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Rote Versus Meaningful Learning[1]

LEARNING INVOLVES THE ACQUISITION of knowledge. This is a commonsense view of learning that has implications for how to teach—such as presenting information to learners in books and lectures—and how to assess—such as testing to see how much of the presented material students can remember (Mayer, 2001). The revised Taxonomy is based on a broader vision of learning that includes not only acquiring knowledge but also being able to use knowledge in a variety of new situations. When taking a knowledge acquisition view of learning, teachers sometimes emphasize one kind of cognitive processing in instruction and assessment—what we call *Remembering*. Like the original Taxonomy, however, the revised Taxonomy is based on the idea that schooling can be expanded to include a fuller range of cognitive processes. The purpose of this article is to describe this fuller range of processes in more detail.

Two of the most important educational goals are to promote *retention* and to promote *transfer* (which, when it occurs, indicates meaningful learning). *Retention* is the ability to remember material at some later time in much the same way it was presented during instruction. *Transfer* is the ability to use what was learned to solve new problems, answer new questions, or facilitate learning new subject matter (Mayer & Wittrock, 1996). In short, retention requires that students remember what they have learned, whereas transfer requires students not only to remember but also to make sense of and be able to use what they have learned (Bransford, Brown, & Cocking, 1999; Detterman & Sternberg, 1993; Haskell, 2001; Mayer, 1995; McKeough, Lupart, & Marini, 1995; Phye, 1997). Stated somewhat differently, retention focuses on the past; transfer emphasizes the future. After reading a textbook lesson on Ohm's Law, for example, a retention test might include questions asking students to write the formula for Ohm's Law. In contrast, a transfer test might include questions asking students to rearrange an electrical circuit to maximize the rate of electron flow or to use Ohm's Law to explain a complex electric circuit.

Although educational objectives for promoting retention are fairly easy to construct, educators may have more difficulty in formulating, teaching, and assessing objectives aimed at promoting transfer (Baxter, Elder, & Glaser, 1996; Mayer, 2002; Phye, 1997). The revised Taxonomy is intended to help broaden the typical set of educational objectives to include those aimed at promoting transfer.

A Tale of Three Learning Outcomes

As an introduction, consider three learning scenarios. The first exemplifies what might be called *no learning*, the second, *rote learning*, and the third, *meaningful learning*.

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No learning

Amy reads a chapter on electrical circuits in her science textbook. She skims the material, certain that the test will be a breeze. When she is asked to recall part of the lesson (as a retention test), she is able to remember very few of the key terms and facts. For example, she cannot list the major components in an electrical circuit even though they were described in the chapter. When she is asked to use the information to solve problems (as part of a transfer test), she cannot. For example, she cannot answer an essay question that asks her to diagnose a problem in an electrical circuit. In this worst-case scenario, Amy neither possesses nor is able to use the relevant knowledge. Amy has neither sufficiently attended to nor encoded the material during learning. The resulting outcome can be essentially characterized as *no learning*.

Rote learning

Becky reads the same chapter on electrical circuits. She reads carefully, making sure she reads every word. She goes over the material, memorizing the key facts. When she is asked to recall the material, she can remember almost all of the important terms and facts in the lesson. Unlike Amy, she is able to list the major components in an electrical circuit. However, when Becky is asked to use the information to solve problems, she cannot. Like Amy, she cannot answer the essay question requiring her to diagnose a problem in an electrical circuit. In this scenario, Becky possesses relevant knowledge but is unable to use that knowledge to solve problems. She cannot transfer this knowledge to a new situation. Becky has attended to relevant information but has not understood it and, therefore, cannot use it. The resulting learning outcome can be called *rote learning*.

Meaningful learning

Carla reads the same textbook chapter on electrical circuits. She reads carefully, trying to make sense out of it. When asked to recall the material, she, like Midori, can remember almost all of the important terms and facts in the lesson. Furthermore, when she is asked to use the information to solve problems, she generates many possible solutions. In this scenario, Carla not only possesses relevant knowledge, she also can use that knowledge to solve problems and understand new concepts. She can transfer her knowledge to new problems and new learning situations. Carla has attended to relevant information and has understood it. The resulting learning outcome can be called *meaningful learning*.

