Using Metacognition to Promote Learning

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Abstract

Metacognition has increasingly been recognized as essential for learning. This paper defines metacognition, discusses its importance, and specifies how faculty can nurture it in students to promote positive learning outcomes. The paper then offers extensive examples based on two formats: (1) activities offered before, during, and after lessons or as ongoing assignments in an online course; and (2) quizzes and examinations (tests), whether multiple choice or essay, that can be analyzed for maximizing future performance.

Some Definitions of Metacognition

Metacognition, simplistically defined, can be described as "cognition about cognition" or "thinking about thinking" (Flavell, Miller & Miller, 2002, p. 175; Shamir, Metvarech, & Gida, 2009, p. 47; Veeman, Van Hout-Wolters, & Afflerbach, 2006, p. 5). However, because metacognition is multifaceted and multi-layered (Dunlosky & Metcalf, 2009, p. 1; Flavell, 1976; Hall, Danielewicz, & Ware , 2013, p. 149; Lovett, 2013, p. 20), more complex definitions are called for. Basically, metacognition must be viewed as an ongoing process that involves reflection and action. Metacognitive thinkers change both their understandings and their strategies. The clearest definitions of metacognition emphasize its nature as a process or cycle.

Several authors (Nilson, 2013, p. 9; Schraw, 2001; & Zimmerman, 1998; 2000; 2002) narrow this process down to three ongoing stages. The first stage, *pre-planning*, emphasizes the need for reflection on both one's own thinking and the task at hand, including reflection on past strategies that might have succeeded or failed. Following this self-reflection, during *planning*, metacognitive thinkers develop and implement—put into action—a plan. In the third and final stage—*post-planning adjustments/revisions*—subsequent analysis following implementation leads to modifications, revised decisions, and new future plans. In an excellent summary, Wirth states that "metacognition requires students both to understand how they are learning and to develop the ability to make plans, to monitor progress and to make adjustments" (as cited in Jaschik, 2011, p. 2).

Why Metacognition Is Important

Over twenty-five years ago, a meta-review of research on learning variables identified student metacognition as an essential variable for producing positive learning outcomes (Wang, Haertel & Walberg, 1990, p. 37). More recently, Bransford, Brown and Cocking (2000) identify metacognition as one of three key learning principles and recommend that "the teaching of metacognitive skills should be integrated into the curriculum in a variety of subject areas" (p. 21). Similarly, Ambrose, Bridges, DiPietro, Lovett, and Norman (2010) consider metacognition to be one of the seven research-based principles for smart teaching. All these scholars regard metacognition as essential to learning.

A three-step process that mirrors the three-step definition of metacognition can help faculty members implement these essential approaches. In the first step, students must not only hear explanations of metacognitive skills, but they must also observe them. The modeling can be done by teachers or by other students (Nilson, 2013, p. 13). These exposures to metacognition result in the thinking essential for the development of strategies based on self-reflection. In the second step, students then practice these metacognitive skills in authentic settings. Such settings can include a discipline-specific curriculum where multiple opportunities to practice metacognition occur. As they act, students also think about the impact of these actions and the alternate approaches that might maximize this impact. During the third or final phase, students receive feedback on their practice efforts, allowing them to develop more effective metacognitive strategies.

Some Examples of Metacognitive Strategies

Teachers committed to student learning often embed opportunities for students to reflect on their learning within their curriculum. These action-oriented opportunities typically take two formats: (1) activities offered before, during, and after lessons or as ongoing assignments in an online course; and (2) quizzes and examinations, whether multiple

choice or essay, that students can analyze to maximize future performance.

Activities to Promote Metacognition

In the first format, teachers conduct activities that lead students to consider their knowledge levels, their learning processes, and their ability to monitor and adjust attempts at problem-solving. Thus, these activities raise metacognitive awareness whether offered prior to the start of a lesson, during a lesson, or at the end of a lesson.

6 **Activities prior to a lesson.** Angelo and Cross (1993) are well aware of the value of metacognitive development. They assert that faculty can promote it by teaching students specific strategies, by endorsing active practice of these strategies, and by providing feedback to students on the success of their efforts. They conclude that educational research provides evidence that directly teaching students metacognitive strategies and skills results in greater and deeper learning (p. 373). Among many other assessment approaches, Angelo and Cross (1993) identify three metacognitive assessment activities employing index cards, (1) focused listing, (2) directed paraphrasing, and (3) application cards. In hybrid courses, these assessments can be completed online and submitted prior to the start of a face-to-face class. These three activities can take place at any point during a lesson, but most often they are used prior to a lesson to determine—for teachers and students—the students' prior knowledge.

