

Support Materials for Core Content for Assessment

Version 4.1

Science

August 2007
Kentucky Department of Education

Introduction to Depth of Knowledge (DOK) - Based on Norman Webb’s Model (Karin Hess, Center for Assessment/NCIEA, 2005)

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 Depth of Knowledge (DOK) levels were developed by Norman Webb as an alignment method to examine the consistency between the cognitive demands of standards and the cognitive demands of assessments.

Descriptors of DOK Levels for Science (based on Webb, March 2002)

Recall and Reproduction – Depth of Knowledge (DOK) 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.

Skills and Concepts/Basic Reasoning – Depth of Knowledge (DOK) Level 2

Skills and Concepts/Basic Reasoning 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.

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.

Strategic Thinking/Complex Reasoning – Depth of Knowledge (DOK) Level 3

Strategic Thinking/Complex Reasoning 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.

Extended Thinking/Reasoning – Depth of Knowledge (DOK) Level 4

Extended Thinking/Reasoning 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 Depth of Knowledge Levels in Science, based on Webb

(Adapted from Karin Hess, Center for Assessment/NCIEA by the Kentucky Department of Education, 2005)

| Recall & Reproduction (DOK 1) | Skills & Concepts/Basic Reasoning (DOK 2) | Strategic Thinking/ Complex Reasoning (DOK 3) | Extended Thinking/Reasoning (DOK 4) |
|---|---|--|---|
| <ul style="list-style-type: none"> a. Recall or recognize a fact, term, definition, simple procedure (such as one step), or property b. Demonstrate a rote response c. Use a well-known formula 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 | <ul style="list-style-type: none"> a. Specify and explain the relationship 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 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 | <ul style="list-style-type: none"> 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 using only a word or two to respond) d. Justify a response e. Identify research questions and design investigations for a scientific problem f. Use concepts to solve non-routine | <ul style="list-style-type: none"> 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 |

Table 1: Examples for each of the Depth of Knowledge Levels in Science, based on Webb

| | | | |
|---|--|---|--|
| <p>process or a set procedure (like a recipe)</p> <p>h. Perform a clearly defined set of steps</p> <p>i. Identify, calculate, or measure</p> <p><i>NOTE: If the knowledge necessary to answer an item automatically provides the answer, it is a Level 1.</i></p> | <p>g. Classify, organize, or estimate</p> <p>h. Compare data</p> <p>i. Make observations</p> <p>j. Interpret, information from a simple graph</p> <p>k. Collect and display data</p> <p><i>NOTE: If the knowledge necessary to answer an item does not automatically provide the answer, then the item is at least a Level 2. Most actions imply more than one step.</i></p> | <p>problems/more than one possible answer</p> <p>g. Develop a scientific model for a complex situation</p> <p>h. Form conclusions from experimental or observational data</p> <p>i. Complete a multi-step problem that involves planning and reasoning</p> <p>j. Provide an explanation of a principle</p> <p>k. Justify a response when more than one answer is possible</p> <p>l. Cite evidence and develop a logical argument for concepts</p> <p>m. Conduct a designed investigation</p> <p>n. Research and explain a scientific concept</p> <p>o. Explain phenomena in terms of concepts</p> | <p>d. Relate ideas <i>within</i> the content area or <i>among</i> content areas</p> <p>e. Develop generalizations of the results obtained and the strategies used and apply them to new problem situations</p> <p><i>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.</i></p> |
|---|--|---|--|

Depth of Knowledge as a “Ceiling”

Core Content statements are identified with a Depth of Knowledge (DOK) levels. This level represents the highest level (ceiling) that items will be designed for the Kentucky Core Content Test.

It is important to note, however, that items will also be developed below the ceiling level. Table 2 provides three examples of social studies core content statements with different “ceilings,” that is, the highest DOK Level at which an item could be assessed. Table 2 also indicates the other DOK levels at which an item could be assessed.

Table 2: Examples of Science Assessment Standards and Potential Assessment Items

| Sample Science Assessment Standard | 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: Represent data collected over a period time, making comparisons and interpretations | 2 | 1 (Measure temperature of water at different times/places) 2 (Construct a graph to organize, display, and compare data) |
| Example C: Interpret data collected for a research question for a scientific problem related to your environment | 3 | 1 (Measure temperature of water at different times/places) 2 (Construct a graph to organize, display, and compare data) 3 (Design an investigation to explain the affect of varying temperatures of the river in different locations) |

Table 3: Examples of Science Core Content Statements and Potential Assessment Items at all levels of DOK.

