Bloom's Taxonomy of Cognitive Operations

The best known and oldest cognition-based schema is Bloom's (Bloom & Associates, 1956) taxonomy or hierarchy of cognitive operations:

- Knowledge: to memorize or recognize facts and terms
- Comprehension: to translate or restate in one's own words
- Application: to utilize, apply, solve, or make useful
- Analysis: to identify, examine, and come to conclusions about parts or components, such as comparing and contrasting and deducing assumptions and implications
- Synthesis: to make new connections among parts or components, such as identifying relationships or creating something new
- Evaluation: to assess, judge, or defend quality, value, or validity

Bloom posited that the operations become more complex and advanced moving from knowledge to evaluation, and that a learner must be able to master all the lower-order ones before becoming adept at the higher-order ones. For example, to conduct a sound analysis of an argument, students must be able to identify relevant facts, terms, and "knowns" of the subject matter; restate them in their own words; and apply them to a problem or real-world situation. Mastering analysis of the subject opens the door to learning synthesis, and synthesis to evaluation.

Anderson and Krathwohl's Revision of Bloom's Taxonomy

Anderson and Krathwohl (2000) introduced a gerund-based revision of Bloom's taxonomy. It more accurately names the lowest-order cognitive operation, gives synthesis a more imaginative nuance, and reorders the two highest-order cognitive operations:

- Remembering
- Understanding
- Applying
- Analyzing
- Evaluating
- Creating

In Bloom's schema, evaluation is the most advanced type of learning, whereas in this revised version creating is the most advanced. Otherwise, the principle is the same: Demonstrating the higher-order cognitive operations is evidence of more advanced learning.

Perry's Stages of Undergraduate Cognitive Development

Another cognition-based framework that posits a progression from basic to more advanced learning is William G. Perry's (1968) stages of undergraduate cognitive development. Whereas the sequence of cognitive operations in Bloom's and Anderson and Krathwohl's hierarchies is open to debate, Perry's stages follow a hard-and-fast order. They outline the process by which a student comes to understand the true nature of knowledge as inherently uncertain, incomplete human creations but still subject to definite standards of comparison on quality, validity, and utility.

In his short four-stage schema (the longer nine-stage schema only makes fine distinctions within the four stages), Perry called the intellectual perspective of the first stage "dualism." Students first look upon a discipline-based body of knowledge as a large aggregate of information, something like a long list of phone numbers. It is a collection of facts, rules, and vocabulary words to memorize. Further, these facts, rules, and terms are "real"; the facts are indisputable, the rules always apply, and the terms name existing things or phenomena. In other words, you can be absolutely certain of the validity and reality of whatever is in that body of knowledge and, by implication, whatever the textbook says. A statement is either "right," if it is found in that body of knowledge, or "wrong," if some piece of knowledge in that body contradicts it. Moreover, disciplinary experts such as faculty have a ready command of all that knowledge. Their job is to simply regurgitate it in writing, as stated in a textbook or an article, or verbally, as said in a lecture, so the students can "absorb" and memorize as many of the facts, rules, and terms as possible.

No doubt this type of fact-anchored, black-and-white, right-or-wrong thinking is characteristic of most undergraduates and, frankly, most people in general. Students in this stage see little organization to the aggregate of information on a subject and, logically enough, believe that the way to learn it is to memorize it for either recognition or regurgitation on the next test. With this perspective on the nature of knowledge, the only level of thinking is remembering, which is the lowest level in Anderson and Krathwohl's taxonomy.

A student will not progress beyond dualism unless she learns that bodies of knowledge contain uncertainty—that is, they do not cover all there is to know. Gaps in knowledge exist. Some future events are not precisely predictable. Questions remain unanswered. The critical question is, Why? At the second of Perry's stages of undergraduate cognitive development, called "multiplicity," the student thinks that the uncertainty stems from the incompetency of experts to find all the answers, or that the instructor is leading her to believe uncertainty exists for the sake of some kind of intellectual exercise.

But she may soon decide that the unknowns are real but only a temporary problem while experts complete their research to "fill in" the factual blanks.

