Calculating Cognitive Depth[1]

For classroom teachers, the more important question is one of practice: How do we create rich environments where all students learn at a high level? One useful tool, Norman Webb's Depth of Knowledge Levels, can help teachers meet that challenge. Depth of Knowledge (DoK) categorizes tasks according to the complexity of thinking required to successfully complete them.

Level 1. Recall and Reproduction: Tasks at this level require recall of facts or rote application of simple procedures. The task does not require any cognitive effort beyond remembering the right response or formula. Copying, computing, defining, and recognizing are typical Level 1 tasks.

Level 2. Skills and Concepts: At this level, a student must make some decisions about his or her approach. Tasks with more than one mental step, such as comparing, organizing, summarizing, predicting, and estimating, are usually Level 2.

Level 3. Strategic Thinking: At this level of complexity, students must use planning and evidence, and thinking is more abstract. A task with multiple valid responses, where students must justify their choices, would be Level 3. Other examples include solving non-routine problems, designing an experiment, or analyzing characteristics of a genre.

Level 4. Extended Thinking: Level 4 tasks require the most complex cognitive effort. Students synthesize information from multiple sources, often over an extended period of time, or transfer knowledge from one domain to solve problems in another. Designing a survey and interpreting the results, analyzing multiple texts to extract themes, or writing an original myth in an ancient style would all be examples of Level 4.

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[1] Adapted from "Depth-of-Knowledge Levels for Four Content Areas" by Norman L. Webb, March 28, 2002

Mathematics Depth-of-Knowledge Levels

Level 1 (Recall) includes the recall of information such as a 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, 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, then grouping or ordering the objects. Some action verbs, such as "explain," "describe," or "interpret" can be classified at different levels depending on the object of the action. Interpreting information from a simple graph, requiring reading information from the graph, 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 will interpret skills very narrowly, as primarily numerical skills, and such interpretation excludes from this level other skills, such as probability skills, which may be more complex simply because they are less common. Other Level 2 activities include explaining the purpose and use of 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 connection 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.

Mathematics Leveled Knowledge Demands

Level 1	Level 2	Level 3	Level 4
- Conduct basic mathematical calculations or follow set procedures - Perform a simple algorithm or apply a formula - Identify/recognize examples of mathematical concepts - Perform a clearly defined series of steps	- Solve routine, multi-step problems - Organize, represent, interpret data in tables, graphs, charts - Formulate a routine problem given data and conditions - Decide how to approach a problem - Interpret information from a simple graph - Compare data - Calculate simple probability	- Apply a concept in another context to solve a problem - Interpret information from a complex graph - Develop a logical argument - Explain/justify one's thinking - Use concepts to solve non-routine problems	- Apply a mathematical model to illuminate a problem or situation - Design a mathematical model to inform and solve a practical or abstract situation - Make several connections among ideas and selecting one approach to solve a problem

Reading Depth-of-Knowledge Levels

Level 1 requires students to receive or recite facts or to use simple skills or abilities. Oral reading that does not include analysis of the text as well as basic comprehension of a text is included. Items require only a shallow understanding of text presented and often consist of verbatim recall from text or simple understanding of a single word or phrase. Some examples that represent but do not constitute all of Level 1 performance are

- Support ideas by reference to details in the text.
- Use a dictionary to find the meaning of words.
- Identify figurative language in a reading passage.

Level 2 includes the engagement of some mental processing beyond recalling or reproducing a response; it requires both comprehension and subsequent processing of text or portions of text. Inter-sentence analysis of inference is required. Some important concepts are covered but not in a complex way. Standards and items at this level may include words such as summarize, interpret, infer, classify, organize, collect, display, compare, and determine whether fact or opinion. Literal main ideas are stressed. A Level 2 assessment item may require students to apply some of the skills and concepts that are covered in Level 1. Some examples that represent but do not constitute all of Level 2 performance are

- Use context clues to identify the meaning of unfamiliar words.
- Predict a logical outcome based on information in a reading selection.
- Identify and summarize the major events in a narrative.

Level 3 Deep knowledge becomes more of a focus at Level 3. Students are encouraged to go beyond the text; however, they are still required to show understanding of the ideas in the text. Students may be encouraged to explain, generalize, or connect ideas. Standards and items at Level 3 involve reasoning and planning. Students must be able to support their thinking. Items may involve abstract theme identification, inference across an entire passage, or students' application of prior knowledge. Items may also involve more superficial connections between texts. Some examples that represent but do not constitute all of Level 3 performance are

- Determine the author's purpose and describe how it affects the interpretation of a reading selection.
- Summarize information from multiple sources to address a specific topic.
- Analyze and describe the characteristics of various types of literature.