| <p>SC-07-1.1.1 Students will:</p> <ul style="list-style-type: none"> • classify substances according to their chemical/reactive properties; • infer real life applications for substances based on chemical/reactive properties. <p>In chemical reactions, the total mass is conserved. Substances are often classified into groups if they react in similar ways. The patterns which allow classification can be used to infer or understand real life applications for those substances.</p> <p style="text-align: right;">DOK 3</p> | | | |
|---|--|---|--|
| Recall and Reproduction | Skills & Concepts/Basic Reasoning | Strategic Thinking/Complex Reasoning | Extended Thinking/Reasoning |
| Describe the characteristics of an acid or base. | Create a chart classifying several different substances into established categories. | Create a chart listing practical applications of different substances and explain why those substances would be appropriate for the applications you suggest. | Conduct an investigation of different chemicals to determine which would be the best choice for a specific application, then test the results, analyze the data and form a conclusion. |
| <p>SC-HS-4.6.8 Students will</p> <ul style="list-style-type: none"> • describe the connections between the functioning of the Earth system and its sources of energy (internal and external). • predict the consequences of changes to any component of the Earth system. <p>Earth systems have sources of energy that are internal and external to the Earth. The Sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from Earth's original formation. DOK 3</p> | | | |

Table 3: Examples of Science Core Content Statements and Potential Assessment Items at all levels of DOK.

| Recall & Reproduction | Skills & Concepts/Basic Reasoning | Strategic Thinking/Complex Reasoning | Extended Thinking/Reasoning |
|---|---|---|--|
| <p>Recite basic facts about Earth's energy sources.</p> <p>Recall definition of radioactive decay and gravitational energy.</p> <p>Do computations relating to half-life.</p> <p>Write a song or poem about Earth's energy sources.</p> | <p>Make observations.</p> <p>Collect and record data.</p> <p>Organize and display data in charts/tables.</p> <p>Explain the energy relationship between the Sun and the Earth Systems.</p> <p>Explain radioactive decay.</p> <p>Explain the role of gravity in Earth's formation.</p> | <p>Generate a research question and design an investigation.</p> <p>Test effects of different variables.</p> <p>Student presentation of information (explain internal and external sources of energy).</p> <p>Defend a position (e.g., nuclear energy use, national energy policy).</p> | <p>Design and conduct an experiment.</p> <p>Student presentation of information (relate effect of human activity on availability of energy).</p> <p>Apply and adapt information to real world situations (e.g., C14 dating).</p> <p>Apply ideas outside of science context (e.g., economic impact of hybrid vehicles).</p> <p>Synthesize content from several resources (e.g., to make decisions regarding alternative power/fuel sources).</p> <p>Integrate concepts for a global understanding of energy (e.g., economics, environment, politics).</p> |

Depth of Knowledge is not verb dependent. It is based on the cognitive complexity of the standard.

Table 4: Same Verb used at 4 Depth of Knowledge Levels

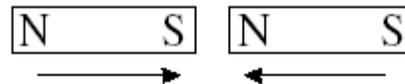
| VERB | LEVEL 1 | LEVEL 2 | LEVEL 3 | LEVEL 4 |
|-----------------|--|--|---|---|
| List | List three properties that can be used to classify objects. | List three groups that a wooden object could be classified as belonging in. | List three unique objects and the physical properties that would prevent each of the objects from sharing a category with any of the others. | List the design steps (including the controlled variables) you would take to investigate the best material for a specific purpose. Provide evidence from your investigation to support your conclusions. |
| Describe | Describe characteristics of metamorphic rocks. | Describe the difference between metamorphic and igneous rocks. | Describe a model that you might use to represent the relationships that exist within the rock cycle. | Describe the approach you would take to ensure that the rock samples you collect are truly representative of the geologic diversity of Kentucky. |

Sample 2004 KCCT Science Released Items

GRADE 4

1. Which is MOST likely to make a rock break open?
- dew evaporating on the rock
 - tree leaves decaying on the rock
 - snow melting in a crack in the rock
 - water freezing in a crack in the rock
-

Use the illustration below to answer question 3.



3. Look at the two magnets above. If you push the two magnets toward each other as shown, the magnets will
- break into many pieces.
 - turn in opposite directions.
 - be pushed away from each other.
 - be pulled toward each other.

Paper Cup Telephone

4. Beth has made a telephone using two paper cups and a string. When she talks into one paper cup, her friend Joe can clearly hear her words through the other paper cup.



- a. Explain how the paper cup telephone works.
b. Name TWO other examples in which sound can travel through solids.

Meat-Eaters

6. Many meat-eaters catch and eat other animals. Meat-eaters have different skills and physical features to help them do this.
- a. Name ONE meat-eater, other than a human, that catches and kills its prey.
b. Describe THREE skills and physical features the meat-eater you chose uses.

