

REVIEW

Strategies for Improving Learner Metacognition in Health Professional Education

Melissa S. Medina, EdD,^a Ashley N. Castleberry, PharmD, MAEd,^b Adam M. Persky, PhD^c

^a University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma

^b University of Arkansas for Medical Sciences College of Pharmacy, Little Rock, Arkansas

^c Eshelman School of Pharmacy, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

Submitted December 7, 2015; accepted August 29, 2016; published May 2017.

Metacognition is an essential skill in critical thinking and self-regulated, lifelong learning. It is important for learners to have skills in metacognition because they are used to monitor and regulate reasoning, comprehension, and problem-solving, which are fundamental components/outcomes of pharmacy curricula. Instructors can help learners develop metacognitive skills within the classroom and experiential setting by carefully designing learning activities within courses and the curriculum. These skills are developed through intentional questioning, modeling techniques, and reflection. This article discusses key background literature on metacognition and identifies specific methods and strategies to develop learners' metacognitive skills in both the classroom and experiential settings.

Keywords: metacognition, critical thinking, active learning, self-awareness, assessment

INTRODUCTION

Imagine the following situation: You ask your class to find and review a journal article. One of your learners, Morgan, begins the assignment the night before the assignment due date. She is unsure where to search for primary literature. Once she finds an article, she underestimates the review time. She spends several hours reviewing and finishes the assignment in the early morning. When the instructor graded the assignment, she receives a poor grade because most questions were not directly and concisely answered. Morgan is surprised by her grade because she spent several hours working on the assignment, which was more than she thought would be necessary.

While many things could explain Morgan's behavior, at the foundation Morgan may have trouble with metacognition. She failed to plan. She did not know where to look for information. She misjudged time. She did not check her work for accuracy. She was overconfident in her predicted grade. All these elements point to poor metacognitive skills.

What is Metacognition?

We can define metacognition as the "thinking about thinking." Because it refers to a person's "knowledge and cognition about cognitive phenomena."^{1,2} This type of

cognition regulates thinking and learning and consists of three self-assessment skills: planning, monitoring, and evaluating. In the case of Morgan, she failed to lay out a plan for her article review; during the process, did not monitor whether she was accomplishing the goal; and once done, did not evaluate her work for correctness.

Researchers have investigated three aspects of metacognition: metacognitive knowledge, metacognitive monitoring, and metacognitive control.³ Metacognitive knowledge is the information you consult when thinking about an idea; it includes the basic facts and concepts. Metacognitive monitoring is the ability to assess cognitive activity whereas metacognitive control is the ability to regulate cognitive activity. In the example above, Morgan may have lacked the knowledge of where to look for an article or how to review an article (metacognitive knowledge). She may have lacked the ability to assess whether she was answering the relevant questions (metacognitive monitoring). She also may be deficient in the control of metacognition by allowing insufficient time for this activity (metacognitive control).

Importance of Metacognition

Metacognition is important to every profession. There are many reasons why metacognition is important in the health sciences, including from being a better learner to becoming a better clinician. During the learning process, metacognition guides our learning strategies. If learners know what they know and do not know, they can focus on acquiring the knowledge they are lacking.

Corresponding Author: Adam M. Persky, 2312 Kerr Hall, CB#7569, Division of Pharmacotherapy and Experimental Therapeutics, Eshelman School of Pharmacy, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599. Tel: 919-966-9104. Fax: 919-962-0644. E-mail: apersky@unc.edu

Metacognitive skills also have a role in critical thinking and problem solving. If you know what you know and do not know, your metacognitive skills help drive you to obtain the missing information, which we refer to as self-directed or self-regulated learning. Finally, being mindful or metacognitively aware can prevent medication errors in clinical settings because of increases in awareness of our thought process leading to better critical thinking and monitoring of actions. As an example, self-assessment errors routinely occur among physicians, nurses, pharmacists and other health care providers.⁴

Metacognition in Medical Errors

Medical errors are one of the leading causes of death in many countries.⁵ Researchers have argued that medical error is partly a cognitive issue.⁶ Medication order entry errors were the fourth leading cause of medication errors in 2003.⁷ These types of errors can occur because the pharmacist did not ask “do the orders make sense for the indication?” (ie, metacognitive monitoring) or “did I check to ensure I entered things correctly?” (ie, evaluation of medical orders or evaluation of entered data). One study cited that most medication errors occur at the prescription and found 40% of errors were related to prescribing the wrong dose and 18% from omitted information.⁸

In addition, physicians, pharmacists, and other health care providers can be overconfident in their assessments leading to medical errors which can lead to hindsight bias which may further hinder learning. Hindsight bias is the “knew it all along” effect and is the belief that an event is more predictable after it becomes known than it was before it became known. During hindsight bias, we lose the ability to recollect the feeling of uncertainty that preceded an event. This bias hinders our appraisal of past events.

Part of the cause of hindsight bias is the subjective feeling of ease associated when we make judgments – a metacognitive function. When people find it easy to come to a conclusion about a particular outcome, they will show greater hindsight bias, particularly regarding foreseeability (“I knew that would happen.”). One reason is that people attribute the subjective ease of the judgment to the certainty of being correct – the answer came easily and thus must be correct. In one study, physicians were asked to guess the likelihood that they would get the correct diagnosis in the future (prospective or foresight) and in the past (retrospectively or hindsight).⁹ The less experienced physicians gave significantly higher estimates in hindsight than in foresight. For easier cases, the more experienced physicians demonstrated hindsight bias; however, for more difficult cases they did not give higher estimates than in foresight. In another study, physicians were asked their confidence and accuracy during right

heart catheterization.¹⁰ Physicians were confident of their estimates, but there was no relationship between confidence and accuracy. Experienced physicians were no more accurate than less experienced ones, although they were significantly more confident. These are two examples of how metacognitive skills may affect clinical judgments.