(1) During a focused listing in a face-to-face classroom, students write at the top of an index card a key concept in the course. Briefly—usually no more than one or two minutes—students write down everything they remember about this concept. This activity lets students know how much they recall—right or wrong—about a given concept. A blank card can be very telling! Faculty members collect the cards and review them to determine students' overall level of knowledge, plus their misconceptions. Many faculty members like using index cards because they are easy to sort into stacks such as "unacceptable," "OK" or "on target." This sorting simplifies the feedback process. Online responses are typically collected through the course- management system. For feedback, faculty typically tell the entire class, not individual students, what they have discovered from the focused listing. They often share the average level of the students' knowledge, discuss misconceptions, if appropriate, and indicate any changes they have made or intend to make in their lesson plans. During this feedback session, students can check their own levels of understanding and can correct any misconceptions that apply to them.

(2) In directed paraphrasing instructors use similar approaches— index cards or online submissions—to accomplish similar ends. Instead, however, of jotting down their current memories of the key concept, students explain or define it in their own words for a specific audience or purpose (e.g., Explain the concept of "extinct" to third graders; Define "chemical cardioversion" to new emergency medical technicians (EMTs).

(3). Application cards, generated and processed in the same way as the two examples above, also provide insights about students' knowledge to both teachers and students. If students can offer real-world applications or examples for important concepts, theories, or procedures, then their knowledge presumably extends beyond mere rote memorization. Examples relevant to students are particularly effective. For instance, after business students are introduced to Stephen Covey's "win-win performance agreements," they can be asked to provide two examples, one from current events and one more relevant example of a win-win performance agreement from their own lives.

Another use of index cards to assess prior knowledge, one applicable only to face-to-face classes, was invented by Dr. John Hertel (personal observation, 2001), a law professor at the U. S. Air Force Academy. When students enter the classroom, he hands them an index card and immediately asks them to write down the main principle of the law case study they read prior to class. After an animated discussion of the case, before the bell rings, he has the students draw a line under their original response and do the same thing: write their now (one hopes!) enhanced understanding of the cases' key principle. For example, one of Dr. Hertel's students initially wrote: "No idea what this case is about. Don't remember." After the discussion, the same student wrote: "One principle is that of loyalty. In a corporation you are required to be loyal and not take their secrets and go create your own business (copy cat)." Clearly, the student recognized that s/he came to class with no prior knowledge of the case but realized that the class exchanges produced subsequent learning.

Hertel's approach is applicable to virtually any discipline. For example, in a literature class students could write down the theme of a given work of literature, such as *Antigone* or *A Lesson Before Dying*. After the discussion, they could draw a line under their original response and write a second definition of the theme.

1 **Activities during a lesson.** During class a number of metacognitive-centered activities are possible. Individual students can actively respond to activities introduced by professors during an in-class lecture or presentation. Cooper and colleagues (Johnson & Cooper, 2003; Robinson & Cooper, 2010) have published extensively on this practice. Here are three examples of what they call "Quick Thinks."

(1) *Complete a sentence starter.* Students are given an incomplete sentence stem or prompt and are asked to provide an appropriate answer to make a complete and accurate sentence. Some responses might involve mere recall such as providing the term "photosynthesis" at the end of this prompt: "A process by which green plants and other specific organisms convert solar energy into chemical energy,

producing oxygen as a by-product is called _____." Other prompts might require open-ended answers, a deliberate tactic to generate higher-order thinking. For example, in an English literature course the prompt could be "Hamlet might be interpreted as a man who _____." Numerous responses are possible, including "a man who doubts his senses; is incapable of making a decision; mistrusts his step-father, suffers from hallucinations," and so forth. Students who complete these responses are reflecting metacognitively on their knowledge of the subject.

(2) *Compare or contrast*. Students receive detailed explanations of two parallel elements such as art or historical movements, theories, or works of literature. Typically, the elements are presented in depth as separate entities without direct comparisons or contracts. Then after a prompt, students make their own connections. Here are two examples: "World War II and the American Civil War shared this similarity: ____." (Correct answers might be "total national involvement; extensive casualties; controversial military leaders," etc.); "The id and the ego share the common element of _____." (Correct answers might be "a focus on power; attempting to influence behavior," etc.)

