning and improvement. Examples of techniques include, but are not limited to, reflection, use of graphic organizers, feedback, use of think-aloud strategies, prediction of outcomes, cognitive debiasing and forcing strategies, and questioning techniques.

- *Reflection.* Faculty can guide learners to reflect on past experiences before feedback sessions, noting whether outcomes met their own objectives for an assignment or encounter. For example, faculty may ask a learner to describe a patient interaction in which bad news was delivered and reflect on their performance during the interaction. Learners also can be asked to focus on actions they might have taken to produce a different outcome. How could they have been more successful? It is helpful for the reflection process to be modeled for learners who are not comfortable with reflective thinking.[42] Mamede et al[22] describe the use of reflection to counter the tendency of first- and second-year residents to engage in cognitive errors such as the tendency to settle on a diagnosis on the basis of how easily it was recalled. Incorporating reflective practice need not entail a major revision of the curriculum. Reflection is routinely used during debriefing of simulation scenarios. It can also be incorporated into curricula during conferences, such as morbidity and mortality sessions, where residents can be asked to reflect on the case presented and identify potential system failures.
- *Use of graphic organizers.* Graphic organizers, which allow for visual representations of information and processes,[43] have been found to enhance knowledge acquisition[44] and retention.[35] Concept maps, one type of graphic organizer, can aid faculty in clarifying concepts for learners.[18] See West et al[45] for a visual depiction of a concept map, which is typically used to organize information. In some situations, graphic organizers may provide the needed visual depiction of a process and its outcome(s), critical for learner understanding. Graphic organizers also can be used to provide overall directions, plans of action, and feedback, thereby functioning as metacognitive scaffolds.
- *Feedback.* As learners often have significant deficits in the capacity to engage in unguided self-assessments of the past performance, it is critical for learners to obtain outside, independent feedback from credible sources.[14,15] Both modifying and reinforcing feedback are important for performance improvement. Although immediate feedback is typically recommended for most learners, Archer[15] noted

that for many high achievers, delayed feedback is often more efficacious than interrupting a task to give a learner immediate feedback.

- *Think-aloud strategies.* Modeling is a frequently used technique in healthcare education to teach learners at all levels.[46] By adding a think-aloud component, faculty can share their own reasoning processes, including how they arrived at certain decisions and how they solve a diagnostic problem. In clinical settings, faculty can articulate how they think through a case to allow students or residents to gain perspective on identified outcomes. Lajoie[47] emphasized the value of measures that help learners understand how experts think. Faculty think-alouds can serve as a scaffold for learners: Explicit modeling fades as students acquire new knowledge and skills. Faculty members have also successfully used the concept of learner think-alouds to better assess clinical reasoning skills in their trainees.[46] Think-aloud strategies, if practiced by faculty before the clinical encounter, should not add unduly to clinical time.
- *Cognitive debiasing and forcing strategies.* In an effort to reduce overconfidence and minimize resulting cognitive biases, learners can be asked to generate counterfactual or disconfirming evidence that supports different conclusions or hypotheses.[39,48] For example, at Scott & White/Texas A&M Health Science Center College of Medicine, pulmonary fellows are queried during informal, small group case presentations and are asked to provide all relevant data while considering disconfirming and confirmatory evidence. Fellows are encouraged to participate in the discussion as the group unpacks the differential diagnosis and reflects on whether or not premature closure has occurred in the decision-making process.[39] As mentioned earlier, reflection also has been used as a cognitive debiasing strategy,[22] with good results. Cognitive forcing strategies (those metacognitive strategies consciously used by clinicians to

Table 2 Example of a Question Card to Guide Self-Questioning

"What Do You Need to Know?"

Use this format to quickly self-assess your knowledge of important, common issues for your patients. This can improve your understanding about what is going on with your patients and will allow you to be a better advocate on their behalf. You will also have done much of the reading for your written analyses for the Preceptor and will have started to separate important from less important information.

"What Do You Need to Know?"—About a Disease or Syndrome

I. Definition
- Can you explain to another what the label means? What it includes/excludes?
- Diagnosis: Complete diagnosis, classification (Is there a further classification or "staging"?) How is the diagnosis made?
- Pathophysiology (non-negotiable information, you must know this)

II. Clinical Picture
- Symptoms, signs, lab (How does each reflect pathophysiology?)
- Who is at risk for this disease? How common is it? Can it be prevented?
- How do age, gender, race, and ethnicity affect prevalence and presentation?
- Differential diagnosis (What else can look like this?)
- Natural history (What happens, if you do nothing, in most patients?)
- Complications (What's the worst, in how many patients?)
- Effect of work and family

III. Treatment (also see "About a Specific Therapy")
- Options for treatment: (Does treatment alter the pathophysiology? Mechanisms)
- Treated history - Is there a standard therapy? How good is it compared with natural history? What should be followed?
- Safety (How "bad" is therapy, risk, costs, and pitfalls?); alternate therapies?