Reaching the third stage represents a qualitative leap in a student's understanding of the nature of knowledge. It rests on the insight that knowledge is not something that really exists "out there" and is merely waiting to be discovered and named. Rather, knowledge is a *human cognitive creation*—scholars' interpretation of specific observations and data, some apparent patterns and trends that experts have identified, a grid that authorities put over a messy reality to make sense of it. Imperfect as it may be, this grid allows us to predict and manipulate our world to some extent and often to increase our collective survival chances. But at its core, knowledge is *inherently* uncertain.

Perry called this third stage "relativism." Although a fairly advanced stage of thinking, it fails to distinguish degrees of quality among different paradigms or grids. The relativistic learner discredits the most informed, well-grounded interpretations and even knowledge itself as "someone's opinion." As a logical extension of this perspective, each opinion rates about the same, and therefore the student's opinion ranks about as valid as the next. Of course, students usually realize that such thinking does not help in factual matters and that they are unlikely to come up with a theory of their own regarding the physics or chemistry of the universe. However, they may use this reasoning to justify their belief in creationism or intelligent design, individualism (in opposition to social structural explanations of human outcomes), and just about any ethical system. Perhaps corrupt government officials and corporate leaders have rationalized their ethical breaches using a relativistic perspective. In fact, relativism can excuse just about any value, belief, and action that human beings are capable of. For this reason, it can be a dangerous landing for students to rest on very long. In time, the libertarian excitement of relativism may wear off as they find themselves having to qualify its principles and live with too many internal contradictions ("It's okay to cheat someone except when the victim is a child, parent, spouse, minister, friend, pregnant woman, etc."). Should this happen, students will welcome entering the next stage of development.

The fourth and final stage is called "commitment," which means making a tentative commitment to the best available paradigm or grid. Students advance this far upon realizing that not all interpretations are equally valid and useful and that the interpretations of experts are not just their opinions. On a personal level, this insight prompts them to choose a certain viewpoint, ideology, or moral code after examining the strengths and weaknesses of various alternatives. Students view their choice as the best they can make for now and understand its limitations and trade-offs. Perhaps at some time in the future, they will adjust or change their commitment as they acquire greater

knowledge and wisdom. On an intellectual level, a student comes to realize, at least for this discipline, that experts compare competing interpretations. They write philosophical treatises arguing the merits and deficits of varying perspectives. They conduct careful scientific research—at crucial junctures, critical experiments—to assess the relative strengths and weaknesses of competing paradigms (Kuhn, 1996). They maintain high, well-developed standards to justify favoring one over another. These may involve scientific evidence, plausibility, precedence, or the safety of human life, depending on the discipline.

Undergraduates do not necessarily progress through these stages of cognitive development. In fact, they may graduate from college with the same dualistic mind-set with which they entered. Faculty may have to consciously help their students advance through the stages. They would do well to set learning outcomes and integrate learning activities with the aim of moving their students through a couple, if not all, of these stages.

Wolcott and Lynch's Thinking Performance Patterns

The final framework that defines *lower-level* through *higher-level learning* was developed by Wolcott and Lynch (2006a; Wolcott, 2006). It is built on a hierarchy of four problem-solving skills that vary by level of complexity (Wolcott, 2006). The least complex (step 1) is identifying, which involves pointing out and describing the relevant information as well as the uncertainties (risks) and unknowns. Step 2 is exploring, which entails interpreting information from different standpoints and organizing it into categories. In Bloom's or Anderson and Krathwohl's hierarchies, this level of thinking would be quite high, overlapping with analysis (of advantages and disadvantages), synthesis/creating (categories), and even evaluation (of the information). But in Wolcott and Lynch's, it is quite basic. Step 3 is prioritizing, which includes drawing and assessing sound conclusions, appraising risk, developing plans and policies, and implementing them with the participation of others. Anderson and Krathwohl's concepts of evaluating and creating are reflected here, but so are leadership and communication. The final step is re-visioning, which combines analyzing the limitations of a problem-solving strategy, charting future directions and strategies, monitoring and evaluating these strategies, and adjusting them as needed. Again, evaluating, creating, and leading are the major challenges, but unlike in the prioritizing step, they are forward looking.