Metacognition and Study Skills

Metacognition is crucial in controlling and guiding thinking.¹ Dunlosky proposed a model of how metacognitive control impacts study time.¹¹ This model included study preparation (self-efficacy evaluation, task appraisal, and initial strategy selection) followed by monitoring and assessing whether the to-be-learned items has been learned and feeding back into the cycle to re-study unlearned material. Several investigators found that learners are unaware of effective study strategies which impact performance.¹²⁻¹⁴

College learners have displayed overconfidence in self-chosen study strategies about academic performance and have demonstrated low correlations between self-predicted and actual performance on learning assessments.^{15,16} This pattern of overconfidence may be more apparent in low-performing learners.^{17,18} The issue of selecting study strategies is complicated because a requirement for selecting a learning strategy is metacognitive knowledge about which learning strategies are beneficial for long-term memory. Several studies report learners using low-impact study strategies such as rereading or highlighting notes.^{12,19,20} In one study, 80% of undergraduates reported that the study skills they use were learned on their own and not taught to them in a formal manner by teachers.¹⁶ These findings are consistent with the health science literature that also found rereading a prominent learning strategy.^{20,21} The selection of poor study strategies raises questions of whether those improvised strategies, presumably based on intuition or metacognitive feedback, are consistent with the evidence. This hypothesis raises a second question whether instruction on learning and memory topics could improve metacognitive awareness of successful learning strategies. Recently it was documented that learners who have engaged in their study skills development use better strategies, but low impact strategies still predominate.²⁰ As a result, faculty members are advised to teach study skills formally to learners.²²

Metacognition and Self-Directed Learning

Most health-professional organizations and accrediting bodies encourage lifelong learning because of the ever-changing biomedical landscape. Lifelong learning requires self-direction and self-regulation. Self-directed learning is the result of allowing learners to make decisions about the information they want to experience or

learn.²³ In a realistic learning situation, self-directed learning is difficult and in a formal education setting, information selection is limited and governed by the instructor.²⁴ While this is limiting, instructors need to set learning objectives for novice learners because these learners are not in a position to be self-directed. They do not know the skills and knowledge needed to become a health professional; also, limiting resources to find information may be appropriate early on to help build efficiency into the learning process (ie, learners do not have to spend large amounts of time searching for relevant information).

Providing guidance can lead to a “passive learning environment.” However, within a passive learning environment, learners selectively attend to different environmental cues.²⁵ As an example of a passive environment, learners actively evaluate what has been said, or engage in self-explanation to decide what other information is required.²⁴ Self-directed learning differs from self-regulation. For example, if the article Morgan found was interesting, she could be self-directed in learning more about the topic. However, she would be self-regulated when balancing this additional learning with her required course learning.

Self-regulation is how individuals guide their goal-directed activities over time. It is designed to maximize the long-term best interests of an individual, resulting in learners controlling their impulses and looking out for their well-being.²⁶ Self-regulated learning modulates various processes (eg, cognitive, behavioral) to reach the desired goal. These regulatory mechanisms are the essentials of self-regulated learning because they are under the control of the learners and would be the basis for future professional development (ie, continual professional development). The self-regulated behaviors include planning, monitoring, attention, and effort.

Both planning and monitoring are components of metacognition. When learners engage in planning activities, they think through what they need to learn and set task-specific goals.^{27,28} Once they plan, they need to monitor. Monitoring refers to paying attention to one’s performance and understanding of the course material.²⁹ Monitoring is a critical component of self-regulation because it provides awareness of one’s knowledge level, which then leads to changes in one’s affect, cognition, and behavior.²⁷ Accurate monitoring enhances the regulation of learning because it provides feedback to what trainees already know and where they need to focus their resources.^{28,30}

Metacognition and Critical Thinking

Critical thinking involves cognitive, dispositional and metacognitive components. The cognitive component represents the abilities to comprehend a problem

and apply cognitive skills to make sound judgments. The disposition component influences the patterns of intellectual activity; these can include the enjoyment of thinking, an open attitude, a careful approach and a mindset for truth seeking.^{31,32} Metacognitive strategies enable learners to supervise and control their thinking processes. At its core, a critical thinker is one in charge of their thinking processes, while metacognitive strategies enable such control to take place. The metacognitive aspects interact with a variety of internal and external factors like type of instruction, motivation, and socio-economic status (Figure 1).

Metacognition is the ability to monitor thinking to use skills and strategies appropriately to achieve a desirable outcome. We discussed this regarding learning strategies and parallels can be made for critical thinking skills. Halpern defines a critical thinker as one who applies appropriate skills and strategies to achieve a desirable outcome.³³ As such, critical thinkers strategically use cognitive skills that are best suited to a particular situation. They are aware of their thinking and thus control their thinking processes. Metacognitive strategies are an important variable during thinking processes.³³ These skills need to be made explicit and public to develop critical thinking skills.³³

Metacognition and the Accreditation Process

Accreditation standards for pharmacy (ACPE) and medicine (AAMC) emphasize metacognitive skills as a critical part of health professional training. For pharmacy education, the college or school provides an environment and culture that promotes self-awareness, self-directed lifelong learning, professional behavior, leadership, collegial relationships, and collaboration within and across academic units, disciplines, and professions. (Standards 4 and 9). The experiential curriculum should provide an inculcation of habits of self-directed lifelong learning

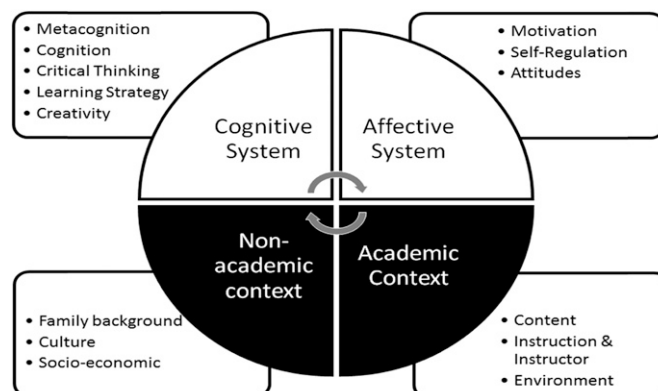


Figure 1. Influence of Internal and External Factors in Cognition

(Standard 12). Standard 4 explicitly states self-awareness as a key factor and that learners use metacognitive practice to regulate their learning. The appendices further emphasize self-directed and lifelong learning including continuous professional development. Similarly, in medicine we see an emphasis on self-directed learning. The faculty of a medical school should ensure that the medical curriculum includes self-directed learning experiences and time for independent study to allow medical learners to develop the skills of lifelong learning. Self-directed learning involves medical learners' self-assessment of learning needs; independent identification, analysis, and synthesis of relevant information; and appraisal of the credibility of information sources (Standard 6.3).

