SCIENCE

INTERPRETATION OF THE SHOW-ME STANDARDS FOR ASSESSMENT

Missouri Department of Elementary and Secondary Education
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This document serves as a guide to the interpretation of Missouri Assessment Program (MAP) data as they report alignment of assessments items with the Show-Me Standards in Performance. Although students are expected to demonstrate mastery of all performance skills, some of these skills cannot be appropriately assessed using a paper-pencil test. The school district should provide all students with appropriate learning experiences that will facilitate student mastery of all process standards. It is also expected that a school district's curricula include appropriate assessments designed to measure each student's mastery of each performance standard.

The Show-Me Standards are built around the belief that the success of Missouri's students depends on both a solid foundation of content knowledge and performance skills and the ability of students to apply their knowledge and skills to the kinds of problems and decisions they will likely encounter after they graduate. MAP assessment items are coded according to the content expectations and performance standards being assessed. In other words, the content knowledge and cognitive process applied by and expected of the student are reflected by the prompt and scoring guide.

Each grade-span science MAP assessment is comprised of three parts:

- A norm-referenced assessment (the Terra Nova section) comprised of twenty-five (25) multiple-choice items, assessing any and all Grade-Level Expectations as appropriate.
- A criterion-referenced assessment comprised of constructed-response items, assessing any and all Grade-Level Expectations as appropriate.
- A criterion-reference assessment (the Performance-Event – or PE – section) comprised of constructed-response items, assessing Grade-Level Expectations in Strand 7: Scientific Inquiry only. Science Performance Event Templates for the 2007-2010 MAP assessment can be found online at: http://www.dese.mo.gov/divimprove/curriculum/science/sciPEdocs.html

These guidelines were used to code the performance standard being assessed by a Science MAP assessment item:

- The performance standard is independent of the content knowledge expected by the prompt. In other words, a specific content expectation cannot be assigned a particular performance standard. Any given performance standard might be appropriately applied within the context of any given content expectation.
    - For example, given Grade Level Expectation ES 2 F 7 e., "Collect and interpret weather data (e.g., cloud cover, precipitation, wind speed and direction) from weather instruments and maps to explain present day weather and to predict the next day's weather", items could be written to several process standards:
        - Examine today's weather map and identify the type of frontal system approaching Kansas City [Process Standard 1.5]

- Examine the weather data collected over the past week. The local weather station has predicted that the temperature tomorrow will be significantly higher because a warm front is coming in. Predict the likely barometric pressure for tomorrow and justify your prediction. [Process Standard 1.6]
- Identify the weather instrument shown in the picture and describe how it works. [Process Standard 1.10]
- Examine the weather map and table of weather data below. Based on your understanding of weather patterns, make a reasonable prediction for tomorrow's temperature, barometric pressure, sky cover, and wind direction. Justify your predictions. [Process Standard 3.5]

- Assessment items are also coded according to depth of knowledge (see addendum at end of document for full descriptions and examples):

  - *Level 1. Recall and Reproduction*
  - *Level 2. Skills and Concepts*
  - *Level 3. Strategic Thinking*
  - *Level 4. Extended Thinking*

  Both content and performance may be assessed at different depths of knowledge, depending on the cognitive demand of content and developmental level of students at different grade levels.

- Items are written and coded to performance standards based on the intended level of understanding and performance. The performance standard being assessed is frequently reflected by the verb used in the prompt. Verbs within the context of the prompt clarify what we wish students *to do* with the expected knowledge or skills. These verbs elicit responses which ideally provide insight into the depth of knowledge/level of understanding required of the student when demonstrating mastery of the item objectives**.** For example, "explain" can address multiple levels of DOK depending upon what must be explained (e.g., "explain" can mean elaborate or justify reasoning).

- In the case of an item with multiple prompts, each assessing a different performance standard, the item is coded to the performance standard reflecting a "higher" level of depth of knowledge and/or level of Bloom's taxonomy of cognitive domain. Example:

  Two science students are having a great time arguing about speed and acceleration as they ride a roller coaster. As they are roaring downhill, Student A screams, "Wow! What acceleration!" Student B shouts, "No, this is not acceleration. This is just going fast!" Who is correct? Explain your answer. [Process Standard 1.6]

As the ride progresses, the students go around a curve while maintaining a speed of 50 miles per hour. Student B screams, "Now this is acceleration!" But Student A replies, "NO, we're still going at the same speed. That's not acceleration." Who is correct? Explain your answer. [Process Standard 1.6]

As the car goes uphill again, it slows down. Identify three forces that cause this negative acceleration. [Process Standard 1.10]

This item would be coded as Process Standard 1.6 because that is the dominant process standard.

For purposes of coding Science MAP assessment items, the following guidelines will be used:

Goal 1: Students in Missouri public schools will acquire the knowledge and skills to gather, analyze, and apply information and ideas

Students will demonstrate within and integrate across all content areas the ability to:

1.1 develop questions and ideas to initiate and refine research

The ability to conduct research in all areas, academic or other, is important, but a prior skill is the ability to identify those things which elicit inquiry. Forming questions and theories about phenomena, whether it be in biology, health, fine arts, or literature, is the first step to really defining research and inquiry, narrowing its focus, and determining the most effective approach to conducting that inquiry. The ability to form precise questions, well formed and focused, is an essential skill for every learning activity.

This standard is most frequently addressed within the performance event (PE). It requires students to demonstrate knowledge and skills specifically related to GLE 7.1Aa: Scientific inquiry includes the ability of students to formulate a testable question and explanation.