These four steps provide the foundation for Wolcott and Lynch's (2006a) five Thinking Performance Patterns. Ascending a hierarchy, the patterns demonstrate more complex and sophisticated thinking skills represented by the steps described in Table 3.1.

TABLE 3.1.

Steps for Better Thinking Performance Patterns

← Less Complex Performance Patterns				More Complex Performance Patterns →
"Confused Fact-Finder" *Performance Pattern 0* *Step 1, 2, 3, & 4 skills weak*	*"Biased Jumper"* *Performance Pattern 1* *Step 2, 3, & 4 skills weak*	*"Perpetual Analyzer"* *Performance Pattern 2* *Step 3 & 4 skills weak*	*"Pragmatic Performer"* *Performance Pattern 3* *Step 4 skills weak*	*"Strategic Re-Visioner"* *Performance Pattern 4* *Strategically integrates step 1, 2, & 3 skills*
Overall Problem Approach: Proceeds as if goal is to find the single "correct" answer	**Overall Problem Approach:** Proceeds as if goal is to stack up evidence and information to support conclusion	**Overall Problem Approach:** Proceeds as if goal is to establish a detached, balanced view of evidence and information from different points of view	**Overall Problem Approach:** Proceeds as if goal is to come to a well-founded conclusion based on objective comparisons of viable alternatives	**Overall Problem Approach:** Proceeds as if goal is to construct knowledge, to move toward better conclusions or greater confidence in conclusions as the problem is addressed over time
Common Weaknesses: • Fails to realistically perceive uncertainties/ambiguities • Does not seem to "get it"; recasts open-ended problem to one having a single "correct" answer • Insists that professors, textbooks, or other experts should provide "correct" answer • Expresses confusion or futility • Uses illogical/contradictory arguments • Cannot evaluate or appropriately apply evidence • Inappropriately cites textbook, "facts," or definitions • Conclusion based on unexamined authorities' views or what "feels right"	**Major Improvements Over Performance Pattern 0:** • Acknowledges existence of enduring uncertainties and the viability of multiple perspectives • Begins to use evidence logically to support conclusions **Common Weaknesses:** • Jumps to conclusions • Stacks up evidence quantitatively to support own view and ignores contrary information • Equates unsupported personal opinion with other forms of evidence • Inept at breaking problem down and understanding multiple perspectives • Insists that all opinions are equally valid, but ignores or discounts other opinions • Views experts as being opinionated or as trying to subject others to their personal beliefs	**Major Improvements Over Performance Pattern 1:** • Presents coherent and balanced description of a problem and its larger context • Identifies issues, assumptions, and biases associated with multiple perspectives • Attempts to control own biases • Logically and qualitatively evaluates evidence from different viewpoints **Common Weaknesses:** • Unable to establish priorities for judging across alternatives • Reluctant to select and defend a single overall solution as most viable, or provides inadequate support for solution • Writes overly long paper in an attempt to demonstrate all aspects of analysis (problems without prioritizing) • Jeopardizes class discussions by getting stuck on issues such as definitions	**Major Improvements Over Performance Pattern 2:** • After thorough exploration, consciously prioritizes issues and information • Articulates well-founded support for choosing one solution while objectively considering other viable options • Conclusion based on qualitative evaluation of experts' positions or situational pragmatics • Effectively incorporates others in the decision process and/or implementation **Common Weaknesses:** • Conclusion doesn't give sufficient attention to long-term, strategic issues • Inadequately identifies and addresses solution limitations and "next steps"	**Major Improvements Over Performance Pattern 3:** • Prioritizes and addresses limitations effectively • Interprets and re-interprets bodies of information systematically over time as new information becomes available • Exhibits a strategic, long-term vision • Spontaneously considers possible ways to generate new information about the problem **Common Weaknesses:** • Not applicable

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The simplest pattern is that of the Confused Fact-Finder, which has mastered none of the skills of the four steps. Paralleling dualism, this mind-set defines *problem solving* as a quest to find the one correct solution or answer.

