Designing Effective Projects: Thinking Skills Frameworks
Marzano's New Taxonomy

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Robert Marzano, respected educational researcher, has proposed what he calls A New Taxonomy of Educational Objectives (2000). Developed to respond to the shortcomings of the widely used Bloom's Taxonomy and the current environment of standards-based instruction, Marzano's model of thinking skills incorporates a wider range of factors that affect how students think and provides a more research-based theory to help teachers improve their students' thinking.

Marzano's New Taxonomy is made up of three systems and the Knowledge Domain, all of which are important for thinking and learning. The three systems are the Self-System, the Metacognitive System, and the Cognitive System. When faced with the option of starting a new task, the Self-System decides whether to continue the current behavior or engage in the new activity; the Metacognitive System sets goals and keeps track of how well they are being achieved; the Cognitive System processes all the necessary information, and the Knowledge Domain provides the content.

The Three Systems and Knowledge

Self-System		
Beliefs About the Importance of Knowledge	Beliefs about Efficacy	Emotions Associated with Knowledge

Metacognitive System			
Specifying Learning Goals	Monitoring the Execution of Knowledge	Monitoring Clarity	Monitoring Accuracy

Cognitive System			
Knowledge Retrieval	**Comprehension**	**Analysis**	**Knowledge Utilization**
Recall Execution	Synthesis Representation	Matching Classifying Error Analysis Generalizing Specifying	Decision Making Problem Solving Experimental Inquiry Investigation

Knowledge Domain		
Information	Mental Procedures	Physical Procedures

Classroom Example

Libby, a 3rd grader is thinking about a slumber party she is going to attend this weekend when her teacher begins a math lesson. Libby's Self-System decides to stop thinking about the party and engage in the lesson. Her Metacognitive System tells her to pay attention and ask questions so she can do the assignment. Her Cognitive System provides her with the thinking strategies she needs to make sense of the teacher's instructions. The mathematical knowledge about concepts and procedures makes it possible for her to complete the problems successfully. Each component of the New Taxonomy contributes to Libby's success at learning the math concept and skills of the lesson.

Knowledge Domain

Traditionally, the focus of most instruction has been in the component of knowledge. Students were assumed to need a significant amount of knowledge before they could think seriously about a subject. Unfortunately, in traditional classrooms, instruction rarely moved beyond the accumulation of knowledge, leaving students with a mental file cabinet full of facts, most of which were quickly-forgotten after the final test.

Knowledge is a critical factor in thinking. Without sufficient information about the subject being learned, the other systems have very little to work with and are unable to engineer the learning process successfully. A high-powered automobile with all the latest technological features still needs some kind of fuel to make it fill its purpose. Knowledge is the fuel that powers the thinking process.

Marzano identifies three categories of knowledge: *information*, *mental procedures,* and *physical procedures*. Simply put, information is the "what" of knowledge and procedures are the "how-to."

Information

Information consists of organizing ideas, such as principles, generalizations, and details, such as vocabulary terms and facts. Principles and generalizations are important because they allow us to store more information with less effort by placing concepts into categories. For example, a person may never have heard of an *akbash*, but once someone knows that the animal is a dog, he knows quite a bit about it.

Mental Procedures

Mental procedures can range from complex processes, such as writing a term paper to simpler tasks such as tactics, algorithms, and single rules. Tactics, like reading a map, consist of a set of activities which do not need to be performed in any particular order. Algorithms, like computing long division, follow a strict order which does not vary by situation. Single rules, such as those covering capitalization, are applied individually to specific instances.

Physical Procedures

The degree to which physical procedures figure into learning varies greatly by subject area. The physical requirements necessary for reading may consist of no more than left-to-right eye movement and the minimal coordination needed to turn a page. On the other hand, physical and vocational education require extensive and sophisticated physical processes, such as playing tennis or building a piece of furniture. Contributing factors to effective physical processing include strength, balance, manual dexterity, and overall speed of movement. Many of the activities which students enjoy in their leisure time such as sports or electronic game-playing require refined physical procedures.