When given a problem, students are asked to develop questions that, when answered, will provide evidence necessary to the proposing of a solution.

Items include those prompting students to:

- Write (or formulate) a testable question.
- Write (or formulate) a testable hypothesis.
- Write (or formulate) a statement of problem.

Some items outside the PE may address GLE 8.3A: "People, alone or in groups, are always making discoveries about nature and inventing new ways to solve problems and get work done." Items include those prompting students to identify a question that was asked, or could be asked, or a problem that needed to be solved when given a brief scenario describing people working alone or in groups to solve an everyday problem or learning through discovery.

Supplementary material about testable questions, hypotheses and statements of problems are provided in the document, Common Errors and Exemplary Responses, which is accessible on the DESE website, www.dese.mo.gov. This document includes the generic prompts, scoring guides, annotated student papers, and suggestions for instruction for elementary, middle and high school.

1.2: conduct research to answer questions and evaluate information and ideas

Every student must be able to define, organize and conduct research, in and outside the library/media center, based on important questions. Moreover, all students should he able to use research and inquiry to critically examine information and ideas with which they are confronted on a daily basis in school and within the media. Basing decisions and conclusions on good information and inquiry is a skill which will serve students within all educational pursuits, in daily living, and in the workplace.

This standard requires students to demonstrate understanding of scientific inquiry and abilities necessary to do scientific inquiry. If students are to develop and apply understanding of scientific inquiry, they must be given frequent opportunity to actively engage in classroom inquiry activities and assessments that require them to gather, analyze, and evaluate evidence.

Again, Goal 1 standards assume active involvement of the student. Therefore, because the PE is actually a performance-based assessment instead of a true performance assessment (i.e., students are provided data, instead of gathering evidence themselves), the student is unable to demonstrate ability to actively conduct research on a paper-pencil test like the MAP.

This standard is ***LOCALLY ASSESSED.***

1.3: design and conduct field and laboratory investigations to study nature and society

Every student should be able to engage in structured and disciplined scientific inquiry, including developing and refining hypotheses, designing a methodology, preparing the experimented procedure, conducting the experiment, observing and recording data, drawing and evaluating conclusions based on the results, and evaluating the experiment based on critical reflection. The discipline and experience of conducting such inquiry will serve- students in every walk of life.

This standard addresses items assessing knowledge of and ability to design scientific investigations. Again, this standard is most frequently addressed within the performance event (PE). These items ask the students to select appropriate investigative methods in order to obtain evidence relevant to the explanation. They also assess the student's abilities to conduct the investigation using information provided within the context of a written scenario in the PE portion of the MAP assessment. Refer to the Science Performance Event Templates for the 2007-2010 MAP assessment (found online at: http://www.dese.mo.gov/divimprove/curriculum/science/sciPEdocs.html) for suggested prompts related to this standard.

Items require students to demonstrate knowledge and skills related to:

- Order the steps in a simple investigation
- (High school) Describe at least three essential steps in the procedure needed to conduct a valid experiment. The procedure must be written so that students in another science class could clearly follow your instructions and successfully complete the investigation.
- Identify qualitative and quantitative observations to be made when collecting evidence (data)
- Identify appropriate tools, techniques, and units of measure to be used for collecting and measuring observable evidence (data)
- Identify the function of a tool (e.g., what information can be observed or measured and for what purpose)
- Identify the advantages or disadvantages of using different tools or technologies to gather information
- Use, read, and record observations (with metric units when appropriate) using the senses (i.e., sight), manipulatives provided with the test, or by reading diagrams of tools/equipments within prompt
- Explain the importance of the independent variable, dependent variables, control (constants), and multiple trials to the design of a valid experiment
- Identify the independent variable, dependent variable(s), and constants (or factors to be held constant) in an experiment
- Explain why it is not always possible to control some conditions (e.g., sampling or testing animals or humans)
- Identify limiting factors that may prohibit the testing of some scientific explanations using the standard experimental "scientific method"
- Calculate the range, average/mean, percent, and ratios for sets of data

Note: It is essential to realize that not all questions in the performance event are coded as 1.3

The purpose of the document is to provide information about the cognitive processes required of the student, not the context of the question. If the item requires students to evaluate a scientific investigation that has already been conducted, the process standard involved may be 1.7 [see more examples under that standard].

- Examine the data table from Jack's experiment. What should he do with the results of Trial 2 when he averages his data? Justify your reasoning.[1.7]
- Evaluate Sally's experimental design. Identify two things Sally could have done differently to make her results more valid. [1.7]

1.4: use technological tools and other resources to locate, select and organize information

Research of all sorts is becoming an increasingly technological activity. Computers, CD-ROMS, the Internet, complex laboratory equipment, computer models, and many more, have joined the ranks of books, periodicals, surveys and questionnaires, as well as other sorts of primary sources. Every student must be skilled in the myriad processes and tools available to facilitate in-depth inquiry into many subjects.

Again, the focus of this Goal is to assess student ability to actively demonstrate ability to use technological tools and other resources to locate, select, and organize information. Due to the limitations of a paper-pencil test, this standard is to be ***LOCALLY ASSESSED***.

1.5: comprehend and evaluate written, visual, and oral presentations and works

Closely related to several of the communication arts standards and Goal 2, this standard requires that students not only be able to find information and data in many forms, but also that they be skilled at understanding that information or those ideas. Finding information is of little use if one is unable to understand it. Moreover, students must be able to critically evaluate the information they read and the data they gather or with which they are confronted to ensure that it is credible, valid and reliable.

