Applying Webb's Depth-of-Knowledge (DOK) Levels in Science

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According to Norman L. Webb ("Depth-of-Knowledge Levels for Four Content Areas," March 28, 2002), interpreting and assigning depth-of-knowledge levels to both objectives within standards and assessment items is an essential requirement of alignment analysis. Four levels of Depth of Knowledge are used for this analysis.

A general definition for each of the four (Webb) Depth-of-Knowledge levels is followed by Table 1, which provides further specification and examples for each of the DOK levels in science. Generally speaking, large-scale, on-demand assessments should only assess Depth-of-Knowledge Levels 1, 2, and 3. Depth-of-Knowledge at Level 4 should be reserved for local assessment and is included here primarily for illustrative purposes.

Descriptors of DOK Levels for Science (based on Webb, March 2002 and TIMSS Science Assessment framework, 2003)

Level 1 Recall and Reproduction requires recall of information, such as a fact, definition, term, or a simple procedure, as well as performing a **simple** science process or procedure. Level 1 only requires students to demonstrate a rote response, use a well-known formula, follow a set procedure (like a recipe), or perform a clearly defined series of steps. A "simple" procedure is well-defined and typically involves only **one-step**. Verbs such as "identify," "recall," "recognize," "use," "calculate," and "measure" generally represent cognitive work at the recall and reproduction level. Simple word problems that can be directly translated into and solved by a formula are considered Level 1. Verbs such as "describe" and "explain" could be classified at different DOK levels, depending on the complexity of what is to be described and explained.

A student answering a Level 1 item either knows the answer or does not: that is, the answer does not need to be "figured out" or "solved." In other words, if the knowledge necessary to answer an item automatically provides the answer to the item, then the item is at Level 1. If the knowledge necessary to answer the item does not automatically provide the answer, the item is at least at Level 2.

Level 2 Skills and Concepts includes the engagement of some mental processing beyond recalling or reproducing a response. The content knowledge or process involved is **more complex** than in level 1. Items require students to make some decisions as to how to approach the question or problem. Keywords that generally distinguish a Level 2 item include "classify," "organize," "estimate," "make observations," "collect and display data," and "compare data." These actions imply **more than one step**. For example, to compare data requires first identifying characteristics of the objects or phenomenon and then grouping or ordering the objects. Level 2 activities include making observations and collecting data; classifying, organizing, and comparing data; and organizing and displaying data in tables, graphs, and charts.

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Some action verbs, such as "explain," "describe," or "interpret," could be classified at different DOK levels, depending on the complexity of the action. For example, interpreting information from a simple graph, requiring reading information from the graph, is a Level 2. An item that requires interpretation from a complex graph, such as making decisions regarding features of the graph that need to be considered and how information from the graph can be aggregated, is at Level 3.

Level 3 Strategic Thinking requires deep knowledge using reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. The cognitive demands at Level 3 are **complex and abstract**. The complexity does not result only from the fact that there could be multiple answers, a possibility for both Levels 1 and 2, but because the multi-step task requires **more demanding reasoning**. In most instances, requiring students to explain their thinking is at Level 3; requiring a very simple explanation or a word or two should be at Level 2. An activity that has more than one possible answer and requires students to justify the response they give would most likely be a Level 3. Experimental designs in Level 3 typically involve more than one dependent variable. Other Level 3 activities include drawing conclusions from observations; citing evidence and developing a logical argument for concepts; explaining phenomena in terms of concepts; and using concepts to solve non-routine problems.

Level 4 Extended Thinking requires **high cognitive demand** and is **very complex**. Students are required to make several connections—relate ideas *within* the content area or *among* content areas—and have to select or devise one approach among many alternatives on how the situation can be solved. Many on-demand assessment instruments will not include any assessment activities that could be classified as Level 4. However, standards, goals, and objectives can be stated in such a way as to expect students to perform extended thinking. "Develop generalizations of the results obtained and the strategies used and apply them to new problem situations," is an example of a Grade 8 objective that is a Level 4. Many, but not all, performance assessments and open-ended assessment activities requiring significant thought will be Level 4.

Level 4 requires complex reasoning, experimental design and planning, and **probably will require an extended period of time** either for the science investigation required by an objective, or for carrying out the multiple steps of an assessment item. However, the extended time period is not a distinguishing factor if the required work is only repetitive and does not require applying significant conceptual understanding and higher-order thinking. For example, if a student has to take the water temperature from a river each day for a month and then construct a graph, this would be classified as a Level 2 activity. However, if the student conducts a river study that requires taking into consideration a number of variables, this would be a Level 4.

