Exploring Cognitive Demand in Instruction and Assessment

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Over the past decades, educators and psychologists have attempted to develop models for understanding cognitive complexity as it relates to designing instruction and assessments. In 1956, Benjamin Bloom headed a group of educational psychologists who developed a classification of levels of intellectual behavior important in learning. Bloom created this taxonomy for categorizing the levels of abstraction of questions that commonly occur in educational settings. Using these levels for analysis, Bloom found that over 95 % of the test questions students encounter at the college level require them to think only at the lowest possible level...the recall of information.

Bloom's committee identified three domains of educational activities: **Cognitive** - mental skills (*Knowledge*); **Affective** - growth in feelings or emotional areas (*Attitude*); and **Psychomotor** - manual or physical skills (*Skills*). The cognitive domain involves knowledge and the development of intellectual skills. Within the cognitive domain, Bloom identified six levels - from the simple recall or recognition of facts, as the lowest level, through increasingly more complex and abstract mental levels, to the highest order, classified as evaluation. Different sources list somewhat different verb examples to represent intellectual activity on each of Bloom's levels. Some of these verb examples are listed here. It is important to note that *sometimes the same verbs appear as examples in more than one cognitive level* (e.g., write, summarize, test, explain, etc.). While educators have found these cues useful in lesson planning, this overlap of verbs indicates that focusing only on verbs to determine level of cognitive demand is not fully adequate.

Bloom's Taxonomy Levels with "verb cues" for questioning

1. ***Knowledge***: arrange, collect, define, describe, duplicate, examine, identify, label, list, memorize, name, order, quote, recognize, relate, recall, repeat, reproduce, show, state, tabulate, tell, who, when, where…
2. ***Comprehension***: associate, classify, contrast, describe, discuss, distinguish, differentiate, estimate, **explain**, express, extend, identify, indicate, interpret, locate, predict, recognize, report, restate, review, select, **summarize**, translate…
3. ***Application***: apply, calculate, choose, change, classify, complete, demonstrate, discover, dramatize, employ, examine, experiment, illustrate, interpret, modify, operate, practice, relate, schedule, show, sketch, solve, use, **write…**
4. ***Analysis***: analyze, appraise, arrange, calculate, categorize, classify, compare, connect, contrast, criticize, differentiate, discriminate, distinguish, divide, examine, experiment, **explain,** infer, question, order, select, separate, **test** …
5. ***Synthesis***: arrange, assemble, collect, combine, compose, construct, create, design, develop, formulate, generalize, integrate, invent, manage, modify, organize, plan, prepare, propose, rearrange, rewrite, set up, substitute, what if?, **write…**

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6. ***Evaluation***: appraise, argue, assess, attach, choose, compare, conclude, convince, decide, defend, estimate, judge, predict, rate, core, select, support, value, evaluate, rank, **test,** measure, recommend, **explain**, discriminate, support, **summarize…**

Since Bloom's early work, many others have used various schemas to describe cognitive demand in different learning and assessment contexts. A few are included here:

National Assessment of Educational Progress (NAEP)	
Aspects of Reading (1990-2005)	**Mathematical Abilities (1990-2005)**
Forming a general understanding Consider the text as a whole and provide a global understanding of it.	**Conceptual understanding** Recognize, label, and generate examples of concepts; use & interrelate models, diagrams, manipulatives, & varied representations of concepts; etc.
Developing interpretation Extend initial impressions to develop a more complete understanding of what was read.	**Procedural knowledge** Select and apply appropriate procedures correctly; verify or justify the correctness of a procedure using concrete models or symbolic methods; or extend or modify procedures to deal with factors inherent in problem settings.
Making reader/text connections Connect information in the text with knowledge & experience.	**Problem solving** Recognize and formulate problems; determine the consistency of data; use strategies, data, models; generate, extend, & modify procedures; use reasoning in new settings; & judge the reasonableness & correctness of solutions.
Examining content and structure Critically evaluating, comparing and contrasting, and understanding the effect of such features as irony, humor, & organization.	

Mathematical Complexity of Items - NAEP 2005 Framework

The demand *on thinking* the items requires:

Low Complexity
Relies heavily on the recall and recognition of previously learned concepts and principles.

Moderate Complexity
Involves more flexibility of thinking and choice among alternatives than do those in the low-complexity category.

High Complexity
Places heavy demands on students, who must engage in more abstract reasoning, planning, analysis, judgment, and creative thought.

Andrew Porter's Survey of Enacted Curriculum	
English Language Arts Cognitive Levels	**Mathematics Cognitive Levels**
Recall Provide facts, terms, definitions, conventions; describe; etc.	**Memorize** Recall basic mathematics facts; etc.
Demonstrate/Explain Follow instructions; give examples; etc.	**Perform procedures** Do computational procedures or algorithms; etc.
Analyze/investigate Categorize, schematize; distinguish fact from opinion; make inferences, draw conclusions; etc.	**Demonstrate understanding** Communicate mathematical ideas; use representations to model mathematical ideas; etc.
Evaluate Determine relevance, coherence, logical, internal consistency; test conclusions; etc.	**Conjecture, generalize, prove** Determine the truth of a mathematical pattern or proposition; write formal or informal proof; etc.
Generate/create Integrate, dramatize; predict probable consequences; etc.	**Solve non-routine problems, make connections** Apply and adapt a variety of appropriate strategies to solve problems; etc.

Norman Webb's Depth of Knowledge Levels (1997)

1. ***Recall*** - Recall or recognition of a fact, information, concept, or procedure

2. ***Basic Application*** *of Skill/Concept* - Use of information, conceptual knowledge, follow or select appropriate procedures, two or more steps with decision points along the way, routine problems, organize/display data

3. ***Strategic Thinking*** - Requires reasoning, developing a plan or sequence of steps to approach problem; requires some decision making and justification; abstract and complex; often more than one possible answer

4. ***Extended Thinking*** - An investigation or application to real world; requires time to research, think, and process multiple conditions of the problem or task; non-routine manipulations, across disciplines/content areas/multiple sources

Webb's work has been applied to different content areas and used in test item development, as well as in alignment studies to determine the degree of alignment (match) between states' standards and the tests used by states for accountability purposes. Webb's Depth of Knowledge (DOK) Levels are also being used more and more by local schools and districts to develop curriculum materials and performance assessments to demonstrate learning.

3 Cognitive complexity: Applying Webb DOK Levels to Bloom's Taxonomy Karin K. Hess, National Center for Assessment, Dover, NH 2005 updated 2006 © Karin K. Hess permission to reproduce is given when authorship is fully cited khess@nciea.org

Webb describes his DOK levels as "nominative" rather than as a taxonomy; DOK levels name 4 different ways students interact with content. Each level is dependent upon how ***deeply*** students understand the content in order to respond, not simply the "verb" used. *The Webb levels do not necessarily indicate degree of "difficulty" in that Level 1 can ask students to recall or restate a simple or a much more complex concept, the latter being much more difficult. Conversely, depth of understanding a concept is required to be able to explain how/why a concept works (Level 2), apply it to real-world phenomena with justification/supporting evidence (level 3), or to integrate one concept with other concepts or other perspectives (level 4).*