GRADE 7

2. An earthquake occurs when the tectonic plates below Earth's surface suddenly shift. These shifts of the tectonic plates are caused by
- movements in Earth's core.
 - movements in Earth's mantle.
 - deposition of sediments.
 - eruption of volcanoes.

-
3. We get energy from the food we eat. The energy in the food first comes from the
- soil.
 - fertilizers used by farmers.
 - sun.
 - vitamins added by food manufacturers.
-

Changes in Landforms

5. Scientists have evidence that the landforms we see on Earth, such as mountains, islands, and canyons, as well as the shapes of continents, are the result of constructive and destructive forces at work over a long period of time. Describe in detail **two** pieces of evidence that show that landforms on Earth are constantly changing. Provide a specific example for each piece of evidence.
-

Extinction

6. A species may become extinct if environmental changes occur and the species does not adapt quickly enough to the changes.
- a. Identify an environmental change that might cause a species to become extinct **and** identify a species that would likely be affected by such a change.
 - b. Describe how extinction of one species can affect other organisms in the ecosystem.

GRADE 11

1. Acids such as HCl (hydrochloric acid) and H₂SO₄ (sulfuric acid) dissociate (separate into ions in water) completely in solution. The ion that acids have in common and that accounts for their properties is
- H⁺.
 - SO₄⁻².
 - Cl⁻.
 - H₂O.
-
2. Evidence suggests that 3.5 billion years ago the atmosphere of Earth had almost no oxygen gas. Approximately 1.8 billion years ago, the oxygen concentration is thought to have increased to 15%. Today the oxygen concentration is 20%. What most likely happened between 3.5 and 1.8 billion years ago to increase the amount of oxygen?
- The number of photosynthetic plant species increased.
 - The number of animal species increased.
 - The amount of water on Earth increased.
 - The amount of solar radiation reaching Earth increased.
-

Mid-Ocean Ridges

5. The theory of plate tectonics explains how mid-ocean ridges are formed.
- a. Draw and label a diagram that shows **how** a mid-ocean ridge forms.
 - b. Describe **two** possible consequences that the formation of mid-ocean ridges has on other locations on Earth.
-

Chemical Reactions and Carbon Dioxide (CO₂) Gas

6. Different kinds of chemical reactions result in the formation of carbon dioxide (CO₂) gas that is released into the atmosphere. These chemical reactions may take place within living organisms or nonliving sources.
 - a. Identify a chemical reaction that takes place within living organisms that releases CO₂ into the atmosphere.
 - b. Identify a chemical reaction that takes place within nonliving sources that releases CO₂ into the atmosphere.

CO₂ is constantly being added to and removed from the atmosphere. Extra CO₂ in the atmosphere may contribute to global warming.

- c. Explain why the chemical reactions you described in **part a** and **part b** may now be adding more or less CO₂ to the atmosphere when compared to the past.

Annotations of KCCT 2004 Science Released Items**Coding: Content Area-Grade-Item #-DOK Level-CCA v.4 Code-annotation**

Science-4-1-DOK 1-SC-P-1.1.3 - This item requires that students recall a basic property of water—that water expands when it freezes. **(Big Idea: Structure and Transformation of Matter)**

Science-4-3-DOK 2-SC-P-1.2.1-This item requires that students interpret a simple diagram and apply a property of magnets—that opposite poles attract. **(Big Idea: Motion and Forces)**

Science-4-4-DOK 2-SC-P-1.2.5- While part B of this item is a level 1 (basic recall/identification of examples), part A requires students to produce a simple description of the concept of sound—vibrations are produced in the vocal cords and those vibrations are transferred to the cup and string, where they are transferred from one end to the other. **(Big Idea: Motion and Forces)**

Science-4-6-DOK 2-SC-04-3.4.1 – This item requires that students understand the relationship between skills or physical features and the function of those skills or features that enable the meat-eater to obtain food. **(Big Idea: Unity and Diversity)**

Science-7-2-DOK 1-SC-07-2.3.2--This requires recall of why movements occur in the Earth's plates. **(Big Idea: The Earth and the Universe)**

Science-7-3-DOK 1-SC-07-4.6.1–This item requires recall of the energy transfer in a common food chain. It is considered foundational knowledge for a 7th grade student. **(Big Idea: Energy Transformations)**

Science-7-5-DOK 3-SC-07-2.3.1 -This item requires students to produce evidence via explanations about continuous constructive and destructive forces that produce changes to the Earth. The examples given in the item stem represent continuous change, and not merely discreet events. **(Big Idea: The Earth and the Universe)**

Science-7-6-DOK 3-SC-07-3.5.1 - This item requires students to apply the concept of cause & effect to an environmental change that may result in a particular species' extinction. The student must produce a justification for their response. **(Big Idea: Biological Change)**

