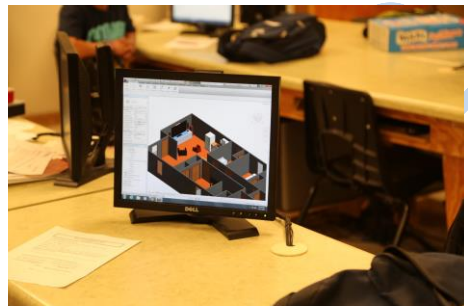
Science & Engineering Practices Support Guide for the South Carolina Academic Standards and Performance Indicators for Science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State Superintendent of Education

South Carolina Department of Education
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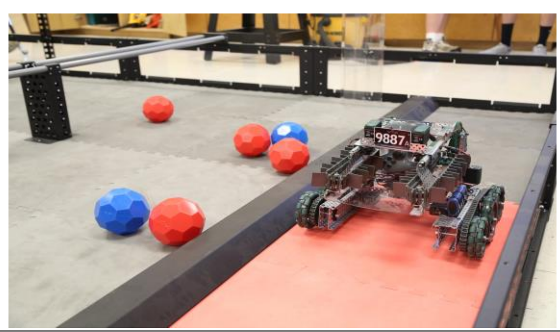

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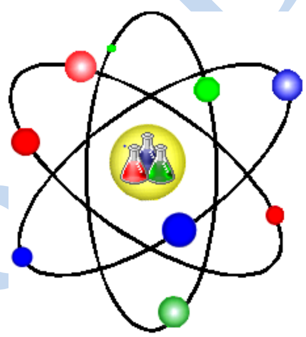

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South Carolina Department of Education

The explication of the science and engineering practices included in this document were revised under the direction of Dr. Julie Fowler, Deputy Superintendent, Division of College and Career Readiness and Cathy Jones Stork, Interim Director, Office of Standards and Learning.

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SCIENCE AND ENGINEERING PRACTICES (SEPS): AN OVERVIEW

One of the most significant and fundamental shifts from the South Carolina Science Academic Standards (2005) to the South Carolina Academic Standards and Performance Indicators for Science (2014) is the incorporating of nine science and engineering practices with the content performance indicators in the form of *student* performance expectations. There is a very deliberate expectation of engaging in science content and concepts through the use of the science and engineering practices, both as a means of developing understanding of these concepts as well as a means of demonstrating that understanding. By comparison, the 2005 science standards employed verbs from the revised Bloom's taxonomy as performance expectations that were primarily focused on conveying relatively straight forward details about specific science content with no clear expectation of how those concepts were to be developed or represented through scientific practices and skills.

Science and engineering practices represent what scientists and engineers do as a matter of routine and illustrate how scientific knowledge and concepts develop through asking questions and conducting investigation, obtaining and analyzing data, constructing explanations, arguing claims supported by evidence, and communicating and evaluating information. They also describe how needs and problems are addressed through the design process that designs, constructs, tests, evaluates, and refines solutions.

Science is the study of the universe and all of its contained phenomena. Engineering is the way we fulfill human needs and solve problems. These practices represent the skills and knowledge necessary for scientists and engineers to accomplish what they do.

Scientific practices start with questioning that leads to inquiry, seeking evidence to ultimately construct explanations and develop models that can be used to best describe and predict (at the present) how and why natural phenomena occur.

Engineering practices start with defining problems and identifying human needs; this process leads to designing, testing, and refining solutions in order to accumulate evidence necessary to determine the best possible solution (at the present) for the perceived need or problem.

The practices common to all areas of science and engineering are:

- Asking questions
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations
- Engaging in scientific argument from evidence
- Obtaining, evaluating, and communicating information
- Constructing devices or designing solutions.

THE ROLE OF EVIDENCE

Evidence is a common theme throughout the application of the science and engineering practices.

- Ask Questions, Define Problems, Plan and Carry out Investigations, Use Models: *Acquiring evidence.*
- Analyze and Interpret Data and Mathematics and Computational Thinking: *Making meaning of the evidence.*
- Engage in Argument, Construct Explanations, Design Solutions, Develop Models: *Using evidence to support claims.*
- Obtain, Evaluate, and Communicate Information, Use Models: *Providing context for the evidence as well as communicating the outcomes supported by the evidence*.

In science, evidence is used to support claims and explanations. In engineering, evidence is used to assess and evaluate solutions.