Oral presentations are not applicable.

This process standard is given to items in which a student uses a graph or table or illustration to answer a question. **The key to this Goal is to understand that all the information needed is <u>explicit</u> in/on the graphic or presentation**. The student will not have to manipulate the information—just read and comprehend it.

Some examples of items that use performance standard 1.5 are:

1. (Given a data table): Which student brought the greatest/least number of apples?
2. (Given a data table): At which two times were the recorded temperatures the same?
3. Use your graph to predict how far a car with mass of x grams would travel (when x is within the data points plotted).
4. (Given an illustration of a thermometer) Record the temperature measured by the thermometer.
5. Examine the electromagnetic spectrum below. Identify a wave with a higher frequency than that of visible light.
6. Examine the graph above. How many days of rain were there in the month of July?
7. Which animal on the chart has the fastest heart rate?
8. Use the classification key below to name an organism shown in the picture.
9. (Given a diagram of a food web) Identify the predator of the rabbit.

It is also essential to remember that not all items with graphics are coded as 1.5.

- If a student is asked to calculate the range of data from a graph or to find the average of numbers in a data table, the items would be coded to 1.3, because the intent of the item is to assess the students' mastery of science inquiry skills.

- When the item requires the student to extrapolate from a graph [for example, extend a pattern beyond the graph in order to make a prediction], the item would be coded as Process Standard 1.6 because the student is required to understand the pattern in the data [see examples provided in 1.6].

- If the item requires a student to articulate the pattern or relationship shown by the graphic, the item would be coded as Process Standard 1.6, again because the student is required to understand a pattern [see examples provided in 1.6].

- If a graphic is provided but is not essential to answering the question, the code would be whatever mental process is required of the student.

- If a graphic is provided but the student must bring additional information to the task in order to answer the question, the code would be whatever mental process is required of the student. One example would be a drawing of a battery, wires, and light bulbs in a circuit, followed by the question, "Which of these best describes this type of circuit?" This would be coded as a 1.10. The necessary information is not explicit in the graphic; the student must have knowledge of the types of circuits to answer the question.

1.6: discover and evaluate patterns and relationships in information, ideas and structures

Recognizing and creating patterns and relationships is the brain's way of making sense of the world of stimuli. Connections among ideas, events, works, people, movements, natural laws, etc. represent the structures that facilitate our understanding and retention of important information and processes. These patterns and relationships are also our means of evaluating the accuracy, value and truth of these things. Students must have experience discovering, describing and evaluating patterns as a means of constructing meaning about the world in which they live.

Items coded as 1.6 run the gamut from simple to complex. In some cases the prompt will provide a fairly familiar pattern and the student would be asked to give the rule that the pattern is illustrating In other cases the student may be required to manipulate the information in order to first recognize the pattern and then explain what is at work.

The key to this process standard, that sets it apart from other standards, is that the item requires convincing evidence of the student's grasp of the pattern. This evidence can be collected in several ways:

1. **The student may be asked to articulate the pattern.**
2. **The student may be asked to evaluate relationships among organisms, structures or concepts by identifying similarities and differences.**
3. **The student may be asked to select a graphic (e.g., graph, data table or drawing) that best represents the pattern described in the prompt.**
4. **The student may be asked to place objects or events in sequential order (expressing a pattern/relationship).**
5. **The student may be asked to classify organisms or objects based on their properties.**
6. **The student may be asked to develop or explain an analogy to demonstrate understanding of a relationship.**

Sample questions:

1. Examine the surface of the ramps used in the experiment. Which ramp do you predict would cause the car to go the slowest? Explain your reasoning.

2. Examine the teeth in the picture. Which teeth belong to a carnivore? Describe the characteristics that made you select those teeth.

3. Mitochondria function most like
   a. a pipeline
   b. a power plant
   c. a packaging plant
   d. an instruction book.

   Explain your reasoning.

4. Examine the drawings of the moon at different phases. Sequence the drawings to show the pattern of moon phases as seen from Earth.

5 The large X on the map above indicates where a powerful earthquake occurred. Explain why it is surprising that it occurred at that location.

6. Examine the data table. Fill in the blanks to complete these sentences:
   The smaller the animal, the _________ its heart rate.
   The larger the animal, the _________its heart rate.

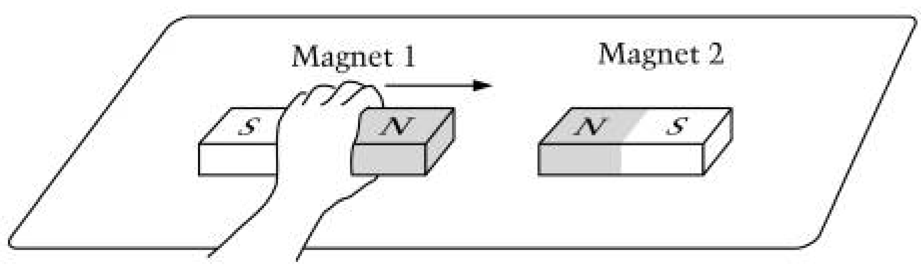
7. Examine the graph from the experiment. What is the relationship between the independent and the dependent variables?

8. Identify two similarities and two differences between the body of a bat and the body of a bird.

9. Use your graph to predict how far a car with mass of y grams would travel (when y is not within the data points plotted). Justify your prediction.