Science-11-1-DOK 1-SC-HS-1.1.5 - This is recall of a basic chemistry concept. **(Big Idea: Structure and Transformation of Matter)**

Science-11-2-DOK 2-SC-HS-4.6.1 - This question goes beyond simple recall. Students make the connection that a greater plant population (implied) will result in an increase in oxygen production. **(Big Idea: Energy Transformations)**

Science-11-5-DOK 2-SC-HS-2.3.10 -This item requires that students graphically represent a scientific phenomena (formation of mid ocean ridges) and to describe a cause/effect relationship resulting from the phenomena. **(Big Idea: Energy Transformations)**

Science-11-6-DOK 2-SC-HS-4.6.4 -While parts A and B require basic recall; Part C demands that the students describe a relationship between the components of the system. **(Big Idea: Energy Transformations)**

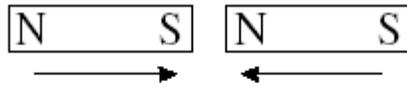
**Sample 2004 KCCT Science Released Items
(with DOK annotations)**

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Science-4-1-DOK 1-SC-P-1.1.3 - This item requires that students recall a basic property of water—that water expands when it freezes. **(Big Idea: Structure and Transformation of Matter)**

Use the illustration below to answer question 3.



3. Look at the two magnets above. If you push the two magnets toward each other as shown, the magnets will
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Science-4-3-DOK 2-SC-P-1.2.1—This item requires that students interpret a simple diagram and apply a property of magnets—that opposite poles attract. **(Big Idea: Motion and Forces)**

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Science-4-4-DOK 2-SC-P-1.2.5- While part B of this item is a level 1 (basic recall/identification of examples), part A requires students to produce a simple description of the concept of sound—vibrations are produced in the vocal cords and those vibrations are transferred to the cup and string, where they are transferred from one end to the other. **(Big Idea: Motion and Forces)**

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 - movements in Earth's mantle.
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 - eruption of volcanoes.

Science-7-2-DOK 1-SC-07-2.3.2--This requires recall of why movements occur in the Earth's plates. **(Big Idea: The Earth and the Universe)**

-
3. We get energy from the food we eat. The energy in the food first comes from the
- soil.
 - fertilizers used by farmers.
 - sun.
 - vitamins added by food manufacturers.

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Science-7-5-DOK 3-SC-07-2.3.1 -This item requires students to produce evidence via explanations about continuous constructive and destructive forces that produce changes to the Earth. The examples given in the item stem represent continuous change, and not merely discreet events. **(Big Idea: The Earth and the Universe)**

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Science-7-6-DOK 3-SC-07-3.5.1 - This item requires students to apply the concept of cause & effect to an environmental change that may result in a particular species' extinction. The student must produce a justification for their response. **(Big Idea: Biological Change)**

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 - SO_4^{-2} .
 - Cl^- .
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Science-11-1-DOK 1-SC-HS-1.1.5 - This is recall of a basic chemistry concept. **(Big Idea: Structure and Transformation of Matter)**

2. Evidence suggests that 3.5 billion years ago the atmosphere of Earth had almost no oxygen gas. Approximately 1.8 billion years ago, the oxygen concentration is thought to have increased to 15%. Today the oxygen concentration is 20%. What most likely happened between 3.5 and 1.8 billion years ago to increase the amount of oxygen?
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Science-11-2-DOK 2-SC-HS-4.6.1 - This question goes beyond simple recall. Students make the connection that a greater plant population (implied) will result in an increase in oxygen production. **(Big Idea: Energy Transformations)**

Mid-Ocean Ridges

5. The theory of plate tectonics explains how mid-ocean ridges are formed.
- a. Draw and label a diagram that shows **how** a mid-ocean ridge forms.
 - b. Describe **two** possible consequences that the formation of mid-ocean ridges has on other locations on Earth.

Science-11-5-DOK 2-SC-HS-2.3.10 -This item requires that students graphically represent a scientific phenomena (formation of mid ocean ridges) and to describe a cause/effect relationship resulting from the phenomena. **(Big Idea: Energy Transformations)**

Chemical Reactions and Carbon Dioxide (CO₂) Gas

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CO₂ is constantly being added to and removed from the atmosphere. Extra CO₂ in the atmosphere may contribute to global warming.

 - c. Explain why the chemical reactions you described in **part a** and **part b** may now be adding more or less CO₂ to the atmosphere when compared to the past.

Science-11-6-DOK 2-SC-HS-4.6.4 -While parts A and B require basic recall; Part C demands that the students describe a relationship between the components of the system. **(Big Idea: Energy Transformations)**