(3) *Support a statement*. Students receive a general statement for which they must provide support using reliable sources such as lecture notes, reading, or informed experts. They need to justify the support rather than merely cite factual information from the instructor, thus causing them to reflect on what they know and don't know. The following declaration is an example: Cancer has multiple causes. (A suitable response might be: "Two highly respected agencies—the International Agency for Research on Cancer (IARC) and the US National Toxicology Program (NTP)—list multiple proven or suspected causes for cancer including those related to genetics, diet, and sun and radiation exposures.")

All these "Quick Think" activities can be extended by having students pair or form small groups to share their responses, discussing also their implications and applications. Nilson (2010) cites the value of group work for promoting metacognitive skills such as self-monitoring. When working in groups, for example, students often pose questions that force teammates to reflect on their own knowledge content and learning processes (p. 201).

2 **Activities After a Lesson.** After the lesson, just before the class concludes, many instructors use a metacognitive approach called the Minute Paper or the Half-Sheet Response. Rather than a minute, typically students receive two-to-three minutes to write responses on an index card to two questions similar to these:

- What was the most important thing you learned during this session?
- What important question remains unanswered?

Simple as they are, these questions encourage students to reflect on their understanding of the lesson they just experienced. Sometimes faculty members collect the Minute Papers at the door, calling them students' "ticket out."

4 **Complex Activities.** More complex assignments can help both students and faculty develop an awareness of metacognition.

The Minute Paper for Papers is a more complex version of the Minute Paper. Also promoting reflection, a Minute Paper for Papers is an attachment handed in with a writing assignment or project. Students on a separate sheet of paper respond to various questions or to prompts about their submission. Typical questions and prompts might be:

- What parts of the paper or project were the most effective?/I'm most satisfied with...
- When were you least satisfied with this paper or project?/I'm least satisfied with...
- What problems arose as you wrote?/I'm having problems with...
- What skills do you feel you improved?/Writing this paper or completing this project lead to improvement in skills such as...
- In writing this essay or completing this project, what did you learn that surprised you?/I was surprised by...
- When editing your paper or project, what were you uncertain about?/When editing, I was most uncertain about...
- What changes would you make to this assignment?/Given two more weeks, I would change...
- How does this assignment contribute to your growth as a professional in X discipline?/This lesson/assignment is important to my role as a professional in [X discipline] because...

Knowledge Surveys (Clauss & Geedey, 2010; Goodson, Slater, & Zubovic, 2015; Nuhfer, 1996; Nuhfer & Knipp, 2003; Wirth & Perkins, 2005), another complex metacognitive activity, help faculty members to determine students' knowledge as a course or unit begins and, just as important, the level of knowledge they possess when the course or unit ends. Taking an actual test is neither feasible because of the time involved nor desirable because students who draw frequent blanks on an initial test may conclude—often with despair and a drop slip—that they have no hope of passing the upcoming course or unit. Thus, Knowledge Surveys ask students simply to indicate their perception of their knowledge of course-related topics without actually "proving" it through their performance. These instructions are typical for a course:

> This Knowledge Survey focuses on topics that we will cover during this course. It is not a test per se. You will be asked to indicate your confidence in your ability to answer given questions or perform given skills, without, however, actually providing the answers or working the problems.

> Because you will take this same Knowledge Survey at the end of the course, it will provide a measure of what you have learned and/or the skills you have acquired. To proceed, please mark one of three responses. Mark "1" if you are fairly certain you can answer the question or perform the skill indicated. Mark "2" if you think you know 50% or more of the answer or if you know exactly where you could retrieve the information in 20 minutes or less. Mark "3" if you cannot answer the question or perform the skill.

These three choices might be phrased as follows:

1. I know this
2. I know at least 50% of the answer or know exactly where to find the answer
3. I don't know

Typical questions will vary depending on the discipline and intent. A question to determine scientific literacy might be: "Provide two specific examples that illustrate why it is important for an educated person to be able to understand science" (Nuhfer & Knipp, 2003). A geologist or a civil engineer might ask a question such as "What are the possible classifications of soil?" (Goodson et al., 2015).

Wirth and Perkins (2005) emphasize that knowledge surveys can help students develop their metacognitive awareness, linking this ability to life-long learning. Comparing the outcomes of knowledge surveys with actual exam scores provides insights into students' self-assessment skills, particularly when the same questions are repeated. Students who miscalculate, repeatedly over-estimating or underestimating their actual knowledge, benefit from this eye-opening evidence. Reflection on these discrepancies and analyses of pre- and post-exam results can help students develop self-assessment strategies.