Meaningful learning occurs when students build the knowledge and cognitive processes needed for successful problem solving. Problem solving involves devising a way of achieving a goal that one has never previously achieved; that is, figuring out how to change a situation from its given state into a goal state (Mayer, 1992). Two major components in problem solving are (a) problem representation, in which a student builds a mental representation of the problem, and (b) problem solution, in which a student devises and carries out a plan for solving the problem (Mayer, 1992).

A focus on meaningful learning is consistent with the view of learning as knowledge construction in which students seek to make sense of their experiences. In constructivist learning, students engage in active cognitive processing, such as paying attention to relevant incoming information, mentally organizing incoming information into a coherent representation, and mentally integrating incoming information with existing knowledge (Mayer, 1999). In contrast, a focus on rote learning is consistent with the view of learning as knowledge acquisition in which students seek to add new information to their memories (Mayer, 1999).

Meaningful learning is recognized as an important educational goal. It requires that instruction go beyond simple presentation of *Factual Knowledge* and that assessment tasks require more of students than simply *recalling* or *recognizing Factual Knowledge* (Bransford, Brown, & Cocking, 1999; Lambert & McCombs, 1998). The cognitive processes summarized here describe the range of students' cognitive activities in meaningful learning; that is, these processes are ways students can actively engage in the process of constructing meaning.

Cognitive Processes for Retention and Transfer

If you are interested mainly in teaching and assessing the degree to which students have learned

some subject matter content and retained it over some period of time, you would focus primarily on one class of cognitive processes, namely, those associated with *Remember*. In contrast, if you wish to expand your focus by finding ways to foster and assess meaningful learning, you need to emphasize those cognitive processes that go beyond remembering.

What are some of the cognitive processes used for retention and transfer? As discussed above, the revised Taxonomy includes six cognitive process categories—one most closely related to retention (*Remember*) and the other five increasingly related to transfer (*Understand, Apply, Analyze, Evaluate,* and *Create*). Based on a review of the illustrative objectives listed in the original Taxonomy and an examination of other classification systems, we have selected 19 specific cognitive processes that fit within these six categories. These 19 cognitive processes are intended to be mutually exclusive; together they delineate the breadth and boundaries of the six categories. In the discussion that follows, each of the six categories, as well as the cognitive processes that fit within them, are defined and exemplified.

Remember

When the objective of instruction is to promote retention of the presented material in much the same form in which it was taught, the relevant process category is *Remember*. Remembering involves retrieving relevant knowledge from long-term memory. *Remembering* knowledge is essential for meaningful learning and problem solving when that knowledge is used in more complex tasks. For example, knowledge of the correct spelling of common English words appropriate to a given grade level is necessary if a student is to master writing an essay. When teachers concentrate solely on rote learning, teaching and assessing focus solely on remembering elements or fragments of knowledge, often in isolation from any context. When teachers focus on meaningful learning, however, remembering knowledge is integrated within the larger task of constructing new knowledge or solving new problems. In other words, when meaningful learning is the goal, then remembering becomes a means to an end, rather than the end itself. The two associated cognitive processes are *recognizing* and *recalling*.

Recognizing (also called *identifying*) involves locating knowledge in long-term memory that is consistent with presented material. For example, in social studies, an objective could be "Identify the major exports of various South American countries." A corresponding test item would be "Which of these is a major export of Colombia? (a) bananas, (b) coffee, (c) silk, (d) tea."

Recalling (also called *retrieving*) involves retrieving relevant knowledge from long-term memory. In literature, an objective could be "Recall the poets who authored various poems." A corresponding test question would be "Who wrote *The Charge of the Light Brigade*?"

Understand

As you can see from the previous section, when the goal of instruction is to promote retention, the most important cognitive process is *Remember*. However, when the goal of instruction is to promote transfer, the focus shifts to the other five cognitive process categories, *Understand* through *Create*. Of these, arguably the largest category of transfer-based educational objectives emphasized in schools and colleges is *Understand*. Students are said to *understand* when they are able to construct meaning from instructional messages—including oral, written, and graphic communications, and material presented during lectures, in books, or on computer monitors. Examples of potential instructional messages are an in-class physics demonstration, a geological formation viewed on a field trip, a computer simulation of a trip through an art museum, or a musical work played by an orchestra, as well as numerous verbal, pictorial, and symbolic representations on paper.

