Science and Engineering Practices in High School (Formerly Skills and Processes)

Introduction: As students progress through high school science, they are to develop increasing proficiency and sophistication in their engagement with the practices of science to learn and apply scientific and engineering concepts. The science practices used by high school students are built upon their previous experiences in both middle school and elementary school science learning. By completion of high school, students should be critical and informed consumers and producers of scientific and engineering information and prepared to engage as active citizens in the ever-changing science and technology found throughout society.

In June 2013, the Maryland State Board of Education adopted the *Next Generation Science Standards* (NGSS) (http://www.nextgenscience.org/) that describes a three dimensional learning environment consisting of Science and Engineering Practices (SEPs), Disciplinary Core Ideas (DCIs), and Crosscutting Concepts (CCCs). The transition to NGSS, which articulates learning outcomes for all students in science, is underway in HCPSS and across Maryland. During the transition, instruction within science classes will shift away from discrete skills/processes and content to a seamless integration of the three aforementioned NGSS components. Teachers should constantly identify opportunities to engage all students in the SEPs through authentic and relevant science experiences. Never should either the skills or processes of science (defined in the current Maryland State Curriculum) or the SEPs (defined within NGSS) be taught separately or in isolation. Students learn science concepts by engaging in science practice.

Maryland adopted the College and Career-Ready Standards for English Language Arts; Literacy in History/Social Studies; and Literacy in Science and Technical Subjects (CCRS) in 2010 (http://mdk12.org/instruction/curriculum/reading/). In science, this means that students in middle school should be engaging regularly with complex texts through close examination. Complex text comes in many forms in science, and students should have ample opportunities to engage with a wide variety as appropriate to the science content and practices under use. Among examples of complex text beyond traditional text are: satellite imagery, data tables, graphical representations, diagrams, audio files, etc. The CCRS State Curriculum Frameworks for reading and writing in science and technical subjects [(http://mdk12.org/share/frameworks/CCSC_Science_gr9-12r.pdf) and (http://mdk12.org/share/frameworks/CCSC_Science_gr9-12w.pdf)] should guide instructional decisions. Resources to support disciplinary literacy within high school science learning environments are available to teachers throughout Canvas and should guide the design and facilitation of learning.

Learning must be accessible to all students, and application of Universal Design principles assures this accessibility. Universal Design for Learning (UDL) is best applied to newly created learning experiences that offer students many options in representation, action and expression, and engagement with the learning. However, UDL principles can also be systematically applied to extant lessons. All teachers are expected to apply UDL principles to learning opportunities for all students each day. Examples of UDL in science are available within the resources on Canvas. More information on UDL can also be found within the Instructional Resources on Alfresco or from the Maryland State Department of Education at http://marylandlearninglinks.org/1021.

The Skills and Processes section of the HCPSS Curriculum in Science includes the skills and processes necessary to learn science in high school. They encompass the expectations and indicators contained in

Core Learning Goal 1 from the high school assessment program. These skills and processes should be addressed as an integrated part of the science curriculum in each high school course and unit.

Goal 1. The student will demonstrate the ability to observe safe procedures when conducting an investigation.

Objectives – The student will be able to:

a. Demonstrate skill in using laboratory and field equipment to perform investigative techniques.
b. Practice safe laboratory procedures and appropriate cleanup and disposal procedures.
c. Demonstrate safe handling of the chemicals and materials of science.

Goal 2. The student will demonstrate the ability to carry out scientific investigations effectively and appropriately employ the instruments, systems of measurements, and materials of science. ***EL***

Objectives - The student will be able to:

a. Use lab equipment to perform investigative techniques.
b. Handle chemicals and materials of science appropriately.
c. Use new instruments and equipment by following instructions in a manual or from oral directions.
d. Use the appropriate units to measure a specified quantity.

