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The Role of Metacognitive Knowledge in Learning, Teaching, and Assessing

A s KRATHWOHL (THIS ISSUE) STATES, the revised Taxonomy contains four general knowledge categories: Factual, Conceptual, Procedural, and Metacognitive. While the first three categories were included in the original Taxonomy, the Metacognitive Knowledge category was added. The purpose of this article is to discuss the Metacognitive Knowledge category and its implications for learning, teaching, and assessing in the classroom.

Metacognitive knowledge involves knowledge about cognition in general, as well as awareness of and knowledge about one's own cognition. One of the hallmarks of psychological and educational theory and research on learning since the original Taxonomy was published is the emphasis on helping students become more knowledgeable of and responsible for their own cognition and thinking. This change cuts across all the different theoretical approaches to learning and development—from neo-Piagetian models, to cognitive science and information processing models, to Vygotskian and cultural or situated learning models. Regardless of their theoretical perspective, researchers agree that with development students become more aware of their own thinking as well as more knowledgeable about cognition in general. Furthermore, as they act on this awareness they tend to learn better (Bransford, Brown, & Cocking, 1999). The labels for this

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general developmental trend vary from theory to theory, but they include the development of metacognitive knowledge, metacognitive awareness, self-awareness, self-reflection, and self-regulation.

Although there are many definitions and models of metacognition, an important distinction is one between (a) knowledge of cognition and (b) the processes involving the monitoring, control, and regulation of cognition (e.g., Bransford et al, 1999; Brown, Bransford, Ferrara, & Campione, 1983; Flavell, 1979; Paris & Winograd, 1990; Pintrich, Wolters, & Baxter, 2000; Schneider & Pressley, 1997). This basic distinction between metacognitive knowledge and metacognitive control or self-regulatory processes parallels the two dimensions in our Taxonomy Table.

Metacognitive knowledge includes knowledge of general strategies that might be used for different tasks, knowledge of the conditions under which these strategies might be used, knowledge of the extent to which the strategies are effective, and knowledge of self (Flavell, 1979; Pintrich et al., 2000; Schneider & Pressley, 1997). For example, learners can know about different strategies for reading a textbook as well as strategies to monitor and check their comprehension as they read. Learners also activate relevant knowledge about their own strengths and weaknesses pertaining to the task as well as their motivation for completing the task. Suppose learners realize they already know a fair amount

about the topic of a chapter in a textbook (which they may perceive as a strength), and that they are interested in this topic (which may enhance their motivation). This realization could lead them to change their approach to the task, such as adjusting their reading approach or rate. Finally, learners also can activate the relevant situational or conditional knowledge for solving a problem in a certain context (e.g., in this classroom; on this type of test; in this type of real-life situation, etc.). They may know, for example, that multiple-choice tests require only recognition of the correct answers, not actual recall of the information, as required in essay tests. This type of metacognitive knowledge might influence how they subsequently prepare for an examination.

In contrast, metacognitive control and self-regulatory processes are cognitive processes that learners use to monitor, control, and regulate their cognition and learning. As such, they fit under the six cognitive process categories and specific cognitive processes in the revised Taxonomy. The metacognitive and self-regulatory processes are well represented in tasks such as checking, planning, and generating. Accordingly, on the Knowledge dimension, Metacognitive Knowledge categories refer only to knowledge of cognitive strategies, not the actual use of those strategies.

Three Types of Metacognitive Knowledge

In Flavell's (1979) classic article on metacognition, he suggested that metacognition included knowledge of strategy, task, and person variables. We represented this general framework in our categories by including students' knowledge of general strategies for learning and thinking (Da - Strategic knowledge) and their knowledge of cognitive tasks as well as when and why to use these different strategies (Db - Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge). Finally, we included knowledge about the self (the person variable) in relation to both cognitive and motivational components of performance (Dc - Self-knowledge).

