Depth-of-Knowledge (DOK) Levels for Mathematics

According to Norman L. Webb, Wisconsin Center for Educational Research ("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." Norman Webb's "Depth-of-Knowledge Levels for Four Content Areas" include: Language Arts (Reading, Writing), Mathematics, Science, and Social Studies.

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. Webb recommends that large-scale, on-demand assessments in mathematics should only assess Depth of Knowledge Levels 1, 2, and 3. Depth of Knowledge at Level 4 in mathematics should be reserved for local assessment.

Level 1 (Recall) includes the recall of information such as fact, definition, term, or a simple procedure, as well as performing a simple algorithm or applying a formula. That is, in mathematics a one-step, well-defined, and straight algorithmic procedure should be included at this lowest level. Other key words that signify a Level 1 include "identify," "recall," "recognize," "use," and "measure." Verbs such as "describe" and "explain" could be classified at different levels depending on what is to be described and explained.

Level 2 (Skill/Concept) includes the engagement of some mental processing beyond a habitual response. A Level 2 assessment item requires students to make some decisions as to how to approach the problem or activity, whereas Level 1 requires students to demonstrate a rote response, perform a well-known algorithm, follow a set procedure (like a recipe), or perform a clearly defined series of steps. 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. Some action verbs, such as "explain," "describe," or "interpret" could be classified at different levels depending on the object of the action. For example, if an item required students to explain how light affects mass by indicating there is a relationship between light and heat, this is considered a Level 2. Interpreting information from a simple graph, requiring reading information from the graph, also is a Level 2. Interpreting information from a complex graph that requires some decisions on what features of the graph need to be considered and how information from the graph can be aggregated is a Level 3. Caution is warranted in interpreting Level 2 as only skills because some reviewers will interpret skills very narrowly, as primarily numerical skills, and such interpretation excludes from this level other skills such as visualization skills and probability skills, which may be more complex simply because they are less common. Other Level 2 activities include explaining the purpose and use of experimental procedures; carrying out experimental procedures; making observations and collecting data; classifying, organizing, and comparing data; and organizing and displaying data in tables, graphs, and charts.

Level 3 (Strategic Thinking) requires reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. In most instances, requiring students to explain their thinking is a Level 3. Activities that require students to make conjectures are also at this level. The cognitive demands at Level 3 are complex and abstract. The complexity does not result from the fact that there are multiple answers, a possibility for both Levels 1 and 2, but because the task requires more demanding reasoning. An activity, however, that has more than one possible answer and requires students to justify the response they give would most likely be a Level 3. 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 problems.

Level 4 (Extended Thinking) requires complex reasoning, planning, developing, and thinking most likely over an extended period of time. 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. However, if the student is to conduct a river study that requires taking into consideration a number of variables, this would be a Level 4. At Level 4, the cognitive demands of the task should be high and the work should be very complex. Students should be required to make several connections-relate ideas *within* the content area or *among* content areas-and have to select one approach among many alternatives on how the situation should be solved, in order to be at this highest level. Level 4 activities include designing and conducting experiments; making connections between a finding and related concepts and phenomena; combining and synthesizing ideas into new concepts; and critiquing experimental designs.

Table 1: Math Descriptors - Combined Webb Depth of Knowledge Levels for Mathematics (Webb, 2002), NAEP 2002 Mathematics Levels of Complexity, and Other Descriptors Related to NECAP GLEs.

(M. Petit, Center for Assessment 2003, K. Hess, Center for Assessment, updated 2005)

Level 1 Recall	Level 2 Skills/Concepts	Level 3 Strategic Thinking	Level 4 Extended Thinking
Examples represent, but do not constitute all Level 1 mathematics performances: • Recall or recognize a fact, definitions, or term • Apply a well known algorithm • Apply a formula • Determine the area or perimeter of rectangles or triangles given a drawing and labels • Identify a plane or three dimensional figure	Examples represent, but do not constitute all Level 2 mathematics performances: • Classify plane and three dimensional figures • Interpret information from a simple graph • Use models to represent mathematical concepts • Solve a **routine** problem requiring multiple steps, or the application of multiple concepts • Compare figures or	Examples represent, but do not constitute all Level 3 mathematics performances: • Interpret information from a complex graph • Explain thinking when more than one response is possible • Make and/or justify conjectures • Develop logical arguments for a concept • Use concepts to solve problems • Perform procedure with	Examples represent, but do not constitute all Level 4 mathematics performances: • Relate mathematical concepts to other content areas • Relate mathematical concepts to real-world applications in new situations • Apply a mathematical model to illuminate a problem, situation • Conduct a project that specifies a problem, identifies solution paths,

• Measure a length • Perform a specified or routine procedure • Evaluate an expression • Solve a one-step word problem • Retrieve information from a table or graph • Recall, identify, or make conversions between and among representations or numbers (fractions, decimals, and percents), or within and between customary and metric measures • Locate numbers on a number line, or points on a coordinate grid • Solves linear equations • Represent math relationships in words, pictures, or symbols	statements • Compare and contrast figures • Provide justifications for steps in a solution process • Extend a pattern • Retrieve information from a table, graph, or figure and use it solve a problem requiring multiple steps • Translate between tables, graphs, words and symbolic notation • Select a procedure according to criteria and perform it	multiple steps and multiple decision points • Generalize a pattern • Describe, compare, and contrast solution methods • Formulate a mathematical model for a complex situation • Provide mathematical justifications • Solve a multiple- step problem, supported with a mathematical explanation that justifies the answer • Formulate an original problem, given a situation	solves the problem, and reports results • Design a mathematical model to inform and solve a practical or abstract situation ***NOTE**: Level 4 requires applying one approach among many to solve problems. Involves complex restructuring of data, establishing and evaluating criteria to solve problems.*