Overview of Instructional Approaches to Teach Metacognition

Metacognitive processes are best taught in conjunction and alignment with cognitive processes and separating the two processes is challenging.³⁴ One key instructional strategy in developing metacognition is cognitive apprenticeship. Cognitive apprenticeship is "learning through guided experience." In this model, the expert's cognitive and metacognitive processes and skills used when performing a task are explicit and public and are the focus of teaching activities.³⁵ There are four dimensions to this model that reflect the three dimensions of metacognition.

The first dimension includes content knowledge (concepts, facts, procedures) and strategic knowledge (heuristic, metacognitive, learning). To think through a process, one must have the content knowledge to think about something. One also needs to have a heuristic (short-cut) or algorithm (formula) to follow to develop the skill. Thus, instruction should have a content component and direct instruction on how to work through a process.

The second dimension of cognitive apprenticeship has a method to demonstrate metacognition. The expert or instructor should model the process – externalizing the thought process. The concept of coaching is appropriate as the expert should help demonstrate and coach learners through the process. Within this procedure, learners reflect on their thoughts, verbalizing their motives and assumptions.³⁴ The process should be scaffolded, ie, offering early examples or demonstrations in a more supportive model leading to a level of independence.

The third dimension of cognitive apprenticeship is an extension of scaffolding, and this concept is the importance of sequencing: increasing task complexity, diversity of problems, and migrating from global to local skills. Task complexity starts with straightforward problems and building complexity with experience. The diversity of problems helps learners build

more generalizable knowledge and skills. When we use a diversity of problems, we are approaching similar problems from different contexts to help build context-independent knowledge and skills. When we learn, we form a memory trace for that information. This memory is dependent on the cues available during the learning context.³⁶ We can recall this information only if we receive the correct cues. If we see the content or skill (or thought process) with a wide array of problems, we can retrieve the information from a variety of cues and contexts and start to make generalities. Finally, after faculty scaffold and sequence appropriately, they move the learners from global skills to local skills. At this point, learners should have a clear conceptual model of the task or process before executing its parts. Developing global skills reflects the idea that seeing the overall structure of the problem or content helps in understanding the individual parts because we can draw on relationships to help reinforce the learning.³⁷

The fourth dimension of cognitive apprenticeship is the sociology of learning and includes situated learning, a community of practice, intrinsic motivation, and exploiting cooperation. This idea is consistent with factors of motivation especially relatedness – we are more motivated to learn or perform when we can relate to the situation or the person. The authenticity of the learning environment (experiential vs. classroom) or the problem (patient case vs. foundational science) helps frame the real-world context which increases motivation. Therefore, situated learning (environment reflects the real-world) increases motivation.³⁸⁻⁴⁰ The last components are social in nature but also consistent with effective learning strategies: a community of practice (engaging in a community to achieve goals) and cooperation (cooperation between learners in problem solving). These methods are real-world since health care is a team process and the research consistently show that learners teaching other learners is an effective strategy (effect sizes above 0.70).⁴¹ Cooperative learning allows for a variety of positive attributes including feedback and communication which help in the metacognitive process.

Strategies to Enhance Metacognition in the Classroom

Several methods can be used to enhance learners' metacognition in the classroom. Methods used during any part of normal instructional approaches include lecture, active learning exercises, or pre-planned activities outside of the classroom. Example methods can be modified based on the knowledge level of the learner and number of learners in the classroom in combination with scaffolding. To note, developing metacognition within

learners is not an easy task.³⁴ Appendix 1 contains some sample metacognitive learning objectives.

General Planning

Learners plan better and learn when their attention focuses on learning objectives established by the instructor. The explicit discussion of the learning objectives starts the metacognitive process by prioritizing the importance of thinking about the learning process over the content. To activate prior knowledge, prompt the learners to think about what they already know that is related to the content of that day and what relevant knowledge they lack.⁴² Next, lead the learners to analyze the distinctions between contrasting information and focus more on these differences rather than the similarity between concepts.^{43,44} Have learners assess the time it will take to complete this activity and where they will find the resources for successful completion of the task to help them think about the process of studying. Additional self-questions to promote learner metacognition about learning can be found in Table 1.⁴⁵

General Monitoring

Learners benefit from monitoring their understanding (ie, metacognitive awareness) during teaching activities.⁴⁶⁻⁴⁸ By checking learning behavior throughout the lecture or teaching activity, learners are reminded of the importance of the learning process. Learners can accomplish this by noting important concepts and writing down questions during the lecture or activity.⁴⁵ Jotting down questions can be facilitated by dividing content into 10-15 minute segments and offering activities to refocus attention to the learning objectives and reflecting on their comprehension of the material. The instructor can help learners learn strategies for retaining information such as chunking, connecting, and elaborating and assist them in organizing the material in ways to recognize patterns and associations. They may regulate the difficulty of the material by breaking down the problem into simpler steps for learners to clearly see the thought process of problem-solving.⁴³ After some practice with simpler questions, incrementally increase the difficulty of the problem. Another way to assist learners in monitoring their thought processes is to provide half-done examples and have learners solve them then discuss possible conclusions. By monitoring smaller pieces of an assignment, the instructor and learners are better able to identify and correct errors in thinking. (Table 1).