Strategic knowledge

Strategic knowledge is knowledge of general strategies for learning, thinking, and problem solving. These strategies are applicable across all or most academic disciplines or subject matter domains in contrast to more specific strategies from the disciplines or domains. Consequently, these strategies can be used across a large number of different tasks and domains, rather than being most useful for one particular type of task in one specific subject area (e.g., solving a quadratic equation in mathematics, applying Ohm's law in science).

Strategic knowledge includes knowledge of the various strategies students might use to memorize material, to extract meaning from text, and to comprehend what they hear in classrooms or what they read in books and other course materials. Although there are a large number of different learning strategies, they can be grouped into three general categories: rehearsal, elaboration, and organizational (Weinstein & Mayer, 1986). Rehearsal strategies refer to the strategy of repeating words or terms to be remembered over and over to oneself, generally not the most effective strategy for learning more complex cognitive processes. In contrast, elaboration strategies include various mnemonics for memory tasks, as well strategies such as summarizing, paraphrasing, and selecting main ideas from texts. These elaboration strategies result in deeper processing of the material to be learned and result in better comprehension and learning than do rehearsal strategies. Finally, organizational strategies include various forms of outlining, concept mapping, and note taking, where the student makes connections between and among content elements. Like elaboration strategies, these organizational strategies usually result in better comprehension and learning than rehearsal strategies.

In addition to these general learning strategies, students can have knowledge of various metacognitive strategies that will be useful to them in planning, monitoring, and regulating their learning and thinking. These strategies include ways individuals plan their cognition (e.g., set subgoals), monitor their cognition (e.g., ask themselves questions as they read a piece of text; check their answer to a math problem), and regulate their cognition (e.g., re-read something they don't understand; go back and "repair" their calculating mistake in a math problem). Again, in this category we refer to students' knowledge of these various strategies, not their actual use.

Finally, there are a number of general strategies for problem solving and thinking. These strategies represent the various heuristics individuals can use to solve problems, particularly ill-defined problems where there is no definitive algorithmic solution. In the problem-solving area they can include the knowledge of means-ends analysis as well as knowledge of working backward from the desired goal state. In terms of thinking, there are a number of general strategies for deductive and inductive thinking, such as evaluating the validity of different logical statements, avoiding circularity in arguments, making appropriate inferences from different sources of data, and drawing on appropriate samples to make inferences.

Knowledge about cognitive tasks

In addition to knowledge about various strategies, individuals also accumulate knowledge about different cognitive tasks. Knowledge of tasks includes knowledge that different tasks can be more or less difficult and may require different cognitive strategies. A recall task is more difficult than a recognition task, for example, because in the recall task, the individual must actively search memory and retrieve the relevant information; while in the recognition task, the emphasis is on discriminating among alternatives and selecting the appropriate answer.

As students develop their knowledge of different learning and thinking strategies and their use, this knowledge reflects the "what" and "how" of the different strategies. However, this knowledge may not be enough for expertise in learning. Students also must develop some knowledge about the "when" and "why" of using these strategies appropriately (Paris, Lipson, & Wixson, 1983). Because not all strategies are appropriate for all situations, the learner must develop some knowledge of the different conditions and tasks where the different strategies are used most appropriately.

If one thinks of strategies as cognitive "tools" that help learners construct their understanding, then just as the carpenter uses a variety of different tools for all the tasks that go into building a house, the learner must use different tools for different cognitive tasks. Of course one tool, such as a hammer, can be used in different ways for dif-

ferent tasks, but this is not necessarily the most adaptive use of the hammer—particularly if there are other tools that are better suited to the task. In the same way, specific learning and thinking strategies are better suited to different tasks. For example, if one confronts a novel problem that is ill-defined, then general problem-solving heuristics may be very useful. In contrast, if one confronts a physics problem regarding the second law of thermodynamics, more specific procedural knowledge, not general metacognitive knowledge, will be much more useful and adaptive for this task. An important aspect of learning about strategies is the knowledge of when and why to use them appropriately.