10. Look at the picture of an African savannah shown above. Which two species of animals are in competition within this ecosystem? Explain how you identified those two species as competitors in this ecosystem.

11.



The picture above shows Maria pushing magnet 1 toward magnet 2, which is lying on a smooth table.
What will happen to magnet 2?
Why will this happen?

13. Examine the diagram of a food web from the eastern forest. According to this food web, which type of animal will die out if all of the mice and voles are killed?

14. A leaf-eating beetle was introduced in the country and quickly spread over millions of acres of land. A parasitic caterpillar which preyed on the beetle was then introduced. Which of the graphs below best describes the likely population growth of the beetle? [prompt followed by four different graphs]

To illustrate the difference between 1.6 and 1.10:

Because science is so much about patterns, it would be easy to code almost any science question 1.6. This would provide teachers with almost no information, however, and would also violate the premise that the process standards must be about what the student has to do mentally. The item must go beyond simply having a pattern in the content, therefore, and require the student provide evidence of understanding of the pattern.

A good example of the difference between Process Standard 1.6 and 1.10 is an item in which students are provided with four drawings of inclined planes and asked to select the inclined plane that would be the most efficient to use to move an object upward. This item **as written** would be coded 1.10: the student is applying knowledge of inclined planes but there is not enough **evidence** for us to be certain the student understands the relationship between distance and work. The item would be coded as 1.6 if there were a follow-up question asking the student to provide an explanation or justification for the choice, since this would require the student to articulate the relationship between distance and work.

To illustrate the difference between 1.5 and 1.6:

a.) Don't fall into the trap of coding anything with classification as 1.6. It depends on what the student has to do **mentally**. In the case of the item with a classification key (Virginia Item #2: Key to Some Fruit Types), the student is indeed "classifying" but all the student has to do mentally is follow the graphic. The process requires multiple steps but none of the steps look for "relationships".

For example, in an item with a data table there is a question about several mice and the food each ate and the mass each gained. The student is asked to recognize a relationship (select the synthesized statement) that is not explicit in the graphic. In a true 1.5, questions would be able to be answered directly from the graphic: which mouse gained the most mass? Which food produced the most gain? In this case, the relationship goes beyond what is explicit. Students often have difficulty with this mental process: they can REPEAT the data, but not synthesize it.

b) All questions about food webs are not necessarily coded as 1.6. Again, it depends on what the student has to do mentally. In a food web where the information can be lifted directly from the graphic, the item would be coded 1.5. An example is an item with a forest food web. The student is asked to identify the organism "most dependent on the earthworm for its food supply". The student can use the arrows on the graphic to answer the question.

If the student is provided with a food web and asked to make a prediction based on a future change in the ecosystem, the item would be coded 1.6, because the student would be providing evidence of understanding of the **relationships** between organisms in the web. An example is an item with an ocean food web. The student is asked to predict which population would probably increase if the zooplankton decreased.

1.7: evaluate the accuracy of information and the reliability of its <u>sources</u>

Students must be aware that information is frequently only as reliable as its source. Too often students accept opinions, fallacious reasoning, hearsay, and all media as "fact". Students must, however, be able to look beyond information to its sources to determine the credibility of both. Good decisions, effective problem solving, good communication, and deep understanding are dependent upon the quality of the information on which they are based.

Items coded to Process Standard 1.7 may occur within the performance event or outside it. Students may be asked to evaluate the reasonableness of an explanation (conclusion). Sample questions include:

- Evaluate the design of an experiment and recognize situations in which factors are not controlled
- Make suggestions for reasonable improvements or extensions of an experiment (fair test)
- Judge whether measurements and computation of quantities are reasonable (and justify the response)

Students may also be asked to identify outliers within a set of data, give possible reasons for their existence, and give possible effects of errors in observations, measurements, and calculations on the formulation of explanations. These items get at the concept of the validity and reliability of data and resultant explanations/conclusions.

- Examine the data table from Judy's experiment. Given the experimental design, describe one reason that could have caused the result in Trial 3.
- Examine the data table from Jack's experiment. What should he do with the results of Trial 2 when he averages his data? Justify your reasoning.
- [Given a scenario] the scientist's hypothesis will be accepted as a valid scientific conclusion if….
- Evaluate Sally's experimental design. Identify two things Sally could have done differently to make her results more valid.

Students may be asked directly to evaluate the credibility of sources of information. These questions are similar to those in Communication Arts that are coded to Process 1.7: ***How might someone judge whether or not [x] is a reliable source of information? Which scientist/report is more reliable?*** For example:

- Which of these sources would be most appropriate to use for a research project investigating whether animal behavior can predict an upcoming earthquake?
  A. The Daily Chronicle – a local newspaper
  B. The Journal of Earth Sciences – a national professional journal
  C. The Evening Report – a national television news program
  D. The World Today – a weekly magazine of important events

1.8: organize data, information and ideas into useful forms (including charts, *tables*, graphs, outlines) for analysis and presentation

Again, closely related to communication standards, this standard recognizes the usefulness of arraying information in various concrete forms to facilitate understanding, communication and analysis. Students must be skilled in the many ways of arraying information for a variety of purposes and audiences.