Shifting from the South Carolina Science Academic Standards (2005), which relied on students developing the capacity to explain, summarize, illustrate, identify, exemplify, compare, etc. scientific concepts, the South Carolina Standards and Performance Indicators for Science (2014) focus on *engaging in the practices of science and engineering as a means to develop understandings of scientific concepts*. This is accomplished primarily through the use of evidence. Throughout the standards, at all grade levels, students are charged with acquiring evidence through investigation, testing, model use, and research as a means of constructing scientific explanations, supporting scientific claims through argumentation, refining and proposing design solutions to problems, communicating scientific concepts, and developing reliable models of natural phenomena.

GATHERING, REASONING, AND COMMUNICATING INFORMATION

Another way to look at the organization of the science and engineering practices is through the lens of Gathering Information, Reasoning with Information, and Communicating Information[1]. In this context, information is not limited to scientific informational texts but also includes data, both observational and measured, as well as claims, explanations, and models supported and developed using evidence.

- Gathering:
  - Obtain Information
  - Ask Questions
  - Define Problems
  - Plan and Carry Out Investigations
  - Use Models to Gather Data
  - Use Mathematics and Computational Thinking

- Reasoning:
    - Evaluate Information
    - Analyze Data
    - Use Mathematics and Computational Thinking
    - Construct Explanations
    - Design Solutions
    - Develop Scientific Arguments from Evidence
    - Use Models to Predict and Develop Evidence
- Communicating:
    - Communicate Information
    - Supporting Claims from Evidence through Argumentation
    - Use Models to Communicate

[1] from *CSSS Session: A Vision for Science Education: The Integration of the NGSS Practices in Classroom Instruction*, Brett Moulding, Peter McLaren, NSTA 2014 National Conference, Boston, MA

PRACTICES AS PERFORMANCE EXPECTATIONS

As defined by the performance indicators of the standards, the science and engineering practices serve to identify performance expectations that our students will demonstrate in the context of disciplinary core content ideas. Not only will these practices serve as a means by which students will develop scientific conceptual understandings, but they will also function as the means by which students will demonstrate these understandings in an authentic manner. These practices should be used to drive the instructional design of learning experiences in such a way as to guide students to develop the capacity to perform these science and engineering practices as part of the process of developing an understanding of scientific concepts.

The practices also serve to drive assessment as teachers are tasked with not only assessing conceptual understandings related to content but also assessing the degree to which their students are able to meet the performance expectations of the different scientific and engineering practices (scaled appropriately for the age and grade of the student).

THE INTERCONNECTED NATURE OF THE PRACTICES

It is important that teachers realize that the eight science and engineering practices are not intended to be used in isolation. Even if a performance indicator for a given standard only lists one of the practices as a performance expectation, scientists and engineers do not use these practices in isolation but rather as part of an overall sequence of practice. When educators design the learning for their students, it is important that they see how a given performance expectation fits into the broader context of the other science and engineering practices. This will allow teachers to provide comprehensive, authentic learning experiences through which students will develop and demonstrate a deep understanding of scientific concepts. One way to consider this relationship is presented in Figure 1.

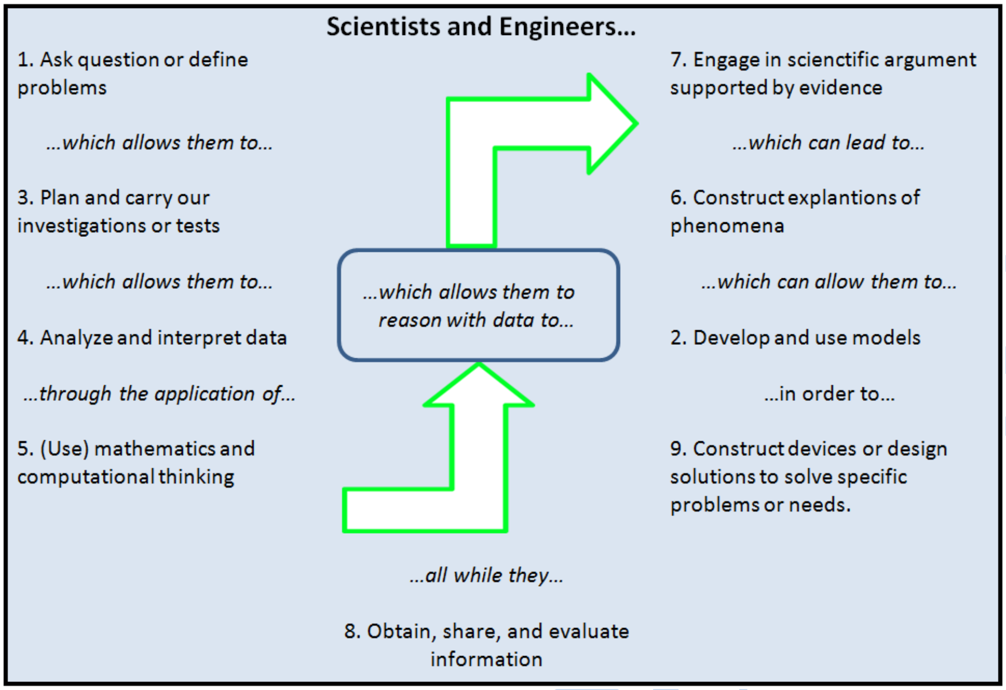

Figure 1: Interconnected nature of the science and engineering practices.