General Evaluating

By evaluating metacognitive skills, learners become more aware of this process and its impact on learning. Creating checklists, rating scales, and rubrics for distribution before the assignment can help learners monitor and

evaluate their thinking as they are working. Additionally, administering a metacognitive questionnaire during an exam can help learners evaluate their thinking during the exam and make corrections accordingly (Appendix 2 provides an example).⁴⁹ Reviewing this questionnaire after the exam along with individual results can also be helpful to identify patterns of incorrect thinking or gaps in preparation and study time. Having learners evaluate their learning is powerful and can lead to change for future learning (Table 1).

Other Strategies

Examination Reviews

Examinations themselves can be a metacognitive method.^{50,51} Reviewing an examination with learners after grades are released can be a powerful way to help them start thinking about their thought process during the examination. Examination reviews occur in a group setting with the entire class or during a one-on-one or small group interaction with learners. During this session, have learners reflect on their answer choice and the actual correct answer. Ask them to reflect on why they got the item incorrect and specifically why this occurred. Ask prompting questions such as: What were your assumptions about this item? What are some alternative ways to approach this question? What piece of knowledge were you missing? By forcing learners to identify the problem in their thought process for each item, you might be able to discern a pattern in behaviors and offer strategies to remedy this. In addition, the small delay in feedback also can enhance learning.⁵²

In addition to reviewing the exam after administration and scoring, a review before the exam can help learners assess their learning strategies and adjust accordingly before the exam. Doing an exam review a couple of days before the exam still gives learners time to change their studying and enhance weak areas. By using questions similar to the format of an examination question, learners familiarize themselves with the examination requirements. Using active learning strategies paired with a group discussion on questions that require critical thinking can be a powerful review tool for learners. A review before and after an examination can benefit learner learning.

Thinking out Loud

A form of modeling is thinking out loud, and this occurs in the classroom.⁴³ For example, provide learners with a complex question or case scenario and let them think about their approach to solving the issue. Then think out loud to model your thought process for how you would solve this issue as a content expert. Have learners compare

Table 1. Sample Self-Questions to Promote Learner Metacognition About Learning^{45,66-68}

Activity	Planning	Monitoring	Evaluating
Class session	<p>“What are the goals of this class session?”</p> <p>“What do I already know about this topic?”</p> <p>“How could I best prepare for this class session?”</p> <p>“What questions do I already have about this topic?”</p> <p>“What are all the things I need to do to accomplish this task?”</p> <p>“What resources do I need?”</p> <p>“How much time do I need?”</p>	<p>“Can I distinguish important information from details? If not, how will I figure this out?”</p> <p>“What insights am I having as I experience this class session?”</p> <p>“What questions are arising for me during the class session?”</p> <p>“What is most challenging for me about this task? Most confusing?”</p> <p>“What learning strategies am I using that are working well or not working well?”</p> <p>“What other resources could I be using to complete this task?”</p>	<p>“What was today’s class session about?”</p> <p>“What did I find most interesting about class today?”</p> <p>“How did the ideas of today’s class session relate to previous class sessions?”</p> <p>“What do I need to go and do now to get my questions answered?”</p> <p>“What worked well for me that I should use next time?”</p> <p>“To what extent did I accomplish the goals of the task?”</p> <p>“If I were the instructor, what would I identify as strengths of my work and flaws in my work?”</p>
Active-learning task and homework assignment	<p>“If I have done something like this before, how could I do a better job this time?”</p> <p>“What study strategies will I use (study groups, practice quizzes, review sessions)?”</p> <p>“Over what period and for how long do I need to study?”</p>	<p>“Which confusions remain and how am I going to get them clarified?”</p> <p>“To what extent am I taking advantage of all the learning supports available to me?”</p>	<p>“What about my exam preparation worked well or did not work well that I should remember next time?”</p> <p>“What questions did I not answer correctly? Why?”</p>
Quiz or exam	<p>“Which material should I spend more/less time on?”</p> <p>“What do I most want to learn in this course?”</p> <p>“Why is it important to learn the material in this course?”</p> <p>“How does success in this course relate to my career goals?”</p>	<p>“How interested am I in this course?”</p> <p>“How confident am I in my learning?”</p> <p>“What could I do to increase my interest and confidence?”</p>	<p>“What confusions do I have that I still need to clarify?”</p> <p>“What have I learned about how I learn in this course that I could use in my future courses? In my career?”</p> <p>“What advice would I give a friend about how to learn in this course?”</p> <p>“If I were to teach this course, how would I change it?”</p>
Overall course			

Adapted with permission from Tanner KD. Promoting student metacognition. *CBE Life Sci Educ.* 2012;11(2):113-120

their thought process to yours to identify gaps, errors, or alignment to improve their thinking. This method also benefits learners in experiential training such as clinical rotations or shadowing experiences. Expert thinking is often internal and not portrayed to learner learners who can negatively reinforce wrong thinking. For example, when experts are problem-solving, they silently sort relevant and irrelevant information before generating a solution. To a novice learner, all of the information can appear important, which can hinder their problem solving. Experts should instead think out loud so novices can better understand what is irrelevant in certain problem-solving situations. By thinking out loud, you show learners how to approach situations and model the process of monitoring your behaviors in professional practice.

Reflection

Reflection is simply the intentional and dynamic process that allows improvement in one's actions, abilities, and knowledge by learning from past experiences.⁵³ To reflect, think back on an experience and analyze the situation. By getting learners to reflect, they think about their actions, abilities, and knowledge and assess improvement in these areas moving forward. Reflection assignments following learning activities (whether in the classroom, simulation, or practice) can help learners think about their thinking and develop plans to grow in these areas. Reflective writing assignments can include responses to three questions: What worked well when preparing for this exam/quiz/assignment? What did not work well when preparing for this exam/quiz/assignment? What will I change before my next exam/quiz/assignment?⁴⁵

Reflection using the "Muddiest Point" allows learners to identify confusion during a lecture or learning activity.⁴⁵ Have learners write down what part of the material remains confusing to them. Then have the learners investigate the issue further to encourage exploration of knowledge and self-directed learning. This quick exercise can have a high yield for metacognitive practice.