This process standard will always be assessed in the performance assessment portion of the science test in order to assess Science Inquiry Strand 7 (IN.1.E.a.) It also and may be assessed elsewhere. The three most frequently used items include:

- Items that have students create a data table for a proposed experiment
- Items that have students complete or create a graph to display data provided from an experiment
- Items that ask students to create a drawing that pictorially displays information already provided

Supplementary material about data tables and graphs are provided in the document, Common Errors and Exemplary Responses, which is accessible on the DESE website, www.dese.mo.gov. This document includes the generic prompts, scoring guides, annotated student papers, and suggestions for instruction for elementary, middle and high school.

1.9: identify, analyze and compare the institutions, traditions, and art forms of past and present societies

Societies are complex gathering places for diverse peoples and institutions. This is true in a local community as much as it is within the larger world. Every society, past and present, including our own is a product of the interaction of different people, beliefs and influences. In order to fully understand the content areas, one must be able to draw on a broad and rich understanding of the world, locally and at large. Such understanding begins with the ability to identify cultures and is refined by the experience of analyzing and comparing the social systems and artifacts of those cultures. Students should see such study as a window into a broader understanding of the world and their own American culture.

Not applicable to science

1.10: apply acquired information and ideas to different contexts in the school, the workplace and everyday life

If we cannot apply what we have learned in school to life, then have we really learned anything? This is an important question and speaks to the highest levels of thinking: synthesis and application. One sure sign that a student has deeply understood what he or she has been asked to learn is his or her ability to apply that information to new situations, problems, and tasks. Such application may be creating something new with that learning or interpreting something differently using that learning. Students must be challenged to go beyond rote memorization to apply their learning in many ways and to many different situations.

Weaknesses in understanding of basic science content knowledge, as opposed to reasoning abilities, frequently prevent students from being able to synthesize or apply knowledge. Items coded to 1.10 capture understanding of necessary science facts and concepts as well as the student's ability to apply that understanding**. The key to this Process Standard is that it represents a single line of reasonin**g. **On the Science MAP, items related to this standard may ask students to do either of the following:**

- **Demonstrate their knowledge of science concepts, facts, or generalizations by answering factual questions**
- **Demonstrate their ability to use or apply that knowledge to some given situation.**

Sample questions:

- Fill in the steps of the water cycle with the appropriate term.
- Circle the objects in the drawing that will be attracted to a magnet.
- Use what you know about materials to describe a way to separate a mixture of iron filings, sawdust and salt.
- While taking a hike you notice a mushroom growing under a tree. What is the role of a mushroom in the forest ecosystem?
- Living organisms are classified into kingdoms. Name one kingdom whose members contain chlorophyll.
- Why do dark-colored clothes help you stay warmer in winter and light-colored clothes help you stay cooler in summer?
- Are mutations always harmful to an organism? Explain your answer.

Goal 2: Students in Missouri public schools will acquire the knowledge and skills to communicate effectively within and beyond the classroom

The capacity to assess these standards at the state level is limited. These standards, as they relate to science, should be assessed locally.

Goal 3: Students in Missouri public schools will acquire the knowledge and skills to recognize and solve problems.

This goal has two obvious parts: recognizing problems and solving problems. Too often emphasis is placed on merely solving problems, and routine problems, at that. Students, however, must be able to recognize, identify, and define problems that they confront. Few problems outside the classroom are routine; most are out of the ordinary and much more complex that the usual school fare. A good portion of problems are present but not always easy to see, so students must develop the ability to discover problems for themselves as part of a useable problem-solving process.

Problem-solving itself is also more complex than many people understand. It is indeed more than just solving a problem. It is a process of steps which frequently loop back on themselves as the process, and subsequently the solution, evolve. Problem solving is also a way of thinking that is reasoned and informed, as well as structured. This goal attempts to identify the important activities within that process, as well as the *ways* of thinking associated with it, as they interact to create workable solutions.

3.1: identify problems and define their scope and elements

Problem-solving is a recursive process that frequently doubles back on itself as new information, additional problems, or solutions begin to emerge. Problem identification and definition are important first elements in this process. In order to succeed in this part of the process, students must be able to approach a situation and determine within a mass of information and data what root problem(s) exists and what contributing problems exist.

This ability to sort through information and narrow one's problem-solving focus helps students hone their critical analysis skills while also giving them experience with budgeting time and effort. Once a problem has been identified, if must be defined. This definition process requires that one frames the problem, that is, determine its component and contributing parts. Students must have frequent experience in the activity of developing a clear understanding of the problem, who owns it, what its parameters are, and what its causes are.

With this sort of definition in hand, students then may begin the process of information gathering necessary to begin developing a solution. This process includes determining what is known about a problem, sorting relevant information from irrelevant information, and determining what else one needs to know (research and information) in order to attack the problem**. The key to this process standard is that the stem of the item must focus on a problem (e.g., the effect of a shopping center on an ecosystem, or the problems associated with global warming).**

Sample questions include:

1. Examine the map of Roseville. The X marks the location of a proposed landfill. Describe at least two environmental problems that the proposed landfill might create for the town.

2. The emerald ash borer is a small, metallic green beetle native to Asia. In 2002 it was discovered in the United States. Emerald ash borer larvae feed on the inner bark of ash trees, disrupting the tree's ability to transport water and nutrients. Left unchecked, this eventually kills the tree. Emerald ash borer populations can spread when people transport firewood containing the larvae to new locations. To date, emerald ash borers have killed 12-15 million ash trees in Michigan, Ohio, Indiana, Illinois and parts of Canada. Ash trees make up a significant percentage of Missouri's wild forests and landscaped urban areas. Because of this, Missouri conservation officials are working hard to keep this invasive pest out of our state.

