Data Analysis and Critical Thinking

Not long ago, the information people needed for decision making was simple and at hand. Today, as life continues to grow more complex, information is becoming more pervasive and ambiguous than ever. Therefore, success in learning and in life requires an understanding of how to effectively interpret and use data.

Teaching thinking, including how to interpret and use data, has been a topic of interest for many educators. Educational researchers have developed a variety of ways to describe the kinds of thinking that students need to exercise to complete complex real-world tasks. Although these models differ, they all have important insights for teachers interested in helping students become more advanced critical thinkers. Common insights include:

- Thinking critically is a complex process that involves the integration of a variety of basic and advanced skills.
- The goal of thinking is the purposeful use of knowledge.
- Higher-order thinking processes can be broken down into more specific subskills.

Bloom's Revised Taxonomy

In 1999, Dr. Lorin Anderson, one of Benjamin Bloom's former students, and his colleagues published an updated version of Bloom's Taxonomy that takes into account a broader range of factors that impact teaching and learning. This revised taxonomy attempts to correct some of the problems with the original taxonomy. Unlike the 1956 version, the revised taxonomy differentiates between *knowing what* (the content of thinking) and *knowing how* (the procedures used to solve problems).

The Cognitive Process Dimension of the revised Bloom's Taxonomy consists of six skills, organized from simplest to most complex.

Skill	Description
Remembering	Retrieving, recognizing, and recalling relevant knowledge from long-term memory
Understanding	Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining
Applying	Carrying out or using a procedure through executing, or implementing

Analyzing	Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing
Evaluating	Making judgments based on criteria and standards through checking and critiquing
Creating	Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing

Marzano's New Taxonomy

In 2000, Robert Marzano, a respected educational researcher, proposed *A New Taxonomy of Educational Objectives*. Marzano's new taxonomy was developed to respond to the shortcomings of the widely used Bloom's Taxonomy and the current environment of standards-based instruction.

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, Metacognitive System, and 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.

Marzano identifies four components of the cognitive system that processes data.

Component	Data Processes
Knowledge Retrieval	• Recalling • Executing
Comprehension	• Synthesizing • Representing
Analysis	• Matching • Classifying • Error Analysis • Generalizing • Specifying
Knowledge Utilization	• Decision Making • Problem Solving • Applying experimental Inquiry • Investigating

A Critical Thinking Curriculum

In Arthur Costa's 2001 book, *Developing Minds: A Resource Book for Teaching Thinking,* Robert Ennis proposes some goals for a critical thinking curriculum. He names three dispositions necessary for critical thinking:

- Commitment to knowing the truth
- Desire to communicate opinions honestly and fairly
- Concern for the dignity and worth of all human beings

Ennis also identifies specific cognitive abilities that contribute to thinking critically.

Constitutive Abilities	
Clarification	• Focusing on a question • Analyzing arguments (identifying conclusions, stated and unstated reasons, and irrelevance) • Asking and answering clarifying and challenging questions
Decision making	• Judging the credibility of a source • Making and judging observations
Inference	• Deducing • Judging the validity of a deduction • Inducing • Judging the validity of an induced argument (evaluating explanatory conclusions, such as claims, interpretations of authors' meanings, historical claims about events, and definitions) • Making and evaluating value judgments • Defining terms and evaluating definitions • Attributing unstated assumptions • Making and evaluating suppositional thinking • Integrating all critical thinking skills
Auxiliary Abilities	
Methodical thinking	• Following problem solving steps • Using Metacognition
Sensitivity to others	• Recognizing others' feelings, level of knowledge, and sophistication
Use of appropriate rhetorical strategies	• Understanding reasoning fallacy terminology

Essential Thinking Skills

Barbara Presseisen, another contributor to Costa's landmark book, addresses the nature of basic and complex thinking skills. She describes a taxonomy of basic thinking skills and connects them to more complex, higher-order thinking processes.

A Taxonomy of Basic Thinking Skills

Thinking Skill	Higher-Order Thinking Processes
Qualifying	• Recognizing units of basic identity • Defining • Gathering facts • Recognizing tasks and problems
Classifying	• Recognizing similarities and differences • Grouping and sorting • Comparing • Making either/or distinctions
Finding Relationships	• Relating parts and wholes • Seeing patterns • Analyzing • Synthesizing • Recognizing sequences and order • Making deductions
Transforming	• Making analogies • Creating metaphors • Making initial deductions
Drawing Conclusions	• Identifying cause and effect • Making distinctions • Inferring • Evaluating

A Model of Complex Thinking Skills

	Problem Solving	Decision Making	Critical Thinking	Creative Thinking
Task	Resolve a known difficulty	Choose the best alternative	Understand particular meanings	Create novel or aesthetic ideas or products
Essential Skills Emphasized	Transforming, conclusions	Classifying, relationships	Relationships, transforming, conclusions	Qualifying, relationships, transforming
Yields	Solution, generalization	Assessment	Sound reasons, proof, theory	New meanings, pleasing products

For more information about critical thinking and teaching thinking, visit http://educate.intel.com/en/ProjectDesign/ThinkingSkills

References

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