Next is the Biased Jumper, which "jumps" to a problem solution without assessing all the data or entertaining alternatives. This type of mind is proficient only in identifying relevant information, which is characteristic of step 1. So it views problem solving as amassing evidence to support its hastily chosen solution. Like Perry's relativistic thinker, the mentality of the Biased Jumper considers all opinions as equally valid but discounts those different from its own. In addition, it sees authorities as trying to force their opinions on others.

Third up the hierarchy lies the Perpetual Analyzer, a mind-set strong in identifying and exploring information (step 2) but weak in the skills of steps 3 and 4. It strives to reach an objective, balanced view of the evidence and represent every approach to the problem. However, it lacks the standards to prioritize and decide among the perspectives available, making informed judgment and committed action impossible. While more sophisticated than the Biased Jumper, the Perpetual Analyzer is also relativistic in regarding all opinions as equally valid, but the latter discounts none of them. In Perry's framework, this is the advanced stage of relativism. The paralysis it engenders readies a person to seek commitment.

The fourth approach to problem solving is represented by the Pragmatic Performer, which is proficient in the skills of steps 1–3. With no problem prioritizing, this mind-set aims to arrive at and implement the most strongly supported conclusion after rationally comparing the various alternatives. It may study expert opinions on the matter and solicit the advice of other involved parties. While prepared to make a commitment to the best available approach, the Pragmatic Performer prefers certainty over tentativeness and may miss some of the limitations and longer term ramifications of the selected decision—in other words, it comes to premature closure and resists contrary evidence and change.

Only the Strategic Re-Visioner brings the thinking skills of all four steps to developing a problem solution. While avoiding closure, this mentality takes action guided by long-term strategic goals. The tentativeness of its commitment to a course of action motivates a continual reassessment of prior decisions and, therefore, ongoing collection and analysis of additional information over time. Because the Strategic Re-Visioner is not emotionally attached to or ego involved with a solution, this mind-set is ever sensitive to the limitations of its chosen strategies and conclusions and is open to adjusting them as conditions change, new information appears, or better alternatives emerge.

Obviously, progressing through the problem-solving skills from steps 1 through 4 and ascending the hierarchy of Thinking Performance Patterns from the Confused Fact-Finder through the Strategic Re-Visioner demonstrates the acquisition of more complex, advanced thinking. When confronted with a fuzzy problem, the student who displays more thinking skills and a higher-level performance pattern in developing a solution is jumping higher hurdles than one who manifests fewer skills and a lower-level performance pattern.

Mathematical and Logical Problems

Anyone who has ever taken a course in mathematics, physics, or computer science knows that the end-of-chapter problems start out with some straightforward drill-type problems that look like those that the chapter used for demonstration. Students can solve these with a plug-and-chug strategy that requires little or no quantitative reasoning or understanding of the concepts and principles involved. As the problems progress, they become more difficult. Perhaps the contexts of the word problems morph in unanticipated ways. Or the problems contain an unexpected unknown. Or they look like a problem from an earlier lesson that required a different algorithm to solve. Or the solutions entail multiple steps. Or they require not just the chapter's lesson but an integration of materials from previous chapters as well. Or visualizing the parts of the problems is essential to determining the right approach. Any number of factors can make problems more challenging.

For whatever reasons, fewer students are able to solve more complex problems, and those who do usually take longer to solve them than the easier problems. Solving such problems, and doing so within a reasonable time frame, demonstrates more advanced thinking than solving only the easier textbook problems.

Summary of the Frameworks

We have reviewed four cognition-based frameworks, one with hierarchies of both problem-solving skills and Thinking Performance Patterns, that define levels of learning from basic through advanced. We have also acknowledged the varying difficulty levels of mathematical and logic-based problems. These different schema for defining levels of learning show that there are various types of advanced learning and many ways to conceive and structure higher hurdles in assignments and test questions.

As Figure 3.1 displays, the height of the hurdles varies independently of the number of hurdles, which is a function of the amount of content