   Identify the challenges faced to keep this pest out of Missouri.

3. Describe two environmental impacts that could result from substituting ethyl alcohol for gasoline.

4. The United States consumed about 19 million barrels of petroleum per day in 2000. This rate continues to increase. Why should this trend concern U.S. citizens?

5. In Spring 2003, a natural rock outcropping in New Hampshire called "The Old Man of the Mountain" collapsed. Explain why this collapse could affect the economy of the region. How might someone benefit from the collapse?

6. Based upon information in the data table, give two reasons why Mars' atmosphere would be a problem for mankind attempting to live on the planet.

3.2: develop and apply strategies based on ways others have prevented and solved problems

This standard and the one following are part of the idea-generation process. This activity draws on all the information gathered through identification and definition to begin developing, brainstorming, if you will, possible solutions. Inherent within this standard is also a connection to Goal I (gather, analyze, and apply information and ideas), representing, in part, application of the gathered information. It is essential that students know how to connect their learning, their research and their study to the task of problem solving. **The key to this standard is that the item focuses on present or future problems, and the student is required to describe a way to *solve* a problem.**

Sample questions:

1. Jose's elementary school is planning to construct a new building on the hill behind the current school. Examine the map of the new construction site. Make two suggestions for ways to prevent erosion when the construction begins.
2. In Missouri certain areas are having problems with an over-population of deer. Use your understanding of predator-prey relationships to explain what has contributed to this problem. Develop a strategy to remedy the problem (minimum of 3 steps).
3. Zebra mussels are invading Missouri streams and taking over the habitat of native mussels. Based on what you read in the article, what are two suggestions you could make to decrease the spread of the invasive species.
7. Cleopatra's Needle is a large stone monument that stood in an Egyptian desert for thousands of years. Then it was moved to New York City's Central Park. After only a few years, its surface began crumbling. What probably caused this crumbling?

   Without moving the monument, how can the city prevent further damage to the stone?

3.3: develop and apply strategies based on one's own experience in preventing and solving problems

Just as one must be able to connect knowledge acquired through study to a problem, one must also be able to draw on personal experience and understanding to solve problems. Students bring a lot of knowledge, experience, and common sense with them to education and to problems. Frequently this personal knowledge can add a level of practicality or reality to the problem-solving process. Students need to be able confidently to bring their own experience and personal knowledge to problem solving rather than relying wholly on theoretical constructs for solutions.

Because this process standard is indistinguishable from 3.2 on a pencil and paper test (we cannot know if the student was taught the strategy or developed it himself), MAP items that assess problem-solving strategies will be coded to 3.2 rather than 3.3.

3.4: evaluate the processes used in recognizing and solving problems

Students are frequently criticized for not being reflective, that is, for not being able to look back at their work, identify strengths or weaknesses in their problem solving strategies, and then develop plans for improving on past performance. This standard asks students to utilize reflection as part of the problem-solving process. To ensure the most appropriate solution has been developed, problem solvers must be able to critically review the thinking which has gone into solving a problem to determine if, indeed, it was appropriate, informed, and reasonable.

This standard does not require students to evaluate the solution to a problem, but rather to evaluate the processes used in coming up with the solution. Because of the amount of information that the student would need to be provided about the problem, the solution, and most important, the thinking behind the solution, the prompt would have to be too long for a standardized assessment. This process standard should therefore be **locally assessed.**

3.5: reason inductively from a set of facts and deductively from general premises
Logical reasoning is part of the problem-solving process. Students must be able to reason well to solve problems. This standard focuses on inductive and deductive reasoning as appropriate tools.
Inductive reasoning is the process by which researchers/thinkers gather evidence, examples or instances and, then based on their gathered information, they develop conclusions.

Example: John throws a ball up repeatedly and every time he throws it, it comes back down. He therefore draws the conclusion that the next time he throws the ball up, it will come back down.

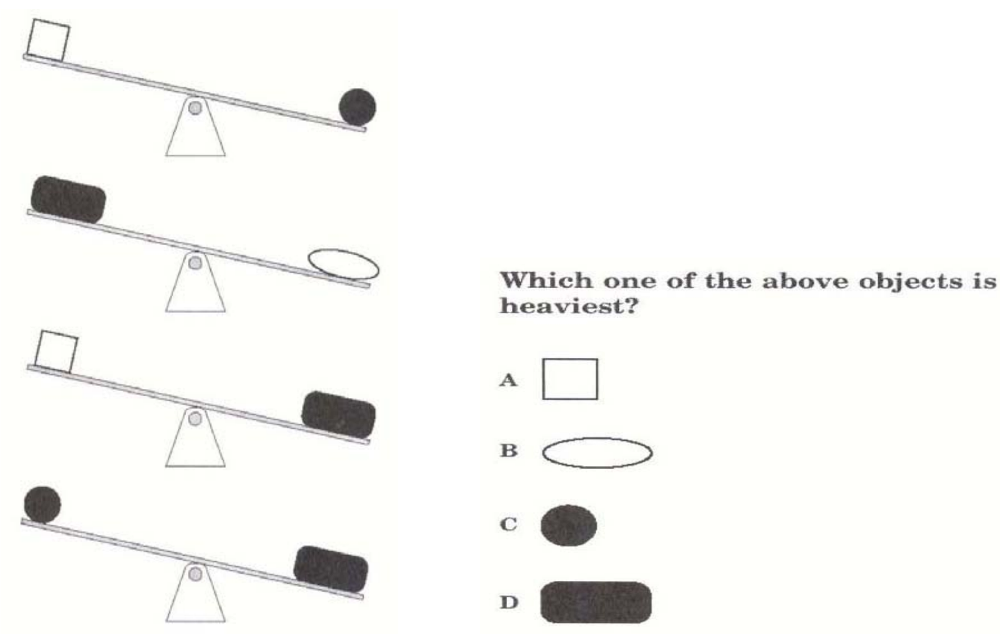
Deductive reasoning begins with general conclusions and applies them to various situations to test their viability, application and generalizability.