"What Do You Need to Know?"—About a Specific Therapy

1. How does it work? (affecting the anatomy or physiology; if a drug, pharmacology; what are the indications?)
2. How good is it? (efficacy [short-term, long-term]; Are there relapses? How good is the evidence?)
3. How bad is it? (risks, side effects, costs, contraindications); alternatives?

"What Do You Need to Know?"—About a Test (Again, There Are 3 Things)

- How does it work? (How does it address the physiology or anatomy? How will we use the result?)
- How good is it? (sensitivity, specificity, reproducibility, predictive value)
- How bad is it? (risk of the procedure, costs, financial, and otherwise)
- What are the alternatives?

Pangaro L. *Uniformed Services University Medicine Clerkship Handbook.* Available at: http://www.usuhs.mil/med/clerkship/index.html. Reprinted with permission from Louis Pangaro, MD (Uniformed Services University, Bethesda, MD). Because learners often do not know which questions to ask, a question card such as the one presented, developed by Dr Pangaro for medical students, can provide a crucial framework for novice health professionals when approaching clinical problem solving.

halt what may have become an automatic decision-making process) can be taught to residents to prevent errors in clinical reasoning and decision making.[38] Strategies typically use the concept of pausing and "stepping back" mentally from the clinical problem at hand to review the case holistically and consider common pitfalls found within a clinical context before proceeding with a course of action.[28,38,39]

- *Predicting outcomes.* Learners can be asked to scrutinize their own performance, develop an action plan based on past performance, articulate strategies to be incorporated, and predict outcomes. This process enables them to assess the quality of their predictions and evaluate strategy use. In this way, they are required to think about their thinking when it comes to a topic with which they are uncomfortable, explore problems they might encounter, develop an action plan, and anticipate possible outcomes and ways to overcome them.[49] For example, this technique may be used when preparing learners for licensing examinations. Learners can use evidence from prior performances to determine strengths and weaknesses. Simulated examinations enable learners to predict their testing outcomes. Learners also may examine their own knowledge, determine whether their own skills meet a particular competence threshold, and identify specific resources, techniques, and methods needed to fill the gaps in their knowledge.[50]
- *Questioning strategies.* Questioning strategies can aid learners in improving overall comprehension. For example, asking authentic questions can prompt deeper thinking about a topic; demonstrate that there may be more than one right answer; challenge learners to rethink their opinion(s) and evaluate their own judgments and evidence; lead students to seek further information; generate discussion, debate, or conversation; and demonstrate a need for further research to improve understanding.[51] Skills that ask students to infer, predict, make connections with prior knowledge, and synthesize information can be enhanced through questioning strategies.
- *Self-questioning.* Self-questioning as a metacognitive technique can involve verbal or written questions, but requires learners to think about the content or context of a problem to construct a question. Self-questioning can occur before, during, or after learning experiences and can result in reflection, realignment in thinking, and "self-correction."[52] Because learners often do not know which questions to ask, a question card such as the one developed by Pangaro[53] for medical students can provide a crucial framework for novice health professionals when approaching clinical problem solving (**Table 2**).
- *Five Whys.* Five Whys is a brainstorming technique that uses questioning to problem solve, uncover root causes, and potentially rule out competing hypotheses. Although simple (ask yourself "why?" at least 5 times when confronted with a problem),[54,55] the technique is by no means simplistic. This technique acts to cut through underlying assumptions regarding an event, process, or error, thereby aiding trainees in combating cognitive biases.[38,39] For example, a resident may discover through Five Whys that her patient is noncompliant when it comes to medication use not because he is in denial regarding his illness, but because he cannot afford to refill the prescription. Assumptions are challenged and recalibrated via the Five Whys process, which involves feedback from diverse stakeholders.

CONCLUSIONS

In this article, we provided an overview of the role of metacognition and its relationship to competencies such as practice-based learning and improvement. We believe learners at all levels will benefit from knowledge of the role of metacognitive processes in their own learning as they strive for continuous self and practice improvement.[21] We recommend that faculty actively teach metacognitive skills to their trainees and discuss the critical role of metacognition in learning,[18] clinical reasoning,[38,39,56] and enhancement of performance.[21] Enhanced metacognitive skills can combat learner overconfidence, which is linked to diagnostic errors in clinical settings[38,39,56] and the propensity of some learners to stop studying before they have actually mastered the material.[48] It is our hope that faculty will be able to use the techniques highlighted in this article to help trainees enhance their own learning and self-assessment processes to deal with increasingly complex healthcare environments.[57]

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