Table 1: Examples for each of the DOK Levels in Science, based on Webb
(Karin Hess, 2007)

Level 1 Recall & Reproduction	Level 2 Skills & Concepts	Level 3 Strategic Thinking	Level 4 Extended Thinking
a. Recall or recognize a fact, term, definition, simple procedure (such as one step), or property b. Demonstrate a rote response c. Use a routine formula or rule d. Represent in words or diagrams a scientific concept or relationship e. Provide or recognize a standard scientific representation for simple phenomenon f. Perform a routine procedure, such as measuring length g. Perform a **simple** science process or a set procedure (like a recipe) h. Perform a clearly defined set of steps i. Identify, calculate, or measure j. Identify the kind of information found in a representation (graph, table, diagram, map) k. Retrieve information from a table or graph to answer a question (e.g., how far did it go?) l. Recall or recognize names and uses for scientific tools m. Use scientific tools to collect & record data (e.g., measure distance or time) **NOTE: If the knowledge necessary to answer an item automatically provides the answer, it is a Level 1.**	a. Specify and explain the relationship (cause-effect) between facts, terms, properties, or variables b. Describe and explain examples and non-examples of science concepts c. Select a procedure according to specified criteria (question to answer) and perform it d. Formulate a routine problem given data and conditions e. Organize, represent, and compare data f. Make a decision as to how to approach the problem and explain it g. Classify, compare, organize, or estimate h. Compare data i. Make observations or predictions (based on observations) j. Interpret information (pattern, trend) from a simple graph k. Collect and display data l. Translate between tables, graphs, words and symbolic notation m. Retrieve information from a table, graph, or figure and use it solve a problem or make a prediction n. Summarize findings **NOTE: If the knowledge necessary to answer an item <u>does not</u> automatically provide the answer, then the item is at least a Level 2. Most actions imply more than one decision.**	a. Interpret information from a complex graph (such as determining features of the graph or aggregating data in the graph) b. Use reasoning, planning, and evidence c. Explain thinking (*beyond* a simple explanation or typical response) d. Justify a response with supporting evidence e. Identify research questions and design investigations for a scientific problem f. Use concepts to solve **non-routine** problems/more than one possible answer g. Develop a scientific model for a complex situation h. Draw conclusion from experimental or observational data, citing evidence/data as support i. Complete a multi-step problem that involves planning and reasoning j. Provide an explanation of a principle k. Justify a response when more than one answer is possible l. Cite evidence and develop a logical argument for concepts m. Conduct a designed investigation and use data to draw conclusions n. Research and explain a scientific concept o. Explain phenomena in terms of concepts	a. Select or devise approach among many alternatives to solve problem b. Based on provided data from a complex experiment that is novel to the student, deduct the fundamental relationship between several controlled variables. c. Conduct an investigation, from specifying a problem to designing and carrying out an experiment, to analyzing its data and forming conclusions d. Relate ideas *within* the domains of the content area or *among* content areas e. Develop generalizations of the results obtained and the strategies used and apply them to new problem situations or investigations **NOTE: Level 4 activities often require an extended period of time for carrying out multiple steps; however, time alone is not a distinguishing factor if skills and concepts are simply repetitive over time.**

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Depth-of-Knowledge as a "Ceiling" NOT as a "Target"

An important consideration of large-scale assessment design is to use the highest Depth-of-Knowledge (DOK) demand implicit in an assessment limit as the "ceiling" for assessment, not the "target." Table 2 provides three examples of *possible* assessment limits with different "ceilings," that is, the highest DOK Level at which it should be assessed. When considering the highest DOK Level as the ceiling not the target, it has the potential to be assessed at Depth-of-Knowledge Levels at the ceiling, and up to the ceiling, depending upon the cognitive demand of the assessment limit. Table 2 also indicates the other DOK levels at which the assessment limit could be assessed.

Table 2 Examples of content indicators and DOK for Assessment Purposes

Sample Science Assessment "Limit"	Ceiling	Potential DOK Levels for Assessment
Example A: Perform a simple science process or a set procedure to gather data	**1**	**1** (Measure temperature of water)
Example B: organize and represent data collected over a period time, making comparisons and interpretations	**2**	**1** (Measure temperature of water at different times or places) **2** (Construct a graph to organize, display, and compare data)
Example C: Answer research questions for a scientific problem related to the environment. Interpret and use data collected to draw and support conclusions.	**3**	**1** (Measure temperature of water at different times or places) **2** (Construct a graph to organize, display, and compare data) **3** (Conduct an investigation to explain the effect of varying temperatures of the river in different locations)

Why is this distinction between "ceiling" and "target" important?

If assessed only as the "target," level, all assessment limits with a Level 2 or Level 3 as their highest demand would only be assessed at those highest levels. This would potentially have two negative impacts on the assessment: 1) The assessment as a whole could be too difficult; and 2) important information about student learning along the achievement continuum would be lost. Multiple items covering a range of DOK levels can provide useful instructional information for classroom teachers.

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