Students *understand* when they build connections between the new knowledge to be gained and their prior knowledge. More specifically, the incoming knowledge is integrated with existing schemas and cognitive frameworks. Cognitive processes in the category of *Understand* include *interpreting, exemplifying, classifying, summarizing, inferring, comparing,* and *explaining*.

Interpreting (also called *clarifying, paraphrasing, representing,* or *translating*) occurs when a student is able to convert information from one form of representation to another. In mathematics,

for example, a sample objective could be "Learn to translate number sentences expressed in words into algebraic equations expressed in symbols." A corresponding assessment item involves asking students to write an equation (using *B* for the number of boys and *G* for the number of girls) that corresponds to the statement, "There are twice as many boys as girls in this class."

Exemplifying (also called *illustrating* or *instantiating*) occurs when a student finds a specific example or instance of a general concept or principle. In art history, an objective might be "Learn to identify various artistic painting styles." A corresponding assessment involves asking students to find a new example of the impressionist style (with *new* meaning an example not included in the textbook or used in class).

Classifying (also called *categorizing* or *subsuming*) occurs when a student determines that something (e.g., a particular instance or example) belongs to a certain category (e.g., concept or principle). In social studies, an objective may be "Learn to classify observed or described cases of mental disorders." A corresponding assessment item is to ask students to observe a video of the behavior of a mental patient and then indicate the mental disorder that is being displayed.

Summarizing (also called *abstracting* or *generalizing*) occurs when a student produces a short statement that represents presented information or abstracts a general theme. The length of the summary depends to a certain extent on the length of the presented material. For example, a sample objective in history could be "Learn to write summaries of events portrayed pictorially." A corresponding assessment item involves asking students to watch a videotape about the French Revolution and then write a cohesive summary.

Inferring (also called *concluding, extrapolating, interpolating,* or *predicting*) involves drawing a logical conclusion from presented information. For example, in learning Spanish as a second language, a sample objective could be "Students will be able to infer grammatical principles from examples." To assess this objective a student may be given the article-noun pairs, "la casa, el muchacho, la senorita, el pero," and asked to formulate a principle for when to use the article *la* and when to use the article *el.*

Comparing (also called *contrasting, mapping,* or *matching*) involves detecting similarities and differences between two or more objects, events, ideas, problems, or situations. In the field of social studies, for example, an objective may be "Understand historical events by comparing them to familiar situations." A corresponding assessment question is "How is the American Revolution like a family fight or an argument between friends?"

Explaining (also called *constructing models*) occurs when a student mentally constructs and uses a cause-and-effect model of a system or series. In natural science, an objective could be "Explain observed phenomena in terms of basic physics laws." Corresponding assessments involve asking students who have studied Ohm's Law to explain what happens to the rate of the current when a second battery is added to a circuit, or asking students who have viewed a video on lightning storms to explain how differences in temperature are involved in the formation of lightning.

Apply

Apply involves using procedures to perform exercises or solve problems and is closely linked with *Procedural Knowledge.* The *Apply* category consists of two cognitive processes: *executing*—when the task is an exercise (i.e., familiar to the learner), and *implementing*—when the task is a problem (i.e., unfamiliar to the learner).

Executing (also called *carrying out*) occurs when a student applies a procedure to a familiar task. For example, a sample objective in elementary level mathematics could be "Learn to divide one whole number by another, both with multiple digits." To assess the objective, a student may be given a worksheet containing 15 whole number division exercises (e.g., 784/15) and asked to find their quotients.

Implementing (also called *using*) occurs when a student applies one or more procedures to an unfamiliar task. In natural science, a sample objective might be "Learn to use the most effective, efficient, and affordable method of conducting a research study to address a specific research question." A corresponding assessment is to give students a research question and have them propose a research study that meets specified criteria of effectiveness,

efficiency, and affordability. Notice that in this assessment task, students must not only apply a procedure (i.e., engage in *implementing*) but also rely on conceptual understanding of the problem and procedure. Thus, unlike *executing*, which relies almost exclusively on cognitive processes associated with *Apply*, *implementing* involves cognitive processes associated with both *Understand* and *Apply*.

