BSCS Guide to the NGSS Scientific Practices: Variations in the Classroom

Less……………………………………………………………………Learner Self-Direction……………………………………………………………………More
More……………………………………………………………Direction from Teacher or Materials……………………………………………………………Less

NGSS Scientific Practice	Classroom Variations			
	A. Learners are provided an example of or instructions for engaging in the scientific practice.	**B. Learners are guided in how to engage in the scientific practice. (Teacher takes a stronger lead)**	**C. Learners are supported in engaging in the scientific practice. (Learner takes a stronger lead)**	**D. Learners independently to engage in the scientific practice.**
1. Asking questions (for science)	A. Students are provided with scientific questions related to a natural phenomenon.	B. Students are guided in using frameworks and strategies for selecting from scientific questions related to a natural phenomenon.	C. Students are supported in posing and revising scientific questions related to a natural phenomenon.	D. Students independently pose and refine scientific questions related to a natural phenomenon.
	A. Students are provided with questions for probing each other's thinking in a way that encourages scientific discourse.	B. Students are guided in using frameworks and strategies for asking questions that probe each other's thinking in a way that encourages scientific discourse.	C. Students are reminded to engage in scientific discourse by asking questions that probe each other's thinking.	D. Students independently engage in scientific discourse by asking questions that probe each other's thinking.
2. Developing and using models	A. Students are provided with models and given their limitations, approximations, and assumptions. They are shown how models can illuminate aspects of a system, and lead to questions, predictions, and explanations about a natural phenomenon.	B. Students are guided in using frameworks and strategies to help them develop and use models and to identify their limitations, approximations, and assumptions. They are guided in using models to generate questions, investigate aspects of a system, make predictions, and develop explanations about a natural phenomenon.	C. Students are supported in creating their own models. They are supported to identify limitations, approximations, and assumptions of models, and use models to generate questions, investigate aspects of a system, make predictions, and develop explanations about a natural phenomenon.	D. Students independently create their own models. They identify limitations, approximations, and assumptions of models, and use models to generate questions, investigate aspects of a system, make predictions, and develop explanations about a natural phenomenon.
3. Planning and carrying out investigations	A. Students are provided with a plan for collecting the data needed to address a scientific question (including the controls, dependent and independent variables, and protocols to follow). Students collect the appropriate data.	B. Students are guided in using frameworks and strategies to help them identify the data needed to address a scientific question and provided with a structure for designing a plan for collecting data (including identifying controls, dependent and independent variables, and protocols to follow). Students collect the appropriate data.	C. Students are supported in some aspect of identifying the data to collect and designing the protocol to address a scientific question and independently engage in other aspects of the practice. The design includes controls, dependent and independent variables, and protocols to follow. Students collect the appropriate data.	D. Students independently identify the data needed to address a scientific question, and independently design a plan based on student-defined parameters for collecting data (including identifying controls, dependent and independent variables, and protocols to follow). Students collect the appropriate data.
4. Analyzing and interpreting data	A. Students are shown how to represent and analyze data to identify patterns, trends, or relationships that reveal the meaning or relevance of the results of an investigation so they may be used as evidence. They are shown how to interpret the data in light of relevant models and theories.	B. Students are guided in using frameworks and strategies to help them represent and analyze data to identify patterns, trends, or relationships that reveal the meaning or relevance of the results of an investigation so they may be used as evidence. They are guided in interpreting the data in light of relevant models and theories.	C. Students are supported in some aspect of representing and analyzing data to identify patterns, trends, or relationships and interpreting the data to identify evidence in light of relevant models and theories. They independently engage in other aspects of the practice.	D. Students independently represent and analyze data to identify patterns, trends, or relationships and interpret the data to identify evidence in light of relevant models and theories.