Example: Lisa understands the concept of gravity. She therefore predicts that when she throws a ball up, it will come back down because of the law of gravity.

Students should be able to perform both kinds of reasoning in and out of problem-solving situations. **The key to this process standard is that the student is involved in problem-solving (either real-life or abstract) that requires multiple understandings and complex reasoning.**

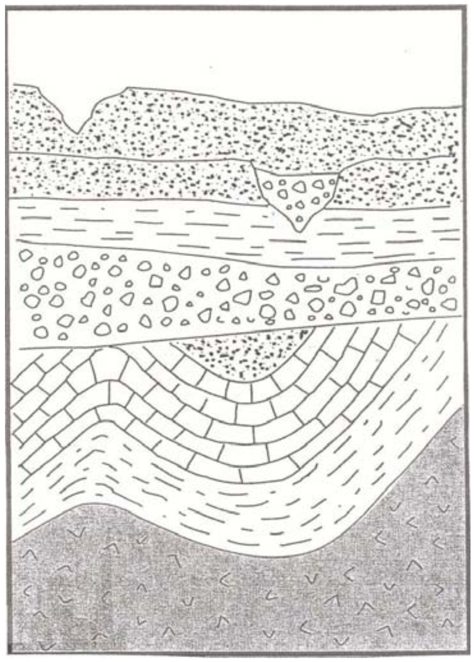
Sample questions:

1. Examine the balances below and answer the question:



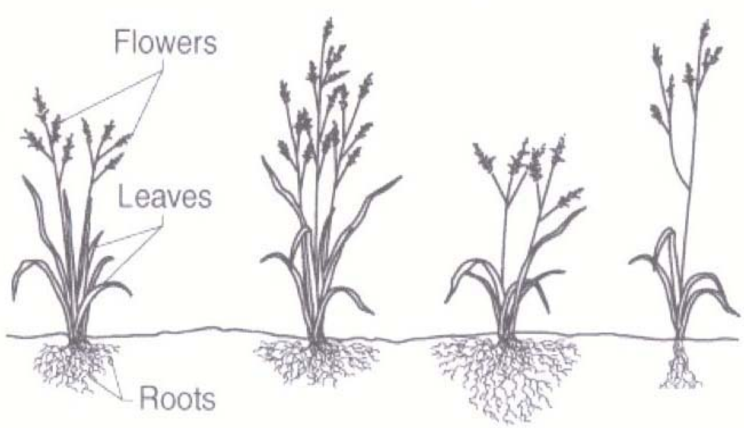
2. Examine the weather map above. Based on your understanding of weather patterns, predict the weather (temperature, barometric pressure, cloud cover and chance of precipitation) for Springfield for the next day. Justify your prediction.

3. Examine the rock layers below. Label the layers in order from the oldest to the youngest.



4. Following the Flood of 1993, the Army Corps of Engineers reinforced the levees located where the Missouri and Mississippi Rivers meet. Predict and explain how the change in this ecosystem may affect other ecosystems further down the Mississippi River.

5. The picture below shows four varieties of the same species of grass that grow in a prairie ecosystem. Which variety has the best chance of surviving a long period of dry weather? Give <u>two</u> reasons why:



The difference between 3.5 and 1.6 or 1.10:

- Both Process Standard 1.6 and 3.5 may be assessed with items that ask students to make predictions, identify cause and effect, draw conclusions, or answer if-then questions. The difference is that in 1.6, the student isn't required to bring as much to the reasoning. Often the pattern or relationship in the question has been taught and the student is recognizing it and articulating it. It is a single line of reasoning (for example, "The inclined plane with the greatest length will allow the car to go up with the least effort.")

- Process Standard 3.5 is more complex, with the student needing to make connections across texts, information or ideas. This requires a greater degree of synthesis. A good example is from the 2001 Middle School Science Test, Performance Event questions. Students are provided with a map of a community, including a stream, feedlot, wastewater treatment plant and swimming area. Students are also provided with three data tables comparing levels of bacteria, kinds of fish, dissolved oxygen, and water temperature at a variety of sites. The item asks students to identify the research site they think is most unhealthy for living things and to justify their answer. This question requires students to understand information from multiple sources and to synthesize that information, therefore it is coded as 3.5 rather than 1.10.

3.6: examine problems and proposed solutions from multiple perspectives

We rarely solve problems in isolation. In most instances, problems, and their solutions, are part of more complex webs of people, systems, and interactions. Once one element is altered, the likelihood that others will be altered is almost certain. Therefore, anyone attempting to solve a problem must look at the problems and their potential solutions from many perspectives to ensure that the solutions selected and implemented will not only solve the problem being addressed, but also not create new problems or more serious problems than the original. This does not mean that all problem-solving involves group thinking, but students should be aware of the complexity of problem solving as it affects other lives and systems.

Sample questions:

1. Describe two social or economic reasons that have made it difficult for alternative fuel cars to become widely accepted in the United States.