Quizzes and Examinations (Tests) to Promote Metacognition

Although knowledge surveys are not exams per se, they are closely related to examinations and quizzes, which make up the second format for providing metacognitive opportunities. The two major types of exams are multiple choice and essay.

5 **Multiple Choice Tests.** Testing students over material, whether the tests "count" toward the final course grade or are merely informal ungraded assessments, offers students powerful opportunities for self-assessment. Many options exist, such as giving a quiz over upcoming material before teaching it. This practice gives both faculty and students insights into students' prior knowledge and makes them aware of material they will be expected to master.

Multiple choice questions offered during class—if students are allowed to pair or form small groups to discuss them—can prompt students to assess their understanding of facts and concepts and also to learn from one another. Three delivery methods for multiple-choice questions are commonly used: (1) Personal Response Systems (Clickers), (2) Hand-held response cards or flash cards (also known as Visible Quizzes), and (3) Immediate Feedback Assessment Techniques (more commonly called "scratch-off quizzes").

(1) Personal Response Systems (PRSs/"clickers") are electronic devices that allow students to respond to multiple-choice questions by pressing a button. The responses are typically recorded so that instructors, like students, also gain insights. New technologies such as Poll Everywhere now offer online versions of the physical clickers, but the purpose and processing remain the same. New technologies have also resulted in devices that allow open-ended responses, but the multiple-choice devices remain the most common. Eric Mazur, a physics professor at Harvard University, developed a learning approach around clickers that he calls Peer Instruction. Practitioners throughout a lecture pose conceptual questions, called Concept Tests, that are based on ideas that students typically find difficult. After students develop their own answers to the question, they pair or form small groups of three or four to discuss the question and try to reach a common consensus. This three-to-five minute discussion compels students to defend their own answers or to change or modify them after their misconceptions are exposed by classmates. Both students and the instructors who are monitoring the discussions through clicker responses gain insights into students' understandings. Research by Lasry (2008) indicates that learning and metacognitive insights are the result of the peer interactions, not the use of clickers per se. Thus, Lasry concludes that any delivery mode, including flash cards, can document the learning that occurs through the students' group-based discussions of course concepts.

(2) Flash cards labeled A, B, C, D, and E, are sometimes called a "Visible Quiz (Staley, 2003; Millis, 2012). As with peer instruction, students in groups discuss the answers to multiple-choice questions posed by instructors, determining what the group believes to be the correct answer. At the instructor's signal, one member in each group holds up the large lettered card representing the group's response. The cards are typically color coded (e.g., all B's might be red; all C's green), making it easy to visually ascertain the responses given by each group, even in large classes.

(3) A lesser-known delivery option uses lottery-like, scratch-off cards called Immediate Feedback Assessment Techniques (IF-AT) quizzes. In this instance, students take a multiple-choice quiz independently and hand it in. They then meet in small groups to take the quiz again, this time debating the correct answer for each question before scratching it off on the IF-AT form. If they choose correctly, the letter they rub off reveals a star. If there is no star, the debate continues, and the group selects another letter they believe to be correct. The correct answers give students immediate feedback on their assumptions. Instructors reviewing the individual quizzes and the subsequent group quizzes also gain insights into their students' understandings. The individual students benefit from the group discussions and receive immediate

feedback on their quiz answers through the debates and the IF-AT results, thus heightening their metacognitive awareness.

7 **Essay Tests.** Some instructors, particularly those in disciplines such as literature, philosophy, and history, may regard multiple-choice questions as too limiting. They prefer essay questions for raising students' metacognitive awareness.

The Question Shuffle provides practice in writing short answer/essay responses similar to those appearing on upcoming exams, but it also has an impact on students' metacognitive skills. Because no grading is involved, this process can be used in any size class, including those over 100 or even 200 or more students.

Developing questions is a positive way to get students to dig deeper into the course content. To formulate questions, students must first review the material for the forthcoming exam, helping them to assess their own knowledge base. After faculty coaching on what constitutes good questions and how to produce them, each student writes on an index card two effective essay questions. On the practice day for the exam, the faculty member pairs the students, directing them to read and evaluate the four available questions (two from each student). After discussion, paired students decide which two questions are the best of the four, subsequently rewriting them on a blank index card. The index cards are then "shuffled" —passed among all students— so that each pair ends up with two different questions.