Another important aspect of conditional knowledge concerns the local situational and general social, conventional, and cultural norms for the use of different strategies. For example, a teacher may encourage the use of certain strategies for reading. A student who knows the teacher's strategic preferences is better able to adapt to the demands of this teacher's classroom. In the same manner, different cultures may have norms for the use of different strategies and ways of thinking about problems. Again, knowing these norms can help students adapt to the demands of the culture in terms of solving the problem.

Self-knowledge

Along with knowledge of different strategies and knowledge of cognitive tasks, Flavell (1979) proposed that self-knowledge was an important component of metacognition. Self-knowledge includes knowledge of one's strengths and weaknesses. For example, a student who knows that he or she generally does better on multiple-choice tests than on essay tests has some metacognitive self-knowledge about his or her test-taking ability. This knowledge may be useful to the student as he or she studies for the two different types of tests. One of the hallmarks of experts is that they know when they don't know something and have to rely on some general strategies for finding the appropriate information. This self-awareness of the breadth and depth of one's own knowledge base is an important aspect of self-knowledge. Finally, individuals need to be aware of the different types

of strategies they are likely to rely on in different situations. An awareness that one overrelies on a particular strategy when there may be other more adaptive strategies for the task could lead to the possibility of a change in strategy use.

In addition to general self-knowledge, individuals also have beliefs about their motivation. These include judgments of their capability to perform a task (self-efficacy), their goals for completing a task (learning or just getting a good grade), and the interest and value the task has for them (high interest and high value versus low interest and low value). Although these motivational beliefs are usually not considered in cognitive models, there is a fairly substantial body of literature emerging that shows important links between students' motivational beliefs and their cognition and learning (Pintrich & Schrauben, 1992; Pintrich & Schunk, 2002; Snow, Corno, & Jackson, 1996). It seems important that just as students need to develop self-knowledge and self-awareness about their knowledge and cognition, they also need to develop self-knowledge and self-awareness about their motivation.

Although self-knowledge itself can be an important aspect of metacognitive knowledge, it is important to underscore the idea that *accuracy* of self-knowledge seems to be most crucial for learning. That is, we are not advocating that teachers try to boost students' self-esteem (a completely different construct from self-knowledge) by providing students with positive, but false, inaccurate, and misleading feedback about their strengths and weaknesses. It is much more important to have accurate perceptions and judgments of one's knowledge base and expertise than to have inflated and inaccurate self-knowledge (Pintrich & Schunk, 2002). If students do not realize they do not know some aspect of factual, conceptual, or procedural knowledge, it is unlikely they will make any effort to acquire or construct new knowledge. Accordingly, we stress the need for teachers to help students make accurate assessments of their self-knowledge, not inflate their self-esteem.

Implications for Learning, Teaching, and Assessing

Metacognitive knowledge can play an important role in student learning and, by implication, in the ways students are taught and assessed in the classroom (Bransford et al., 1999). First, as previously noted, metacognitive knowledge of strategies and tasks, as well as self-knowledge, is linked to how students will learn and perform in the classroom. Students who know about the different kinds of strategies for learning, thinking, and problem solving will be more likely to use them. After all, if students do not know of a strategy, they will not be able to use it. Students who do know about different strategies for memory tasks, for example, are more likely to use them to recall relevant information. Similarly, students who know about different learning strategies are more likely to use them when studying. And, students who know about general strategies for thinking and problem solving are more likely to use them when confronting different classroom tasks (Bransford et al., 1999; Schneider & Pressley, 1997; Weinstein & Mayer, 1986). Metacognitive knowledge of all these different strategies enables students to perform better and learn more.

In addition, metacognitive knowledge of all these different strategies seems to be related to the transfer of learning; that is, the ability to use knowledge gained in one setting or situation in another (Bransford et al., 1999). Students are often confronted with new tasks that require knowledge and skills they have not yet learned. In this case, they cannot rely solely on their specific prior knowledge or skills to help them on the new task. When experts find themselves in this situation, they are likely to use more general strategies to help them think about or solve the problem. In the same manner, students, who by definition lack expertise in many areas, need to know about different general strategies for learning and thinking in order to use general strategies for new or challenging tasks.

