Science: Categories of Engagement (DOK)

Like DOK, the following tool is intended to be used to differentiate between and among the different types of complexity of engagement required by learning expectations and tasks. The descriptions used for the four Categories are intended to reflect the types of expectations in current science standards, including, (but not exclusive to) the NGSS and other 3-D or Framework-influenced standards.

Note that these categories DO NOT represent a progression or sequence in terms of learning. Students may engage directly with a higher complexity task, and later incorporate tasks of lower complexity, that all together contribute to an overall learning goal.

This tool differentiates complexity of engagement from sophistication of thinking. All complexities of engagement are expected across grade bands, at grade-band appropriate sophistication of thinking. This is consistent with NGSS, which expects a variety of complex performance expectations across grades and expects “increasing sophistication of student thinking” as students move through the grade bands (Appendix E).

This document contains Draft language to describe the four Categories of Engagement as apply to science. Tables are included that detail the relationship between each Category and 3-D or Framework-influenced standards including NGSS.
Science - Category 1

Category 1 is defined by the recall of information, such as a discrete fact, definition, or term, as well as performance of a simple grade-level-appropriate science process or procedure. Category 1 tasks require students to provide a rote response, use a well-known formula, follow a set procedure (e.g. use a balance, read information from a Periodic Table, follow a protocol), or perform a clearly defined or scripted series of steps. Finding a particular point on a graph or otherwise directly reading data from graphs, charts, or maps is considered Category 1 work. Simple word problems that can be directly translated into and solved by a formula are considered Category 1. In the context of multidimensional science standards, Category 1 tasks are, by definition, unidimensional—for example, requiring recall of a particular disciplinary core idea or “fact.” Category 1 expectations and tasks do not require students to engage in sense-making, do not require transfer of ideas, and do not require knowledge-in-use. It is important to note that any assessment of student proficiency as relates to the Next Generation Science Standards (NGSS) or other Framework-based standards should not include Category 1 items. An explicit goal of Framework-based standards is to promote a shift away from assessing students on Category 1 types of tasks. Students may, however, engage in Category 1 tasks in the classroom in the context of broader work to make sense of a phenomenon. For example, students may need to use particular measurement tools, recall appropriate safety protocols, and learn new terms. Students may be expected to develop fluency with Category 1 expectations.

Some examples that represent, but do not constitute all of, Category 1 performance are:

- Recall or recognize a fact, term, relationship, structure, or property.
- Reproduce in words or diagrams a typical or routinely used representation or model of a scientific concept or relationship.
- Provide or recognize a standard scientific representation for common phenomena.
- Perform a grade level-appropriate routine procedure, such as measuring length or completing a basic Punnett square.
Category 2 tasks require knowledge-in-use rather than in isolation of purpose or context. At Category 2, tasks require application of underlying grade-level-appropriate conceptual understanding and therefore engagement in mental processing beyond recalling or reproducing a response. Tasks require students to make some decisions about how to approach a question or problem, including requiring transfer between and among ideas and concepts. At Category 2, transfer would occur between and among parallel or related concepts. Category 2 tasks include aspects of making sense of a phenomenon that involve fairly straightforward or routine relationships or interactions between and among concepts. In these contexts, students must use science and engineering practices to demonstrate knowledge of core ideas. Making original comparisons, using one’s own background knowledge to draw connections between and among science concepts, and conceptualizing scientific relationships in words, graphics, visuals, and other common representations are activities that are typically a Category 2. Tasks that require purposeful organizing, displaying, and interpreting of data in tables, graphs, and charts are also considered Category 2. Students may represent ideas mathematically or use routine mathematical and statistical concepts and processes to represent relationships between variables. At Category 2, reasoning with evidence is done in the context of tasks such as explaining relationships in terms of observations or science concepts. A task requiring a rationale equivalent to an explanation grounded in conceptual understanding would be Category 2. Some examples that represent, but do not constitute all of, Category 2 performance, are:

- Specify and explain in one’s own words the relationship between concepts, properties, or variables; observe, describe, and/or compare grade-appropriate patterns.
- Differentiate between and among ideas that are considered scientific fact, reasoned hypothesis, and speculation.
- Engage in sense-making related to the relationships between and among concepts in the context of a fairly routine phenomenon or problem, given data and conditions.
- Organize and represent data to show basic patterns or relationships relevant to making sense of a phenomenon.
- Interpret data to make sense of concrete relationships or to inform an explanation or design solution relevant to a phenomenon.
- Interpret or explain phenomena in terms of science concepts.
- Develop a fairly straightforward model that demonstrates underlying conceptual understanding and/or use a model that is a common representation of a phenomenon or concept to solve a problem, make sense of a relationship, etc.
- Apply conceptual understanding of disciplinary ideas to identify limitations of models.
- Make predictions for cause-and-effect relationships that are fairly straightforward but that require some consideration of the factors that influence outcomes.
Category 3

Category 3 expectations and tasks involve the use of science and engineering practice(s) and most likely engage crosscutting concepts to solve grade-appropriate, non-routine problems. Conceptual understanding of science ideas and concepts may be applied to hypothetical contexts or used to support design solutions, claims, and arguments. The cognitive demands at Category 3 are abstract and may involve innovative thinking. Category 3 tasks require grade-level-appropriate sophisticated reasoning, planning with consideration of purpose and constraints, and using robust evidence to make original arguments. The complexity does not result only from the fact that there could be multiple approaches and solutions to a problem, a possibility for both Category 1 and 2, but because the task requires more demanding, thorough, and abstract reasoning. Category 3 tasks are likely to prompt productive struggle as students may need to grapple with the context and information provided to figure out how to even begin to approach making sense of a phenomenon or problem. Tasks that require students to provide a rationale for their thinking or engage in scientific argumentation that involves heavy reasoning grounded in appropriate evidence are Category 3. An authentic science or engineering problem that has more than one possible solution and requires students to justify the response with appropriate evidence would most likely be a Category 3. Work may require transfer of ideas across diverse concepts, contexts, and disciplines. Some examples that represent, but do not constitute all of Category 3 performance, are:

- Identify appropriate research questions and design brief investigations to help make sense of a phenomenon or science/engineering problem.
- Engage in abstract sense-making related to a complex and novel (to the student) phenomenon or problem, given data and conditions, to develop hypotheses, logical conclusions, or original scientific arguments grounded in evidence.
- Develop and/or use a novel (to the student) model to describe a complex, non-routine phenomenon or concept.
- Conduct critical analyses of models, requiring the synthesis of disciplinary ideas.
- Form robust and defensible conclusions about non-routine problems or phenomena based on experimental data.
- Evaluate the bias, credibility, or accuracy of a scientific claim expressed in a text.
- Critically analyze causes for different conclusions based on scientific investigations of or reports about the same phenomenon.
- Evaluate alternative design solutions to an engineering problem.
- Propose revisions for aspects of experimental design grounded in evaluative review.
- Define authentic constraints and incorporate considerations for these constraints into problem-solving work.
- Analyze data to inform revisions to a proposed process or system.
- Develop a novel mathematical or computational simulation of a phenomenon.
Category 4

Category 4 demands are at least as complex as those of Category 3, but a main factor that distinguishes the two categories is the need to perform activities over days and weeks (Category 4) rather than in one sitting (Category 3). The extended time that accompanies this type of activity allows for more extensive planning, consideration of potentially intricate contingencies (dependent and interacting pieces) within and across systems, and thinking about implications of choices across time. Category 4 science tasks parallel the types of iterative and non-linear engagement involved in authentic and extended science inquiry and engineering design processes. Category 4 tasks require sustained metacognitive awareness.

Note that an 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. Category 4 requires grade-level-appropriate complex reasoning, experimental design and planning, as well as an extended period of time for completion. For example, if a student is expected to take the water temperature from a river each day for a month and then construct a graph, this would be considered a Category 2 activity. However, if the student is engaged in all aspects of planning and carrying out an authentic scientific investigation or design solution then the task would be a Category 4. While many science standards expect students to engage at Category 4, on-demand assessment instruments are inappropriate tools for judging student proficiency as relates to Category 4 expectations; these tasks are most appropriate for classroom assessment. Some examples that represent, but do not constitute all of, a Category 4 performance are:

- Plan and carry out a scientific investigation that will yield appropriate data that could be used as evidence to answer scientific questions related to real-world problems.
- Plan, test, and revise a design solution for a real-world problem.
- Analyze the results of multiple studies on a particular science topic or design solution to form an original conclusion about the subject.
- Use trials of a scientific investigation or design solution to evaluate strengths and weaknesses of an experimental design and develop a revised and more optimized approach.
- Conduct broad-scope, systems-level analyses of novel problems.