5. Using mathematics and computational thinking	A. Students are given appropriate mathematical routines and tools for computational thinking, as well as step-by-step instructions for applying them to qualitative or quantitative data sets to represent their ideas, solve problems, describe relationships, and make predictions about natural phenomena.	B. Students are guided in using appropriate mathematical routines and tools for computational thinking, and in applying these routine and tools to qualitative or quantitative data sets to represent their ideas, solve problems, describe relationships, and make predictions about natural phenomena.	C. Students are supported to identify appropriate mathematical routines and tools for computational thinking, and then supported in applying them to qualitative or quantitative data sets to represent their ideas, solve problems, describe relationships, and make predictions about natural phenomena.	D. Students independently identify and apply appropriate mathematical routines and tools for computational thinking to qualitative or quantitative data sets to represent their ideas, solve problems, describe relationships, and make predictions about natural phenomena.
6. Constructing explanations (for science)	A. Students are provided a causal explanation of a phenomenon and identify how it links scientific ideas with observations and data in order to make sense of some aspect of the natural world.	B. Students are guided in using frameworks, and strategies to help them in constructing a causal explanation (or evidence-based account) of a phenomenon, linking scientific ideas with observations and data in order to make sense of some aspect of the natural world.	C. Students are supported in constructing a causal explanation (or evidence-based account) of a phenomenon using scientific ideas and appropriate evidence from observations or data in order to make sense of some aspect of the natural world.	D. Students independently construct a causal explanation of a phenomenon using scientific ideas and appropriate evidence from observations or data in order to make sense of some aspect of the natural world.
7. Engaging in argument from evidence	A. Students are given a scientific argument and provided with instructions on how to critically evaluate it in light of the evidence quality, strengths and limitations of the reasoning, and alternative explanations. They are shown a revised argument based on the results of its evaluation.	B. Students are guided in using frameworks, or strategies to help them engage in scientific argumentation and in how to critically evaluate the argument in light of the evidence quality, strengths and limitations of the reasoning, and alternative explanations. They are guided to revise their argument based on their evaluation.	C. Students are supported as they engage in scientific argumentation and in how to critically evaluate the argument in light of the evidence quality, strengths and limitations of the reasoning, and alternative explanations. They are encouraged to revise their argument based on their evaluation.	D. Students independently engage in scientific argumentation and in critically evaluating the argument in light of the evidence quality, strengths and limitations of the reasoning, and alternative explanations. They revise their argument based on their evaluation.
8. Obtaining, evaluating, and communicating information	A. Students are given examples of how information from scientific texts can be integrated with current understanding and examples of salient ideas, sources of error, mythological flaws, and distinctions between observations and inferences, arguments and explanations, and claims from evidence. They are provided with step-by-step instructions for presenting results of inquiry to peers.	B. Students are guided in using frameworks, or strategies for evaluating and integrating information from scientific texts, producing text, and for communicating ideas and results of inquiry to peers. They are given guidelines for identifying salient ideas, sources of error, mythological flaws, and for distinguishing between observations and inferences, arguments and explanations, and claims from evidence.	C. Students are supported in evaluating and integrating information from scientific texts, producing text, and for communicating ideas and results of inquiry to peers. They are coached in identifying salient ideas, sources of error, mythological flaws, and for distinguishing between observations and inferences, arguments and explanations, and claims from evidence.	D. Students independently evaluate and integrate information from scientific texts, produce text, and communicate ideas and results of inquiry to peers. They independently identify salient ideas, sources of error, mythological flaws, and distinguish between observations and inferences, arguments and explanations, and claims from evidence.