Finally, in terms of learning, self-knowledge can be either an important facilitator or a constraint. Students who know their own strengths and weaknesses can adjust their own cognition and thinking to be more adaptive to diverse tasks and, thus, facilitate learning. If, for example, a student realizes that she does not know very much about a particular topic, she might pay more attention to the topic while reading and use different strategies to make sure she understands the topic being studied. In

the same manner, if a student is aware that she has difficulties on certain tests (e.g., mathematics versus history tests), then she can prepare for an upcoming mathematics test in an appropriate manner. Students who lack knowledge of their own strengths and weaknesses will be less likely to adapt to different situations and regulate their own learning in them. For example, if a student reads a text and thinks he understands it, but in reality does not, then he will be less likely to go back and reread or review the text to make sure it is understood. Similarly, a student who believes he understands the material thoroughly will not study for an upcoming test to the same extent as a student who knows he does not understand the material. A student who believes he understands the material when he does not will not do well on the test of that material because he did not study as well as the student who had an accurate perception of his lack of knowledge. Accordingly, lack of self-knowledge can be a constraint on learning.

There are several implications of the relationships among metacognitive knowledge, learning, teaching, and assessing. In terms of instruction, there is a need to teach for metacognitive knowledge *explicitly*. Teachers may do this in some lessons, but in many cases the instruction is more *implicit*. Simply stated, many teachers assume that some students will be able to acquire metacognitive knowledge on their own, while others lack the ability to do so. Of course, some students do acquire metacognitive knowledge through experience and with age, but many more students fail to do so. In our work with college students (see Hofer, Yu, & Pintrich, 1998; Pintrich, McKeachie, & Lin, 1987), we are continually surprised at the number of students who come to college having very little metacognitive knowledge; knowledge about different strategies, different cognitive tasks, and, particularly, accurate knowledge about themselves. Given the fact that students who go on to college are more likely to be better students in general suggests that there is a need to explicitly teach metacognitive knowledge in K-12 settings.

Having said this, it is not our expectation that teachers would teach for metacognitive knowledge in separate courses or separate units, although this can certainly be done (see Hofer et al., 1998;

Pintrich et al., 1987). It is more important that metacognitive knowledge is embedded within the usual content-driven lessons in different subject areas. General strategies for thinking and problem solving can be taught in the context of English, mathematics, science, social studies, art, music, and physical education courses. Science teachers, for example, can teach general scientific methods and procedures, but learning will likely be more effective when it is tied to specific science content, not taught in the abstract. Of course, in some skill areas, such as reading or writing, the teaching of metacognitive knowledge about different general strategies for reading comprehension or writing is both acceptable and desirable.

The key is that teachers plan to include some goals for teaching metacognitive knowledge in their regular unit planning, and then actually try to teach and assess for the use of this type of knowledge as they teach other content knowledge. One of the most important aspects of teaching for metacognitive knowledge is the explicit labeling of it for students. For example, during a lesson, the teacher can note occasions when metacognitive knowledge comes up, such as in a reading group discussion of the different strategies students use to read a section of a story. This explicit labeling and discussion helps students connect the strategies (and their names/labels) to other knowledge they may already have about strategies and reading. In addition, making the discussion of metacognitive knowledge part of the everyday discourse of the classroom helps foster a language for students to talk about their own cognition and learning. The shared language and discourse about cognition and learning among peers and between students and teacher helps students become more aware of their own metacognitive knowledge as well as their own strategies for learning and thinking. As they hear and see how their classmates approach a task, they can compare their own strategies with their classmates' and make judgments about the relative utility of different strategies. This type of discourse and discussion helps makes cognition and learning more explicit and less opaque to students, rather than being something that happens mysteriously or that some students "get" and learn and others struggle and don't learn.