Analyze

Analyze involves breaking material into its constituent parts and determining how the parts are related to each other and to an overall structure. This category includes the cognitive processes of *differentiating*, *organizing*, and *attributing*. Therefore, objectives classified as *Analyze* include learning to determine the relevant or important pieces of a message (*differentiating*), the ways in which the pieces of a message are configured (*organizing*), and the underlying purpose of the message (*attributing*). Although learning to *Analyze* may be viewed as an end in itself, it is probably more defensible educationally to consider analysis as an extension of *Understanding* or as a prelude to *Evaluating* or *Creating*.

Improving students' skills in analyzing educational communications can be found as a goal in many fields of study. Teachers of science, social studies, the humanities, and the arts frequently express "learning to analyze" as one of their important objectives. They may, for example, wish to develop in their students the ability to (a) connect conclusions with supporting statements; (b) distinguish relevant from extraneous material; (c) determine how ideas are connected to one another; (d) ascertain the unstated assumptions involved in what is said; (e) distinguish dominant from subordinate ideas or themes in poetry or music; and (f) find evidence in support of an author's purposes for writing an essay.

Differentiating (also called *discriminating, selecting, distinguishing,* or *focusing*) occurs when a student discriminates relevant from irrelevant parts or important from unimportant parts of presented material. In mathematics, an objective could be "Distinguish between relevant and irrelevant numbers in a word problem." An assessment item could require that students circle the relevant numbers and cross out the irrelevant numbers in a word problem.

Organizing (also called *finding coherence, integrating, outlining, parsing,* or *structuring*) involves determining how elements fit or function within a structure. An objective in social studies could be "Learn to structure a historical description into evidence for and against a particular explanation." In a corresponding assessment students could be asked to prepare an outline showing which facts in a passage on American history support and which facts do not support the conclusion that the American Civil War was caused by differences in the rural and urban composition of the North and the South.

Attributing (also called *deconstructing*) occurs when a student is able to determine the point of view, biases, values, or intent underlying presented material. For example, in social studies, a sample objective could be "Learn to determine the point of view of the author of an essay on a controversial topic in terms of his or her theoretical perspective." A corresponding assessment task could ask students whether a report on Amazon rain forests was written from a pro-environment or pro-business point of view. A corresponding assessment in the natural sciences could be to ask a student to determine whether a behaviorist or a cognitive psychologist wrote an essay about human learning.

Evaluate

Evaluate is defined as making judgments based on criteria and standards. The criteria most often used are quality, effectiveness, efficiency, and consistency. They may be determined by the student or given to the student by others. The standards may be either quantitative (i.e., is this a sufficient amount?) or qualitative (i.e., is this good enough?). This category includes the cognitive processes of *checking* (which refers to judgments about internal consistency) and *critiquing* (which refers to judgments based on external criteria).

Checking (also called *coordinating, detecting, monitoring,* or *testing*) occurs when a student detects inconsistencies or fallacies within a process or product, determines whether a process or product has internal consistency, or detects the effectiveness of a procedure as it is being implemented. When combined with *planning* (a cognitive process in the category, *Create*) and *implementing* (a cognitive process in the category, *Apply*), checking involves

determining how well the plan is working. A sample objective in social science could be "Learn to detect inconsistencies within persuasive messages." A corresponding assessment task could involve asking students to listen to a television advertisement for a political candidate and point out any logical flaws in the persuasive message. A sample objective in science could be "Learn to determine whether a scientist's conclusion follows from the observed data." An assessment task could involve asking students to read a report of a chemistry experiment in order to determine whether the conclusion follows from the results of the experiment.

Critiquing (also called *judging*) occurs when a student detects inconsistencies between a product or operation and some external criteria, determines whether a product has external consistency, or judges the appropriateness of a procedure for a given problem. *Critiquing* lies at the core of what has been called critical thinking. In *critiquing*, students judge the merits of a product or operation based on specified or student-determined criteria and standards. In social science, an objective could be "Learn to evaluate a proposed solution (e.g., eliminate all grading) to a social problem (e.g., how to improve K-12 education) in terms of its likely effectiveness."