Classroom Example

Most curriculum standards are organized around concepts which are usually labeled by one or two words. A concept such as "triangles" would include all the information components:

- Vocabulary (information): isosceles, equilateral, hypotenuse
- Generalization (information): All right triangles have one angle of 90 degrees.
- Mental procedures: Conducting proofs and figuring the length of the side of a right triangle
- Physical procedures: Constructing triangles with a compass and ruler

Cognitive System

The mental processes in the Cognitive System take action from the knowledge domain. These processes give people access to the information and procedures in their memory and help them manipulate and use this knowledge. Marzano breaks the Cognitive System down into four components: *knowledge retrieval, comprehension, analysis,* and *knowledge utilization*. Each process is composed of all the previous processes. Comprehension, for example, requires knowledge retrieval; analysis requires comprehension, and so on.

Knowledge Retrieval

Like the knowledge component of Bloom's Taxonomy, Knowledge Retrieval involves recalling information from permanent memory. At this level of understanding, students are merely calling up facts, sequences, or processes exactly as they have been stored.

Comprehension

At a higher level, Comprehension requires identifying what is important to remember and placing that information into appropriate categories. Therefore, the first skill of comprehension, *synthesis*, requires the identification of the most important components of the concept and the deletion of any that are insignificant or extraneous. For example, a student learning about the Lewis and Clark expedition should bother to remember the route that the explorers took but not how many weapons they carried with them. Of course, what is considered important about a concept depends on the context in which it is learned, so the information that is stored about a topic would vary by situation and student.

Through *representation*, information is organized in categories that make it more efficient to find and use. Graphic organizers, such as maps and charts, encourage this cognitive process. Interactive thinking tools such as the *Visual Ranking Tool* which allows students to compare their evaluations with others, the *Seeing Reason Tool* which helps students develop maps of systems, and the *Showing Evidence Tool*, which supports the creation of good arguments, also serve the purpose of representing knowledge.

Analysis

More complex than simple comprehension, the five cognitive processes in Analysis are *matching, classifying, error analysis, generalizing,* and *specifying*. By engaging in these processes, learners can use what they are learning to create new insights and invent ways of using what they have learned in new situations.

Knowledge Utilization

The final level of cognitive processes addresses the use of knowledge. Marzano calls these processes Knowledge Utilization, or Using Knowledge. The processes of using knowledge are especially important components of thinking for project-based learning since they include processes used by people when they want to accomplish a specific task.

Decision-making, a cognitive process involves the weighing of options to determine the most appropriate course of action.

Problem-solving occurs when an obstacle is encountered on the way to achieving a goal. Sub-skills for this process include identification of and analysis of the problem.

Experimental inquiry involves generating hypotheses about physical or psychological phenomena, creating experiments, and analyzing the results. Third graders designing bean plant experiments and analyzing ideal conditions for growth are conducting experimental inquiry. For more information on this project, see the Unit Plan, The Great Bean Race.

Investigation is similar to experimental inquiry but involves past, present, or future events. Unlike experimental inquiry which has specific rules for evidence based on statistical analysis, investigation requires logical arguments. In an experimental inquiry, learners observe and record direct data about phenomena. In an investigation, the information is less direct. It comes from the research and opinions of others through their writings, speaking, and other work. High school physics students who research current physics issues and use what they learn to persuade lawmakers to fund particular types of research are conducting investigations. See Help Wanted! Physicist for details on this project.

Metacognitive System

The metacognitive system is the "mission control" of the thinking process and regulates all the other systems. This system sets goals and makes decisions about which information is necessary and which cognitive processes best suit the goal. It then monitors the processes and makes changes as necessary. For example, a middle-school student who is contributing to a virtual museum about different rocks first establishes the goals of what his Web page will have on it and what it will look like. Then he chooses what strategies he will use to find out what he needs to know in order to create the page. As he implements the strategies, he monitors how well they are working, changing or modifying how he is working in order to complete the task successfully.

Research on metacognition, particularly in literacy and mathematics, makes a convincing case that instruction and support in the control and regulation of thinking processes can have a strong impact on achievement (Paris, Wasik, Turner, 1991; Schoenfeld, 1992).