Another reflective method is self-explanation. When learners use self-explanation, they are asking themselves to explain their process and what they can do next time. This technique has been used to facilitate the transfer of learning and problem solving.⁵⁴

Adding Judgments of Understanding

Asking learners to prospectively make judgments (eg, I predict my score on this exam to be. . .) or retrospectively make judgments (eg, for the test question I just completed, my confidence in my answer is. . .) can help learners monitor or evaluate their learning. These

types of judgments have been used within higher education and courses in pharmacy.^{17,18,55} When asked these questions, learner accuracy in predicting grades improves and moves from being overconfident to underconfident with reductions in bias.^{18,49} See Appendix 3 for an example of a weekly monitoring exercise with judgments of understanding.

Strategies to Enhance Metacognition in the Experiential Setting

In addition to classroom instruction, raising learners' metacognition is important in the experiential setting. To date, there is less research in this educational setting, but opportunities exist to develop and research metacognitive development.

Mastery Goal Setting

Artino and colleagues in 2012 found that learners' metacognitive skills (planning, goal setting, monitoring comprehension, and evaluating learning) correlated positively with mastery goal structures, which are environments that emphasize developing competence, mastering new skills and learning to understand.⁵⁶ Mastery goal structures contrast with performance-approach goal structures that focus on demonstrating proficiency and peer comparison and performance-avoid goal structures that encourage avoiding looking incompetent.⁵⁶ Both performance-approach and avoidance structures are associated with procrastination, avoidance of help-seeking, and poor grades, which are goal orientations that become predominant in the experiential setting.⁵⁶ Learners in the experiential setting may resort to these goal orientations because it is a time when the bulk of learners' grades are derived directly from observation instead of tests, and they may adapt behaviors to avoid looking incompetent.⁵⁶ Based on these findings, preceptors should consider encouraging learners to adapt mastery-oriented goals and seek help when needed. One way preceptors support mastery goal structures is to offer formative assessments paired with feedback that emphasizes progress and mastery of knowledge, skills, and attitudes.⁵⁶ These formative assessments can take a variety of forms from case discussions, journal clubs, or presentations – typically practices that normally occur during experiential rotations. These should regularly occur to help the learner develop. These feedback sessions may be an opportunity to use the verbalization strategies found in Appendix 4.

Questioning and Feedback

Another way preceptors can help their learners on rotation is to emphasize metacognitive skills from the beginning of training coupled with immediate feedback

regarding technique. This method was shown to help novice medical learners on a surgery rotation learn laparoscopic surgery skills using simulation software.⁵⁷ There are questions that preceptors regularly can ask learners to promote metacognitive awareness, including questions related to planning, monitoring, and evaluating. Research with elementary school learners showed that when teachers asked learners two questions, “what did you learn about yourself today regarding the subject area?” and “What did you learn that you can consistently replicate well?” their metacognitive awareness increased.⁵⁸ Based on these results, preceptors could ask learners questions found in Table 2.

Another important aspect of experiential education is the purpose of asking questions. Often we might hear of preceptors “pimping” learners – that is to ask questions under the guise of educating them but the real purpose is to determine hierarchy. Questioning should be Socratic and developmental compared to evaluative and demeaning (Table 3).⁵⁹⁻⁶²

To effectively ask questions, preceptors should do the following:⁵⁹ diagnose the learners (ie, what level are they at) and teach to that level; avoid asking questions for questions’ sake (for eg, questions about trivia, historical facts, non-meaningful eponyms, and impossible, guess-what-I’m-thinking questions); tell learners your goal in asking questions; emphasize important learning points; and do not attempt to embarrass intentionally or humiliate the learners.

Clinical Documentation with Explanation

Written and verbal communication require an explanation of the thought process. For example, if you are making a recommendation to a physician for a specific drug, you should explain why you chose that drug (drug allergy to another drug, lab levels, adverse effects, other disease states). By explicitly documenting reasoning, metacognition is modeled and could lead to better communication and patient outcomes. As an example, SOAP notes may include an additional page that documents the rationalization and resources used to arrive at the plan. SOAP notes have been used to improve reflection and learning in medical physiology in medical learners and help faculty reflect on learning in dental hygiene education.⁶³ The use of clinical documentation may be especially impactful when novices can compare their documents to experienced clinicians and when clinicians verbalize their process as they develop the document.

Experiential Rotation Structure

Finally, the overall structure of experiential education should be scaffolded – both between and within

Table 2. Questions to Ask During Experiential Settings

Planning	Monitoring	Evaluating
“How did your planning for rounds today help you manage your patients?”	“How did you prioritize what information you needed to cover with the patient for their discharge planning?”	“How well are you recalling and applying your knowledge from the didactic curriculum to this rotation experience and what could you do to improve?”
“Do you think you are allotting enough time to prepare for rounds and manage your patients for the day and how do you know?”	“Did the patient or health care provider implement the recommendation you recommended and what do you think influenced that decision?”	“How integrated do you think you are on your interprofessional health care team and how do you know?”
“How much time did you dedicate to search the literature for the guidelines you used today to make your recommendations and was it enough time?”	“What template are you using to write your SOAP notes and document your patient encounters and how is it working for you?”	“How well do you think you conveyed your topic to the hospital staff today during your inservice and what evidence do you have to support that impression?”
	“Give reasons to support your clinical decision.” “Give reasons that weaken your conclusion.” “What assumptions did you make?”	