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

BSCS Guide to the NGSS Scientific Practices: Brief Descriptions

1. Asking questions (for science)	Science begins with a question about a phenomenon and seeks to develop theories that can provide explanatory answers to such questions. A basic practice of the scientist is formulating empirically answerable questions about phenomena, establishing what is already known, and determining what questions have yet to be satisfactorily answered (Framework, p. 50). Scientific questions arise in a variety of ways. They can be driven by curiosity about the world, inspired by the predictions of a model or theory, or they can be stimulated by the need to solve a problem. What distinguishes scientific questions from other types of questions is that they can be answered by appealing to evidence, including evidence that has been gathered by others, or that might be gathered by planning and conducting an investigation. The ability to ask good questions and clearly define problems is essential for everyone (NGSS Appendix F). One way students engage in scientific discourse is by asking questions of one another (BSCS Guide).
2. Developing and using models	Science often involves the construction and use of a wide variety of models and simulations to help develop explanations about natural phenomena. Models make it possible to go beyond observables and imagine a world not yet seen. Models enable predictions of the form "if . . . then . . . therefore" to be made in order to test hypothetical explanations (Framework, p. 50). Models include diagrams, physical replicas, mathematical representations, analogies, and computer simulations. Although they do not correspond exactly to the real world, they do bring certain features into focus while obscuring others. All models contain approximations and assumptions that limit the range of validity and predictive power, so it is important for students to recognize their limitations. In science models are used to represent a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate ideas to others. Students can be expected to evaluate and refine models through an iterative cycle of comparing their predictions with the real world and then adjusting them to gain insights into the phenomenon being modeled (NGSS Appendix F).
3. Planning and carrying out investigations	Scientific investigation may be conducted in the field or the laboratory. A major practice of scientists is planning and carrying out a systematic investigation. Observations and data collected from such work are used to test existing theories and explanations or to revise and develop new ones (Framework, p. 50). In laboratory experiments, students are expected to decide which variables are to be treated as results or outputs, which are to be treated as inputs and intentionally varied from trial to trial, and which are to be controlled, or kept the same across trials. In the case of field observations planning involves deciding how to collect different samples of data under different conditions, even though not all conditions are under the direct control of the investigator. Scientific investigations may be undertaken to describe a phenomenon, or to test a theory or model for how the world works. Over time students are expected to become more systematic and careful in their methods (NGSS Appendix F).
4. Analyzing and interpreting data	Scientific investigations produce data that must be analyzed in order to derive meaning. Because data usually do not speak for themselves, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Sources of error are identified and the degree of certainty calculated. Modern technology makes the collection of large data sets much easier, thus providing many secondary sources for analysis (Framework, p. 51). Features and patterns in the data are interpreted in light of relevant models and theories (BSCS Guide). As students mature they are expected to expand their capabilities to use a range of tools for tabulation, graphical representation, visualization, and statistical analysis. Students are also expected to improve their abilities to interpret data by identifying significant features and patterns, use mathematics to represent relationships between variables, and take into account sources of error. Whether analyzing data for the purpose of science or engineering, it is important that students present the data so that it serves as evidence to support their conclusions (NGSS Appendix F).
5. Using mathematics and computational thinking	In science, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks, such as constructing simulations, statistically analyzing data, and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable predictions of the behavior of physical systems, along with the testing of such predictions. Moreover, statistical techniques are invaluable for assessing the significance of patterns or correlations (Framework, p. 51). The identification of patterns or correlations support scientists in solving problems, describing relationships, and making predictions about natural phenomena (BSCS Guide). Students are expected to use mathematics to represent physical variables and their relationships, and to make quantitative predictions. Other applications of mathematics in science and engineering include logic, geometry, and at the highest levels, calculus. Computers can enhance the power of mathematics by automating calculations, approximating solutions to problems that cannot be calculated precisely, and analyzing large data sets available on the Internet to identify meaningful patterns. Students are expected to use laboratory tools connected to computers for observing, measuring, recording, and processing data. Students are also expected to engage in computational thinking, which involves strategies for organizing and searching data, creating sequences of steps called algorithms, and using and developing new simulations of natural and designed systems. Mathematics is a tool that is key to understanding science. As such, classroom instruction must include critical skills of mathematics and enhance all of science through the use of quality mathematical and computational thinking (NGSS Appendix F).
6. Constructing explanations (for science)	The goal of science is the construction of theories that can provide explanatory accounts of features of the world (natural phenomena). A theory becomes accepted when it has been shown to be superior to other explanations in the breadth of phenomena it accounts for and in its explanatory coherence and parsimony. Scientific explanations are explicit applications of theory to a specific situation or phenomenon, perhaps with the intermediary of a theory-based model for the system under study. The goal for students is to construct logically coherent explanations of phenomena that incorporate their current understanding of science, or a model that represents it, and are consistent with the available evidence (Framework, p. 52). As a practice, students are expected to construct their own explanations as well as apply standard explanations that they learn about from their teachers or reading (NGSS Appendix F).
7. Engaging in argument from evidence	In science, reasoning and argument are essential for identifying the strengths and weaknesses of a line of reasoning and for finding the best explanation for a natural phenomenon. Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated (Framework, p. 52). Scientists engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to identify strengths and weaknesses of claims. Student engagement in scientific argumentation is critical if students are to understand the culture in which scientists live, and how to apply science and engineering for the benefit of society. Students are expected to use argumentation to listen to, compare, and evaluate competing ideas and methods based on their merits (NGSS Appendix F).
8. Obtaining, evaluating, and communicating information	Science cannot advance if scientists are unable to communicate their findings clearly and persuasively or to learn about the findings of others. A major practice of science is thus the communication of ideas and the results of inquiry—orally, in writing, with the use of tables, diagrams, graphs, and equations, and by engaging in extended discussions with scientific peers. Science requires the ability to derive meaning from scientific texts (such as papers, the Internet, symposia, and lectures), to evaluate the scientific validity of the information thus acquired, and to integrate that information (Framework, p. 53). Being able to read, interpret and produce scientific text are fundamental practices of science, as is the ability to communicate clearly and persuasively. Being a critical consumer of information about science requires the ability to read or view reports of scientific advances or applications, whether found in the press, the Internet, or in a town meeting, and to recognize the salient ideas, identify sources of error and methodological flaws, distinguish observations from inferences, arguments from explanations and claims from evidence. Scientists employ multiple sources to acquire information that is used to evaluate the merit and validity of claims, methods, and designs (NGSS Appendix F January Draft). Students are expected to obtain, evaluate, and communicate information and results of scientific inquiries to peers (BSCS Guide).

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Achieve, Inc. (2013). *NGSS Public Release II Appendix F*. Downloaded January 8, 2013 from http://www.nextgenscience.org/next-generation-science-standards