The pairs then decide which of the two is a better question. These selection processes occur quickly—usually within five minutes total—so that most of class time can be focused on responding to the carefully vetted questions that have gone through three "screening" layers. The screening leads students to the highest level of Bloom's Taxonomy (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956)—evaluation—and strengthens their metacognitive skills by challenging them to reflect on their ability to answer the proposed questions.

Both members of the pair write an answer/essay on the question they selected, ideally in the same amount of time they will be given on the exam. When the teacher calls "time," the two partners then read and analyze each other's essay, discussing how they could combine the two to make the strongest possible response. This step builds metacognitive awareness because students can self-assess the strengths and weaknesses of their own essay and gain different perspectives by reviewing their partner's answer to the same question.

Both students and faculty members benefit metacognitively from a Question Shuffle. The students receive feedback from their peer on how well they did, and faculty members gain insights into students' level of knowledge prior to an exam. Additional benefits are numerous. Students can practice generating and evaluating good questions; they can also practice writing authentic exam responses, often gaining different perspectives from reading alternative answers to their own. Teachers also receive an additional "pay-off": the availability of a large test bank of questions with possible answers. Most faculty use at least some of these student-generated questions on the actual exam.

3 **Analysis of Test Results.** As indicated earlier, exams themselves can promote metacognition if they are placed within the context of the learning process. However, even more awareness can occur by prompting students to reflect on their study practices, exam results, and future modifications for study processes and exam procedures.

Too often when exams are returned, students merely glance at the score without further thought. Lovett (2008; 2013) circumvents this superficiality by using what she calls "Exam Wrappers." She describes these as "structured reflection activities that prompt students to practice key metacognitive skills after they get back their graded exams" (Lovett, 2013, p. 18). On a short handout, students complete three activities: (1) recalling exactly how they prepared for/studied for the examination ("reflect"); (2) itemizing and thinking about what errors they made on the exam and why they occurred ("compare"); and finally, (3) drawing up a plan to prepare differently for the next exam ("adjust").

Similarly, as she debriefs students after returning an exam, Weimer (2002) encourages metacognition in order to give them a sense of control over their learning. She asks students to write down the numbers of the questions they missed and then has them perform three types of analysis to identify patterns:

1. Students review their notes to find out if they missed class on the days they also missed questions;
2. Students determine the source of the missed questions after Weimer indicates which questions came from the required readings and which were covered in her lectures;
3. Students identify answers they changed on the exam, noting how many changes resulted in correct answers.

After the analysis is complete, students write a reflective note outlining the steps they will take to prepare for the next exam based on their insights about the exam just returned.

Some practitioners use a two-step analysis model, building in metacognitive practices before students submit an exam and then afterwards when they receive the graded product. Barkley (2010), for example, describes a two-fold practice she labels "Post-Test Analysis." Prior to preparing the exam, an instructor identifies a taxonomy such as Bloom's taxonomy of the cognitive domain (Bloom et al., 1956) on which she will base the questions. Before they submit their exams, students respond to the following directives:

a. predict your exam score;
b. rate your effort in studying for the exam on a scale of

1 (lowest) to 10 (highest);
c. list the specific learning strategies you used to study for the exam (for example, memorized definitions through flashcards, rewrote and reviewed lecture notes, created outlines of reading assignments, and so forth); and
d. identify what you found easiest and most difficult about the exam and why. (p. 337)

After receiving the graded exam, either during class or as a homework assignment, students analyze the results on a worksheet that includes the taxonomy and the directions:

a. describe your emotional response to your exam score (surprised? disappointed? relieved? and so forth);
b. compare your actual score with your predicted score;
c. go back through each exam question and identify the level of the learning taxonomy used in each exam question;
d. calculate the proportion of items you answered correctly or incorrectly at each classification level;
e. determine the source of each question (book, lecture, homework assignment);
f. reflect upon and describe any changes in strategies or amount of time studying you plan to do to prepare for the next exam; and
g. offer me any feedback on how your peers or I could help you better prepare for the exam. (pp. 337-338)

Regardless of the discipline, a thoughtful analysis of study practices and exam results gives students useful metacognitive insights into their preparation and performance.

Conclusion

As we have seen, metacognition is a complex but valuable skill that can nurture students' learning and their self-awareness of the learning process. It is best conceived as a three-step process that can occur through deliberately designed activities. Such activities can take place before, during, and after face-to-face lessons or through online learning. They can also be built around both multiple choice and essay examinations. Immersing students in these metacognitive activities—assuming there are opportunities for practice and feedback—can result in students who are reflective learners.

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