It must be noted that this is not the only way this relationship can be structured. For example, models can be used to generate data or as a source of information that can provide context for an investigation. Questions can be asked not only as a precursor to an investigation but as a result of the outcomes of an investigation.

FORMAT OF THE SCIENCE AND ENGINEERING PRACTICES STANDARD

At the beginning of each grade level standard, there is a science and engineering practices standard that serves to define the role of the science and engineering practices in the broader context of developing an understanding of science concepts, developing scientific thinking habits of mind, and engaging in science in a manner consistent with work done by scientists and engineers. This standard is followed by a pair of conceptual understandings which represent what concepts, understandings and core disciplinary ideas the teachers should be looking for evidence of when assessing their students in terms of overall capacity to perform as scientists and engineers.

For example,

- **Standard 5.S.1:** The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content.
    - **5.S.1A. Conceptual Understanding:** The practices of science and engineering support the development of science concepts, develop the habits of mind that are necessary for scientific thinking, and allow students to engage in science in ways that are similar to those used by scientists and engineers.

- **5.S.1B. Conceptual Understanding:** Technology is any modification to the natural world created to fulfill the wants and needs of humans. The engineering design process involves a series of iterative steps used to solve a problem and often leads to the development of a new or improved technology.

While this example comes from the 5th grade standards, it is the same in all grades and subjects.

Each of these conceptual understandings is followed by one or more performance indicators that serve to functionally define the performance expectations for each of the nine practices in terms of how they are integrated into the content-specific performance indicators that follow and what sort of tasks students will be expected to perform to develop the scientific conceptual understandings for each content strand as well as how they will be expected show evidence of that conceptual understanding through the use of each practice.

INTEGRATION, NOT ISOLATION

It is important to note that although the science and engineering practices are defined by a separate academic standard, teachers should not teach these performance indicators on their own, disconnected from scientific concepts and content:

"It is critical that educators understand that the science and engineering practices are not to be taught in isolation. There should not be a distinct "Inquiry" unit at the beginning of each school year. Rather, the practices need to be employed within the content for each grade level or course. Students should engage in scientific and engineering practices as a means to learn about the specific topics identified for their grade levels and courses." (p. 3)

This statement from the standards document communicates not only the expectations that these performance indicators are *not* to be treated as a separate unit of study, but also that it will be through these practices that students come to develop the conceptual understandings identified in each subsequent content strand. The science and engineering practices are not simply a means of validating content information and expected outcomes through lecture, direct instruction, and/or scripted labs and activities. Rather, students will learn science *through the application and use* of the science and engineering practices embedded within each set of content performance indicators.

FORMAT OF SEPS SUPPORT DOCUMENT

The format of this document is designed to be structurally uniformed for each of the science and engineering practices. For each, you will find the following sections--

- **Grade Level Progressions**
  - This section includes a chart of the specific science and engineering practice indicators within each grade band.

- **Specific Changes Per Grade**
  - This section highlights each change as the indicator progresses and becomes increasingly complex. Specific differences are noted in italics.
- **Defining Characteristics**
  - This section provides an overview of the defining characteristics of the science and engineering practice indicator in order provide a deeper conceptual understanding of the purpose and function of the practice and its role in science and engineering disciplines.
- **Instructional Guidance and Considerations**
  - This section provides guidelines for educators on how to use the science and engineering practice indicator as a performance expectation in a learning experience.
- **Evidence of Mastery**
  - This section provides a list of evidence of student success factors that educators can use when assessing a student's performance through the lens of the science and engineering practice indicator.
- **Connections with Other Science and Engineering Practices**
  - This section illustrates connections between the specific science and engineering practice indicator and the other eight science and engineering practices to provide educators with guidance on integrating multiple practices throughout the learning experience.
- **Performance Task Examples**
  - This section provides a chart of several grade-band examples of performance tasks related to science content standards and indicators that reflect the specific science and engineering practice indicators as performance expectations. This section also provides corresponding examples of performance tasks that do not meet the criteria of performance expectations for the given science and engineering practice.