2. Dams can be built across rivers to provide hydroelectric power for the people around the dam. Why might farmers be against building dams? Why might townspeople be in favor of building dams?

3. Genetic engineering of plants has made it possible for a company to develop a type of alfalfa hay that is "Round-up Ready". In other words, farmers can spray their fields with herbicides to kill weeds but the spray will not damage the alfalfa.
   Describe one environmental and one economic reason to be either for or against using this genetically-engineered plant.

3.7: evaluate the extent to which a strategy addresses the problem

Determining a solution to a problem is not the end of the process. Indeed, problem-solvers need to take a longer view of the process and include critical follow-up among the activities inherent in good problem solving. Whether it is following the progress and impact of a solution in action or using logical progression to predict the outcomes of solutions, students need to be willing and able to review solutions to evaluate their effectiveness.

The key to this process standard is that the student must be provided with a solution to a problem (either one already tried or one that is proposed) and be required to evaluate its effectiveness. Did it "work"? How well did it work? What were its limitations?

Sample questions:

Building dams across the rivers in the Northwest increased energy from hydroelectric power but also caused the population of wild salmon to decrease drastically, since the fish could not swim upstream to lay their eggs. Fish ladders, like the one in the picture, were built along many rivers to help the salmon move upstream in the fall. Examine the graph that shows the population of wild salmon over the past 100 years. Based on the data, have fish ladders proven to be the solution to the problem of decreasing numbers of salmon? Explain your reasoning.

The Barkens neighborhood of family homes is bordered by a community with many polluting factories. In hopes of eliminating the pollutants from their air, the Barkens citizens are proposing to build solar panels and wind generators for their own neighborhood homes. Evaluate their proposed solution to the problem of polluted air.

3.8: assess the costs, benefits and other consequences of proposed solutions to problems

Closely related to Standard 3.7, this standard is an important reflective activity. Before implementing a solution, students should be able to accurately assess the costs of their solutions, the benefits, and the consequences in terms of dollars, but also in terms of human costs, goodwill costs, physical consequences, aesthetic consequences, etc. This activity within the process is tantamount to "looking before you leap." Doing this before implementing a solution is critical in order to prevent other problems or at least anticipate consequences before they are reality.

In this process standard, students are presented with a problem and a proposed solution, and then asked to identify possible costs, benefits, advantages, disadvantages or generic consequences.

Sample questions:

1. A city council wants to build a trash incinerator that will generate heat to be used for heating homes. Some citizens are in favor of their plan, while other citizens oppose it.

   Besides the fact that homes will be heated, what is one advantage of building the incinerator?

   What is one disadvantage of building the incinerator?

2. Some people have proposed that ethyl alcohol (ethanol), which can be produced from corn, should be used in automobiles as a substitute for gasoline. Assuming that gasoline and ethyl alcohol cost the same per gallon, what would be one advantage to using ethanol? What is one disadvantage?

3. Some people believe that recombinant DNA technology has serious disadvantages. Describe one disadvantage that might result from the use of recombinant DNA technology. Describe one benefit that might result from the use of recombinant DNA technology.

Goal 4: Students in Missouri public schools will acquire the knowledge and skills to make decisions and act as responsible members of society.

> ***The capacity to assess these standards at the state level is limited. These standards, as they relate to science, should be assessed locally.***

Science Levels of Depth-of-Knowledge
(retrieved online July 5, 2006 at:
http://facstaff.wcer.wisc.edu/normw/All%20content%20areas%20%20DOK%20levels%2032802.doc

Interpreting and assigning depth-of-knowledge levels to objectives both within standards and assessment items is an essential requirement of alignment analysis. Four levels of depth of knowledge are used for this analysis. Because the highest (fourth) DOK level is rare or even absent in most standardized assessments, reviewers usually will be making distinctions among DOK levels 1, 2 and 3. Please note that, in science, "knowledge" can refer both to content knowledge and knowledge of science processes. This meaning of knowledge is consistent with the National Science Education Standards (NSES), which terms "Science as Inquiry" as its first Content Standard.

Level 1. Recall and Reproduction

Level 1 is the 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. Some examples that represent but do not constitute all of Level 1 performance are:

- Recall or recognize a fact, term, or property.
- Represent in words or diagrams a scientific concept or relationship.
- Provide or recognize a standard scientific representation for simple phenomenon.
- Perform a routine procedure such as measuring length.

Level 2. Skills and Concepts

Level 2 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. Some examples that represent, but do not constitute all of Level 2 performance, are:

- Specify and explain the relationship between facts, terms, properties, or variables.
- Describe and explain examples and non-examples of science concepts.
- Select a procedure according to specified criteria and perform it.
- Formulate a routine problem given data and conditions.
- Organize, represent and interpret data.

Level 3. Strategic Thinking

Level 3 requires 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. Some examples that represent, but do not constitute all of Level 3 performance, are:

- Identify research questions and design investigations for a scientific problem.
- Solve non-routine problems.
- Develop a scientific model for a complex situation.
- Form conclusions from experimental data.

Level 4. Extended Thinking

Tasks at Level 4 have **high cognitive demands** and are **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. Some examples that represent but do not constitute all of a Level 4 performance are:

- Based on provided data from a complex experiment that is novel to the student, deduct the fundamental relationship between several controlled variables.
- Conduct an investigation, from specifying a problem to designing and carrying out an experiment, to analyzing its data and forming conclusions.