Level 4 Higher order thinking is central and knowledge is deep at Level 4. The standard or assessment item at this level will probably be an extended activity, with extended time provided. 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. Students take information from at least one passage and are asked to apply this information to a new task. They may also be asked to develop hypotheses and perform complex analyses of the connections among texts. Some examples that represent but do not constitute all of Level 4 performance are

- Analyze and synthesize information from multiple sources.
- Examine and explain alternative perspectives across a variety of sources.
- Describe and illustrate how common themes are found across texts from different cultures.

Writing Depth-of-Knowledge Levels

Level 1 requires the student to write or recite simple facts. This writing or recitation does not include complex synthesis or analysis but basic ideas. The students are engaged in listing ideas or words as in a brainstorming activity prior to written composition, are engaged in a simple spelling or vocabulary assessment or are asked to write simple sentences. Students are expected to write and speak using Standard English conventions. This includes using appropriate grammar, punctuation, capitalization and spelling. Some examples that represent but do not constitute all of Level 1 performance are

- Use punctuation marks correctly.
- Identify Standard English grammatical structures and refer to resources for correction.

Level 2 requires some mental processing. At this level students are engaged in first draft writing or brief extemporaneous speaking for a limited number of purposes and audiences. Students are beginning to connect ideas using a simple organizational structure. For example, students may be engaged in note-taking, outlining or simple summaries. Text may be limited to one paragraph. Students demonstrate a basic understanding and appropriate use of such reference materials as a dictionary, thesaurus, or web site. Some examples that represent but do not constitute all of Level 2 performance are

- Construct compound sentences.
- Use simple organizational strategies to structure written work.
- Write summaries that contain the main idea of the reading selection and pertinent details.

Level 3 requires some higher level mental processing. Students are engaged in developing compositions that include multiple paragraphs. These compositions may include complex sentence structure and may demonstrate some synthesis and analysis. Students show awareness of their audience and purpose through focus, organization and the use of appropriate compositional elements. The use of appropriate compositional elements includes such things as addressing chronological order in a narrative or including supporting facts and details in an informational report. At this stage students are engaged in editing and revising to improve the quality of the composition. Some examples that represent but do not constitute all of Level 3 performance are

- Support ideas with details and examples.
- Use voice appropriate to the purpose and audience.
- Edit writing to produce a logical progression of ideas.

Level 4 Higher-level thinking is central to Level 4. The standard at this level is a multi-paragraph composition that demonstrates synthesis and analysis of complex ideas or themes. There is evidence of a deep awareness of purpose and audience. For example, informational papers include hypotheses and supporting evidence. Students are expected to create compositions that demonstrate a distinct voice and that stimulate the reader or listener to consider new perspectives on the addressed ideas and themes. An example that represents but does not constitute all of Level 4 performance is •

- Write an analysis of two selections, identifying the common theme and generating a purpose that is appropriate for both.

English Language Arts Leveled Knowledge Demands

Level 1	Level 2	Level 3	Level 4
• Demonstrate a shallow understanding of text presented • Demonstrate simple understanding of a single word or phrase • Support ideas by reference to details in the text • Identify figurative language in a reading passage • Recall elements and details of story structure, such as sequence of events, character, plot, setting • Describe the features of a place or people • Use appropriate punctuation, grammar, capitalization, spelling • Generate simple sentences, list, brainstorm	• Demonstrate comprehension and subsequent processing of text • Identify literal main ideas • Use context clues to identify the meaning of unfamiliar words • Identify and summarize the major events in a narrative • Predict logical outcomes based on information in a reading selection • Describe the cause/effect of a particular event • Identify patterns • Write first-drafts, take notes, outline, summarize • Generate compound sentences • Execute simple organizational strategies to structure written work	• Explain, generalize, or connect ideas • Identify abstract themes • Infer across an entire passage • Determine the author's purpose and describe how it affects the interpretation of a reading selection • Summarize information from multiple sources to address a topic • Analyze and describe the characteristics of various types of literature • Support complex ideas with details and examples • Generate multi-paragraph compositions • Craft complex sentence structures • Produce written synthesis or analysis • Organize logical progression of ideas • Provide written facts, details, and examples	• Describe and illustrate how common themes are found across different texts • Analyze and synthesize information from multiple sources • Examine and explain alternative perspectives across a variety of sources • Generate multi-paragraph composition • Produce written synthesis or analysis of complex themes and ideas from multiple texts • Display an evident awareness of purpose and audience • Utilize a distinct, engaging voice