In addition to the development of a classroom discourse around metacognitive knowledge, another important instructional strategy is the modeling of strategies, accompanied by an explanation of them. For example, as the teacher is solving a problem for the class, he might talk aloud about his own cognitive processes as he works through the problem. This provides a model for students, showing them how they use strategies in solving real problems. In addition, the teacher also might discuss why he is using this particular strategy for this specific problem, thereby also engaging students in issues concerning the conditional knowledge that governs when and why to use different strategies. As experts in their field, teachers have all kinds of implicit knowledge about strategies and when and why they are appropriate to use; however, students often lack the means to gain access to this knowledge. If the knowledge is never shared through discussion, modeling, or explicit instruction, it is difficult for students to learn.

In terms of implications for assessment, the inclusion of metacognitive knowledge in the revised Taxonomy is not meant to generate the development of separate sections of standardized or formal classroom tests on metacognitive knowledge. Metacognitive knowledge is important in terms of how it is used by students to facilitate their own learning. In this sense, it is more likely that any assessment of metacognitive knowledge by teachers will be informal rather than formal. For example, if teachers are teaching and discussing metacognitive knowledge as part of their normal classroom discourse, they will need to talk to their students about metacognitive knowledge and, perhaps more importantly, actually listen to the students as they talk about their own cognition and learning. As a result of these conversations, teachers will become aware of the general level of metacognitive knowledge in their classrooms and will be able to judge fairly quickly the level and depth of students' metacognitive knowledge. In many respects, this is no different from what teachers do to assess the level of content knowledge their students bring to their classrooms. They start a discussion, ask some questions, listen to the answers, and talk with the students. Based on this discourse, they can quickly estimate the depth of students'

prior knowledge. This type of informal assessment can be used to calibrate the instruction to help students gain both content knowledge (whether it be factual, conceptual, or procedural) and metacognitive knowledge.

From these informal "assessment conversations," teachers also may be able to make inferences about the level of metacognitive knowledge of individual students. Just as there is variance in the content knowledge that students bring to the classroom, it is likely there will be a wide distribution of metacognitive knowledge in a class of 20–30 students. This information about individual students can be used to adapt instruction to individual differences. Teachers can talk to students individually or in small groups to estimate levels of metacognitive knowledge. Finally, more formal questionnaires and interview procedures can be used to assess students' metacognitive knowledge concerning their learning strategies as well as their knowledge about different tasks and contexts (see Baker & Cerro, 2000; Pintrich et al., 2000).

As mentioned previously, an important component of metacognitive knowledge is self-knowledge. In terms of assessment, a focus on self-knowledge implies that students should have the opportunity to assess their own strengths and weaknesses. Although this will occasionally happen in larger, public groups, it is important for motivational reasons that self-assessment is more private, occurring between one teacher and one student (see Pintrich & Schunk, 2002). In this way, students are able to meet individually with their teachers to discuss their perceptions of their own strengths and weaknesses, and teachers can provide them with feedback about these perceptions. Portfolio assessment sometimes offers students the opportunity to reflect on their work as represented in the portfolio and this certainly provides self-assessment information to them. As students have more opportunities to reflect on their own learning, they will develop more self-knowledge that can be helpful to them.

Conclusion

In summary, metacognitive knowledge is a new category of knowledge in the revised Taxonomy. However, given its important role in learning, it is a welcome and much-needed addition. Although there

are different kinds of metacognitive knowledge, three general types are of particular importance. Strategic knowledge refers to knowledge of strategies for learning and thinking. Knowledge of tasks and their contexts represents knowledge about different types of cognitive tasks as well as classroom and cultural norms. Finally, self-knowledge is a critically important component of metacognitive knowledge. Because metacognitive knowledge in general is positively linked to student learning, explicitly teaching metacognitive knowledge to facilitate its development is needed. As the revised Taxonomy emphasizes, the need to align objectives, instruction, and assessment requires us to consider the role that metacognitive knowledge plays in the classroom.

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