Create

Create involves putting elements together to form a coherent or functional whole; that is, reorganizing elements into a new pattern or structure. Objectives classified as *Create* involve having students produce an original product. Composition (including writing), for example, often, but not always, involves cognitive processes associated with *Create*. It can, in fact, be simply the application of procedural knowledge (e.g., "Write this essay in this way"). The creative process can be broken into three phases: (a) problem representation, in which a student attempts to understand the task and generate possible solutions; (b) solution planning, in which a student examines the possibilities and devises a workable plan; and (c) solution execution, in which a student successfully carries out the plan. Thus, the creative process can be thought of as starting with a divergent phase in which a variety of possible solutions are considered as the student attempts to understand the task (*generating*). This is followed by a convergent phase, in which a solution method is devised and turned into a plan of action (*planning*). Finally, the plan is executed as the solution is constructed (*producing*). Not surprisingly, then, *Create* can be broken down into three cognitive processes: *generating*, *planning*, and *producing*.

Generating (also called *hypothesizing*) involves inventing alternative hypotheses based on criteria. When *generating* transcends the boundaries or constraints of prior knowledge and existing theories, it involves divergent thinking and forms the core of what can be called creative thinking. In *generating*, a student is given a description of a problem and must produce alternative solutions. For example, in social science, an objective could be "Learn to generate multiple potentially useful solutions for social problems." A corresponding assessment item could ask students to suggest as many ways as possible to assure that everyone has adequate medical insurance. An objective from the field of mathematics could be "Generate alternative methods for achieving a particular end result." A corresponding assessment could be to ask students to list alternative methods they could use to find which whole numbers yield 60 when multiplied together. For each of these assessments, explicit scoring criteria are needed.

Planning (also called *designing*) involves devising a method for accomplishing some task. However, *planning* stops short of carrying out the steps to create the actual solution for a given problem. In *planning*, a student may establish subgoals (i.e., break a task into subtasks to be performed when solving the problem). Teachers often skip stating *planning* objectives, instead stating their objectives in terms of *producing*, the final stage of the creative process. When this happens, *planning* is either assumed or is implicit in the *producing* objective. In this case, *planning* is likely to be carried out by the student covertly, in the course of constructing a product (i.e., *producing*). In *planning*, a student develops a solution method when given a problem statement. In mathematics, an objective could be "List the steps needed to solve geometry problems." An assessment task may ask students to devise a plan for determining the volume of the frustum of a pyramid (a task not previously considered in

class). The plan may involve computing the volume of a large pyramid, then computing the volume of a small pyramid, and, finally, subtracting the smaller from the larger.

Producing (also called *constructing*) involves inventing a product. In *producing*, a student is given a functional description of a goal and must create a product that satisfies the description. In science, for example, an objective might be "Learn to design habitats for certain species and certain purposes." A corresponding assessment task may ask students to design the living quarters of a space station.

Conclusion

The primary goal of this article has been to examine how teaching and assessing can be broadened beyond an exclusive focus on the cognitive process of *Remember*. The revised Taxonomy contains descriptions of 19 specific cognitive processes associated with six process categories. Two of these cognitive processes are associated with *Remember*; 17 are associated with the five more complex cognitive process categories: *Understand*, *Apply*, *Analyze*, *Evaluate*, and *Create*.

Our analysis has implications for teaching and assessing. On the teaching side, two of the cognitive processes help to promote retention of learning, whereas 17 of them help foster transfer of learning. Thus, when the goal of instruction is to promote transfer, objectives should include the cognitive processes associated with *Understand, Apply, Analyze, Evaluate*, and *Create*. The descriptions in this chapter are intended to help educators generate a more complete range of educational objectives that are likely to result in both retention and transfer.

On the assessment side, our analysis of cognitive processes is intended to help educators (including test designers) broaden the way they assess learning. When the goal of instruction is to promote transfer, assessment tasks should involve cognitive processes that go beyond *recognizing* and *recalling*. Although assessment tasks that use these two cognitive processes have a place in assessment, these tasks can, and often should, be supplemented with those that utilize the full range of cognitive processes required for transfer of learning.

Note

1. This article is based on Chapter 5, The Cognitive Process Dimension in *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives* (Anderson, Krathwohl, et al., 2001) and is reproduced by permission of the publisher. I am pleased to acknowledge that the following authors contributed to this article: Lorin W. Anderson, David R. Krathwohl, Paul Printrich, and Merlin Wittrock. I also gratefully acknowledge the assistance of the entire team of *Taxonomy* authors.

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