Table 3. Comparison of the Socratic Teaching Method vs Clinical “Pimping”

Technique	Socratic Method	“Pimping”
Goals	Connect new knowledge to existing knowledge; Teach	Evaluate learners; Establish hierarchical order; Teach
Types of questions	Probing and leading, making connections	Factual, about history, eponyms, lists
Setting	One-on-one, small group	Small group

Reprinted with permission from Oh RC, Reamy BV. The Socratic method and pimping: optimizing the use of stress and fear in instruction. *Virtual Mentor*. 2014;16(3):182-186.⁵⁹

a rotation. Learners should be started with a more supportive environment and moved toward more independence; this can support their metacognitive development. This scaffolding or progressive problem-solving approach is a critical part of developing expertise. It is the gaining of experience for both content but process that is important. Experts are more metacognitively aware than novices because the progression of problem solving requires the cognitive and metacognitive processes.⁶⁴

SUMMARY

Metacognition refers to a person’s ability to regulate their thinking and learning and consists of the self-assessment skills: planning, monitoring, and evaluating. These important skills reduce self-assessment errors, such as hindsight bias, among health care providers. The new pharmacy, medical, and nursing education accreditation standards emphasize metacognitive skills and the related skills in critical thinking and self-directed learning. Studies reporting formal teaching of these skills are often lacking which further emphasizes the need to teach health care learners explicitly metacognitive skills during their training. Suggestions for teaching metacognitive skills in the didactic setting include cognitive apprenticeships, exam reviews, modeling of metacognitive skills, thinking out loud protocols, reflection assignments, self-explanation methods, and judgment of understanding assignments. In the experiential setting, faculty members can emphasize mastery goal setting, use questioning techniques that promote metacognitive awareness coupled with feedback about learner efforts in this area, request clinical documentation with an explanation, and scaffold learners during the rotation. Overall, using these teaching strategies regardless of setting can raise learners’ self-awareness and help metacognitive thinking to occur more automatically. Metacognition’s role in clinical decision making is important as it is a means to address “what to learn,” “when to learn,” and “how to learn.”⁶⁵

ACKNOWLEDGMENTS

The authors thank Cindy Stowe and John Dunlosky for their input during manuscript preparation, and Kayley

Lyons, Shelby Hudson, and Tom Angelo for their help during the editing process.

REFERENCES

1. Flavell JH. Metacognition and cognitive monitoring: a new area of cognitive-developmental inquiry. *Am Psychol*. 1979;34(10):906-911.
2. Jacobs J, Paris S. Children’s metacognition about reading: issues in definition, measurement, and instruction. *Educ Psychol*. 1987;22(3):255-278.
3. Dunlosky J, Metcalfe J. *Metacognition*. Los Angeles, CA: SAGE; 2009.
4. Dunning D, Heath C, Suls JM. Flawed self-assessment: implications for health, education, and the workplace. *Psychol Sci*. 2004;5(3):69.
5. Zineldin M, Zineldin J, Vasicheva V. Approaches for reducing medical errors and increasing patient safety: TRM, quality and 5 Qs method. *TQM Journal*. 2014;26(1):63-74.
6. Zhang J, Patel VL, Johnson TR. Medical error: is the solution medical or cognitive? *J Amer Med Inform Assoc*. 2002;9(6):S75-S77.
7. Bell C, Moore J, Couldry R, Grauer D. The use of individualized pharmacist performance reports to reduce pharmacist-related medication order entry errors following electronic medical record implementation. *Hosp Pharm*. 2012;47(10):771-775.
8. Ibáñez-García S, Rodríguez-González CG, Martín-Barbero ML, Sanjurjo-Saez M, Herranz-Alonso A. Adding value through pharmacy validation: a safety and cost perspective. *J Eval Clin Pract*. 2016;22(2):253-260.
9. Dawson NV, Arkes HR, Siciliano C, Blinkhorn R, Lakshmanan M, Petrelli M. Hindsight bias: an impediment to accurate probability estimation in clinicopathologic conferences. *Med Decis Making*. 1988;8(4):259-264.
10. Dawson NV, Connors AF Jr, Speroff T, Kemka A, Shaw P, Arkes HR. Hemodynamic assessment in managing the critically ill: is physician confidence warranted? *Med Decis Making*. 1993;13(3):258-266.
11. Dunlosky J, Thiede KW. What makes people study more? An evaluation of factors that affect self-paced study. *Acta Psychol*. 1998;98(1):37-56.
12. Karpicke J, Butler A, Roediger Iii H. Metacognitive strategies in student learning: do students practise retrieval when they study on their own? *Memory*. 2009;17(4):471-479.
13. Carrier LM. College students’ choices of study strategies. *Percept Motor Skills*. 2003;96(1):54-56.
14. Bjork RA, Dunlosky J, Kornell N. Self-regulated learning: beliefs, techniques, and illusions. *Ann Rev Psychol*. 2013;64(1):417-444.
15. Winne PH, Jamieson-Noel D. Exploring students’ calibration of self reports about study tactics and achievement. *Contemp Educ Psychol*. 2002;27(4):551-572.