Goal 3. The student will demonstrate the ability to access and process information from readings, diagrams, investigations, or oral communications. ***EL***

Objectives – The student will be able to:

a. Read a technical selection and interpret it appropriately.
b. Use relationships discovered in the lab to explain phenomena observed outside of the laboratory.

Goal 4. The student will demonstrate the ability to formulate questions that lead to a testable hypothesis which demonstrate logical connections between scientific concepts and the design of an investigation. ***EL***

Objectives – The student will be able to:

a. Identify and pose meaningful, answerable scientific questions.
b. Formulate and test a working hypothesis.
c. Design experimental approaches, which answer scientific questions.
d. Write clear, step-by-step instructions for conducting an investigation. Explain the need for verifiable data.
e. Use data to confirm, modify, or reject a hypothesis.

Goal 5. The student will demonstrate the ability to design experimental approaches that answer scientific questions. ***EL***

Objectives - The student will be able to:

a. Recognize questions that can be tested scientifically.
b. Identify appropriate independent and dependent variables.
c. Identify proper controls in an experiment.
d. Select appropriate instruments and materials to conduct an experiment.
e. Write clear, step-by-step instructions for conducting an investigation.
f. Defend the need for verifiable data.

Goal 6. The student will demonstrate the ability to use mathematical processes (measuring, calculating, etc.) when conducting investigations, analyzing information, and displaying information.

Objectives – The student will be able to:

a. Organize data appropriately using techniques such as tables and webs.
b. Create graphs with axes labeled with appropriate quantities, appropriate units on axes, axes labeled with appropriate intervals, independent and dependent variables on correct axes, appropriate title.
c. Describe the thinking involved in performing a mathematical problem.

Goal 7. The student will demonstrate the ability to conclude, justify, and support that data analysis is a vital aspect of the process of scientific inquiry and communication. ***EL***

Objectives - The student will be able to:

a. Analyze data to make predictions, decisions, or draw conclusions.
b. Determine the relationships between quantities and develop the mathematical model that describes these relationships.
c. Check graphs to determine that they do not misrepresent results.
d. Describe trends revealed by data.
e. Use experimental data from various investigators to validate results.
f. Determine the sources of error that limit the accuracy or precision of experimental results.
g. Use analyzed data to confirm, modify, or reject a hypothesis.
h. Use models and computer simulations to extend the understanding of scientific concepts.

Goal 8. The student will demonstrate the ability to apply mathematical processes to solve problems.

Objectives - The student will be able to:

a. Use math skills including unit conversions, manipulating and solving algebraic equations, scientific notation, and proportional relationships.
b. Solve problems methodically by identifying known and unknown quantities, identifying appropriate equations, and determining the reasonableness of an answer.
c. Use ratio and proportion in appropriate situations to solve problems.
d. Use computers and graphing calculators to perform calculations for tables, graphs, and spreadsheets.
e. Express and compare small and large quantities using scientific notation and relative order of magnitude.
f. Manipulate quantities and numerical values in algebraic equations.

g. Judge the reasonableness of an answer.

Goal 9. The student will demonstrate the ability to carry out effective scientific investigations, analyze data, communicate results, and apply results to explain phenomena occurring outside the laboratory. *EL*

Objectives - The student will be able to:

a. Modify or affirm preexisting scientific conceptions.
b. Identify trends and sources of error.
c. Analyze data.
d. Make predictions and explain everyday phenomena.

Goal 10. The student will demonstrate the ability to use appropriate communication methods, both written and oral, to present the processes and results of scientific investigations. *EL*

Objectives - The student will be able to:

a. Summarize data.
b. Explain scientific concepts and processes through drawing, writing, and oral communication.
c. Use computers and other technologies to create visual presentations (scale drawings, photographs, digital images, *PowerPoint*, etc.).
d. Use computers and other technologies to produce tables, graphs, and spreadsheet calculations.
e. Explain, construct, and use various classification systems.
f. Describe similarities and differences when explaining concepts and principles.
g. Communicate conclusions derived through the synthesis of ideas.