Self-System

As any teacher knows, providing students with instruction in cognitive strategies, even with metacognitive skills, is not always enough to ensure that they will learn. Teachers also are often pleasantly surprised to discover that a student has accomplished a task that they considered to be far too difficult. These situations occur because at the root of all learning is the Self-System. This system is comprised of the attitudes, beliefs and feelings that determine an individual's motivation to complete a task. The factors that contribute to motivation are: *importance, efficacy*, and *emotions*.

Importance

When a student is confronted with a learning task, one of her first responses is to determine how important the task is to her. Is it something she wants to learn or believes she needs to learn? Will the learning help her accomplish a pre-determined goal?

Efficacy

Efficacy, as defined by a developer of social learning theory, Albert Bandura (1994), refers to people's beliefs about their ability to accomplish a task successfully. Students with a high degree of self-efficacy face challenging tasks head-on, with the belief that they have the resources to be successful. These students become deeply engaged in these tasks, persist at working on the task, and overcome the challenges.

Bandura describes some ways in which students can develop feelings of self-efficacy. The most powerful way is through successful experiences. The experiences must be neither too difficult nor too easy. Repeated failure undermines self-efficacy, but success at overly simple tasks fails to develop a sense of resilience necessary for persisting at difficult tasks.

Emotions

Although students cannot control their emotions related to a learning experience, these feelings have a huge impact on motivation. Effective learners use their metacognitive skills to help them deal with negative emotional responses and take advantage of positive responses. For example, a student with a negative emotional feeling about reading technical materials could decide to read his chemistry textbook when he is exceptionally alert, rather than just before he goes to sleep at night.

In the Classroom with Marzano's New Taxonomy

Elementary Example

Lonnie is a fourth grader participating in the project-based unit, From Sea to Sea, in which he will look at cities in his region and their importance as commercial and trade centers. Lonnie is motivated almost completely by his emotional response to class activities. He sees little value in typical school-type assignments, but he is a curious boy, and often finds something in the subjects he's studying to interest him. He is a confident learner with a high opinion of his ability to accomplish assigned tasks even though he doesn't always complete them.

Lonnie is not a lazy boy, but he often flits from one thing to another without following through on plans. His teacher knows her students quite well and realizes that she does not need to spend extra time building up Lonnie's sense of efficacy. She also knows that he will easily pick up the cognitive strategies that he needs in order to complete the project. The areas in which he needs the most help are with his emotional responses and metacognition. Since the project allows for some choices, the teacher will help Lonnie choose a local business that interests him. He is very interested in motorcycles, so she encourages him to do research on that business. She also provides him with checklists of tasks to be accomplished and time for reflecting on his work to develop his metacognitive abilities.

By working with Lonnie to build up his metacognitive skills and providing projects that allow him to pursue his interests, his teacher is creating an environment in which he can think deeply about what he is learning. At the same time she is helping him build skills and strategies that will serve him throughout his life.

Secondary Example

Jessica is working on the unit, Play Ball, a project-based unit in which students study the mathematics of baseball. She prefers her humanities courses like English and world history, and she has no interest in baseball whatsoever. She did, however, decide at an early age that she wanted to be a journalist and knows that she wants to go to a private college with an excellent journalism program. Therefore, she sees the work she does in her math class as important because it helps her achieve her goal of getting into a good college even though it is not particularly interesting to her.

Jessica is a high-achiever, but she is not as good in math as she is in writing, and so she's a bit reluctant to get too engaged in the project for fear she will disappoint herself and others. Since her teacher knows this about her, she makes sure that Jessica has the prerequisite skills and knowledge and gives her lots of encouragement. When Jessica's Self-System has provided her the motivation to learn, her other systems can take charge of her learning process.

Jessica begins the unit by learning the definitions of some basic vocabulary words. As she works through the project, the teacher gives instruction that supports her learning through the different systems. When she is asked to compare different players' statistics, the teacher models the kinds of matching she needs to do, and when she reaches the point of the project where she chooses an aspect of baseball to research further, the teacher gives her some instruction in decision making.

To encourage metacognitive thinking, the teacher schedules small-group reflection sessions at critical points in the project and Jessica writes in her journal reflecting on how her work is going. By addressing all the systems as well as the knowledge domain, Jessica's geometry teacher increases the likelihood that Jessica will develop higher-order thinking skills in mathematics and that she will be able to apply what she has learned in new situations.

References

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