16. Kornell N, Bjork RA. The promise and perils of self-regulated study. *Psychon Bull Rev.* 2007;14(2):219-224.
17. Hacker DJ, Bol L, Horgan DD, Rakow EA. Test prediction and performance in a classroom context. *J Educ Psychol.* 2000;92(1):160-170.
18. Hartwig MK, Persky AM. Repeated cumulative testing in a classroom: underconfidence-with-practice for authentic course material. In preparation.
19. Hartlep KL, Forsyth GA. The effect of self-reference on learning and retention. *Teach Psychol.* 2000;27(4):269-271.
20. Persky AM, Hudson S. A snapshot of student study strategies across a professional pharmacy curriculum: are students using evidence-based practice? *Curr Teach Learn Pharm.* 2016;8(2):141-147.
21. Hagemeyer NE, Hess R Jr, Hagen KS, Sorah EL. Impact of an interprofessional communication course on nursing, medical, and pharmacy students' communication skill self-efficacy beliefs. *Am J Pharm Educ.* 2014;78(10):Article 186.
22. Persky AM, Alford EL, Kyle J. Not all hard work leads to learning. *Am J Pharm Educ.* 2013;77(5):Article 89.
23. Thiede KW, Dunlosky J. Toward a general model of self-regulated study: an analysis of selection of items for study and self-paced study time. *J Exp Psychol Learn Mem Cogn.* 1999;25(4):1024-1037.
24. Gureckis TM, Markant DB. Self-directed learning: a cognitive and computational perspective. *Persp Psychol Sci.* 2012;7(5):464-481.
25. Rehder B, Hoffman AB. Eyetracking and selective attention in category learning. *Cogn Psychol.* 2005;51(1):1-41.
26. Sitzmann T, Ely K. A meta-analysis of self-regulated learning in work-related training and educational attainment: what we know and where we need to go. *Psychol Bull.* 2011;137(3):421-442.
27. Pintrich PR. Issues in self-regulation theory and research. *J Mind Behav.* 2000;21(1-2):213-220.
28. Zimmerman BJ. Self-efficacy: an essential motive to learn. *Contemp Educ Psychol.* 2000;25(1):82-91.
29. Kanfer R, Ackerman PL. Motivation and cognitive abilities – an integrative aptitude treatment interaction approach to skill acquisition. *J Appl Psychol* 1989;74(4):657-690.
30. Dunlosky J, Kubat-Silman AK, Hertzog C. Training monitoring skills improves older adults' self-paced associative learning. *Psychol Aging.* 2003;18(2):340.
31. Facione PA, Facione NC. Externalizing the critical thinking in knowledge development and clinical judgment. *Nurs Outlook.* 1996;44(3):129-136.
32. Ku KYL, Ho IT. Metacognitive strategies that enhance critical thinking. *Metacogn Learn.* 2010;5(3):251-267.
33. Halpern DF. Teaching critical thinking for transfer across domains: dispositions, skills, structure training, and metacognitive monitoring. *Am Psychol.* 1998;53(4):449-455.
34. Hacker DJ, Dunlosky J. Not all metacognition is created equal. *New Dir Teach Learn.* 2003;2003(95):73-79.
35. Stalmeijer RE. When I say ... cognitive apprenticeship. *Med Educ.* 2015;49(4):355-356.
36. Gallo DA, Geraci L, Iii HLR. Processing approaches to cognition: the impetus from the levels-of-processing framework. *Memory.* 2002;10(5):319-332.
37. Bransford JD, Johnson MK. Contextual prerequisites for understanding: some investigations of comprehension and recall. *J Verbal Learn Verbal Behav.* 1972;11(6):717-726.
38. Finney S, Pyke J. Content relevance in case-study teaching: the alumni connection and its effect on student motivation. *J Educ Busin.* 2008;83(5):251-258.
39. Frymier AB, Houser ML. Does making content relevant make a difference in learning? *Commun Res Report.* 1998;15(2):121.
40. Frymier AB, Shulman GM. What's in it for me – increasing content relevance to enhances student motivation. *Commun Educ.* 1995;44(1):40-50.
41. Rosenshine B, Meister C. Reciprocal teaching: a review of the research. *Rev Educ Res.* 1994;64(4):479-530.
42. Schwartz DL, Bransford JD. A time for telling. *Cogn Instruct.* 1998;16(4):475-522.
43. Beyer BK. *Improving Student Thinking: A Comprehensive Approach.* Boston, MA: Allyn and Bacon; 1997.
44. Kalyuga S, Ayres P, Chandler P, Sweller J. The expertise reversal effect. *Educ Psychol.* 2003;38(1):23-31.
45. Tanner KD. Promoting student metacognition. *CBE Life Sci Educ.* 2012;11(2):113-120.
46. Hacker DJ, Bol L, Bahbahani K. Explaining calibration accuracy in classroom contexts: the effects of incentives, reflection, and explanatory style. *Metacog Learn.* 2008;3(2):101-121.
47. Hartwig MK, Was CA, Isaacson RM, Dunlosky J. General knowledge monitoring as a predictor of in-class exam performance. *Br J Educ Psychol.* 2012;82(3):456-468.
48. Nietfeld JL, Cao L, Osborne JW. The effect of distributed monitoring exercises and feedback on performance, monitoring accuracy, and self-efficacy. *Metacog Learn.* 2006;1(2):159-179.
49. Schneider EF, Castleberry AN, Vuk J, Stowe CD. Pharmacy students' ability to think about thinking. *Am J Pharm Educ* 2014;78(8):Article 148.
50. Karpicke JD, Blunt JR. Retrieval practice produces more learning than elaborative studying with concept mapping. *Science.* 2011;331(6018):772-775.
51. Roediger III HL, Putnam AL, Smith MA. Ten benefits of testing and their applications to educational practice. *Psychol Learn Motiv Adv Res Theory.* 2011;55:1-36.
52. Mullet HG, Butler AC, Verdin B, von Borries R, Marsh EJ. Delaying feedback promotes transfer of knowledge despite student preferences to receive feedback immediately. *J Appl Res Mem Cogn.* 2014;3(3):222-229.
53. Castleberry AN, Payakachat N, Ashby S, et al. Qualitative analysis of written reflections during a teaching certificate program. *Am J Pharm Educ.* 2016;80(1):Article 10
54. Aleven VAWMM, Koedinger KR. An effective metacognitive strategy: learning by doing and explaining with a computer-based cognitive tutor. *Cogn Sci.* 2002;26(2):147-179.
55. Nietfeld JL, Cao L, Osborne JW. The effect of distributed monitoring exercises and feedback on performance, monitoring accuracy, and self-efficacy. *Metacogn Learn.* 2006;1(2):159-179.
56. Artino Jr AR, Dong T, Dezee KJ, et al. Achievement goal structures and self-regulated learning: Relationships and changes in medical school. *Acad Med.* 2012;87(10):1375-1381.
57. Uemura M, Tomikawa M, Nagao Y, et al. Significance of metacognitive skills in laparoscopic surgery assessed by essential task simulation. *Min Invas Therap Allied Technol.* 2014;23(3):165-172.
58. Perry NE, VandeKamp KO, Mercer LK, Nordby CJ. Investigating teacher-student interactions that foster self-regulated learning. *Educ Psychol.* 2002;37(1):5-15.
59. Oh RC, Reamy BV. The Socratic method and pinging: optimizing the use of stress and fear in instruction. *Virtual Mentor.* 2014;16(3):182-186.

American Journal of Pharmaceutical Education 2017; 81 (4) Article 78.

60. Brancati FL. The art of pimping. *JAMA*. 1989;262(1):89-90.
61. Detsky AS. The art of pimping. *JAMA*. 2009;301(13):1379-1381.
62. Tofade T, Elsner J, Haines ST. Best practice strategies for effective use of questions as a teaching tool. *Am J Pharm Educ*. 2013;77(7):Article 155.
63. Jacks ME, Blue C, Murphy D. Short- and long-term effects of training on dental hygiene faculty members' capacity to write SOAP notes. *J Dent Educ*. 2008;72(6):719-724.
64. Chi MTH, Glaser R, Farr MJ. *The Nature of Expertise*. Hillsdale, NJ: L. Erlbaum Associates; 1988.
65. Marcum JA. An integrated model of clinical reasoning: dual-process theory of cognition and metacognition. *J Eval Clin Pract*. 2012;18(5):954-961.
66. Ertmer PA, Newby TJ. The expert student: strategic, self-regulated, and reflective. *Instruct Sci*. 1996;24(1):1-24.
67. Schraw G. Promoting general metacognitive awareness. *Instruct Sci*. 1998;26(1/2):113-125.
68. Coutinho SA. The relationship between goals, metacognition, and academic success. *Educate*. 2007;7(1):39-47.
69. Hartman H, Sternberg RJ. A broad BACEIS for improving thinking. *Instruct Sci*. 1992;21(5):401-425.

Appendix 1. Outcome/Objective Statements

By the end of this course, you should be able to:

Comprehend the limits of your memory for a particular task and create a means of external support.

Self-monitor your learning strategies and then adapt the strategies if they are effective.

Notice whether you comprehend something you just read and then modify your approach if you did not comprehend it.

Skim subheadings of unimportant information to get to the information you need.

Rehearse a skill to gain proficiency.

Self-test to see how well you learned something.

Verbalize your thought process for a particular task.

Appendix 2. Exam Item Assessment

Name: _____

Select up to 5 questions that you feel certain you answered incorrectly and tell why you think that was the case. This information will be used to assess the metacognitive skills of the class. This form will NOT affect your grade or standing in this course in any way.

	Item Description (not just the item number)	Question was confusing or difficult to understand	I was not prepared for this item	Other
1	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> _____
2	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> _____
3	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> _____
4	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> _____
5	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> _____

What percent score do you think you made on this examination (0-100%)? _____

Rate your ability to perform well on a multiple-choice examination (1=poor TO 5=excellent).

1 2 3 4 5

Rate your ability to perform well on a short-answer examination (1=poor TO 5=excellent).

1 2 3 4 5

(From Schneider EF, Castleberry AN, Vuk J, Stowe CD. Pharmacy students' ability to think about thinking. *Am J Pharm Educ* 2014;78(8):Article 148)

Appendix 3. Example Weekly Monitoring Exercise

Weekly monitoring exercise sheet

Please indicate below your overall understanding of the content from today's class on **pharmacodynamics**:

0% Accurate

100% Accurate

What specific concept(s) from today's class on pharmacodynamics did you find difficult to understand?

Specifically, what will you do to improve your understanding of the concept(s) you listed above?

1. Cefazolin is bactericidal (ie, kills bacteria) antibiotic. Based on this information, what categories best characterize this pharmacodynamic effect regarding being direct/indirect and reversible/irreversible?

- A) Type A & B (i.e., Reversible)
- B) Type B & D (i.e., Indirect)
- C) Type C & D (i.e., Irreversible)
- D) Type A & C (i.e., Direct)

	Direct Effect	Indirect Effect
Reversible	Type A	Type B
Irreversible	Type C	Type D

0% Accurate

100% Accurate

2. Methadone's use in the treatment of pain can become problematic due to lack of a reliable dose conversion between methadone and other opioid analgesics. Below is a list of other IV analgesic options used to treat pain. Based on the information, which is the most potent medication?

- A) Morphine
- B) Hydromorphone
- C) Codeine
- D) Meperidine

	Approximate Equivalent Dose (mg)	Half-life (h)
Morphine	10	1.5-4.5
Codeine	100	3-4
Hydromorphone	1.5	2-3
Meperidine	75	15-30

0% Accurate

100% Accurate

(Adapted from Nietfeld JL, Cao L, Osborne JW. The effect of distributed monitoring exercises and feedback on performance, monitoring accuracy, and self-efficacy. *Metacog Learn.* 2006;1(2):159-179 by Persky and Dinsmore, personal communication)

Appendix 4. Example of Verbalization Techniques to Develop Metacognition

	Definition	Level of Verbalization		
		Level 1: Verbal Content	Level 2: Nonverbal Content	Level 3: Explanation of Content
Type of verbal report		Reflects information that is in verbal form	Reflects information that is in nonverbal form and recoded into a verbal form	Reflects information that is in a verbal or nonverbal form and the additional thinking that is contributing to this information
Concurrent	Reporting information as it forms concurrently with ongoing thinking	“Keep talking what you’re thinking as you read the patient’s history.”	“Talk aloud as work out a pharmacotherapy plan for this patient.”	“Explain how you make use of the current guidelines or experiences as you read the patient case.”
Retrospective	Reporting from experience	“Tell me what you remember about Patient X that you had yesterday in clinic.”	“What can you remember about you worked up Patient X from yesterday’s clinic visit.”	“Now that you have thought about Patient X explain how you comprehend their situation.”
Prospective	Reporting of current thoughts or remembered past experiences for the purpose of predicting future states	“Now that you have had instruction on antihypertensives, how confident are you that you can correctly answer questions about this topic on rotations.”	“Now that you have seen the first few steps on working up this patient, how confident are you that you can complete the pharmacotherapy plan.”	“Explain how you could more accurately predict what you will remember about antihypertensives you just learned about when you are going to be tested on it next week.”

Adapted with permission from Hacker DJ, Dunlosky J. Not all metacognition is created equal. *New Dir Teach Learn.* 2003 (95):73-79.³⁴