

Next Generation Science Standards

Science and Engineering Practices*

All Grades

SEP #1: Asking questions and defining problems

Grades K-2.

Progresses to simple descriptive questions that can be tested

- Ask questions based on observations to find more information about the natural and/or designed world(s)
- Ask and/or identify questions that can be answered by an investigation
- Define a simple problem that can be solved through the development of a new or improved object or tool

Grades 3-5

Progresses to specifying qualitative relationships

- Ask questions about what would happen if a variable is changed
- Identify scientific and non-scientific questions
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships
- Use prior knowledge to describe problems that can be solved
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost

Grades 6-8

Progresses to specifying relationships between variables and clarifying arguments and models

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information
- Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument
- Ask questions to determine relationships between independent and dependent variables and relationships in models
- Ask questions to clarify and/or refine a model, an explanation, or an engineering problem
- Ask questions that require sufficient and appropriate empirical evidence to answer
- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles
- Ask questions that challenge the premise(s) of an argument or the interpretation of a data set
- Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions

Grades 9-12

Progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations

- Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information
- Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships
- Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables
- Ask questions to clarify and refine a model, an explanation, or an engineering problem
- Evaluate a question to determine if it is testable and relevant
- Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field with available resources, and, when appropriate, frame a hypothesis based on a model or theory
- Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design
- Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and/or environmental considerations

SEP #2: Developing and using models

Grades K-2.

Progresses to include using and developing models that represent concrete events or design solutions

- Distinguish between the model and the actual object, process, and/or events the model represents*
- Compare models to identify common features and differences*
- Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s)*
- Develop a simple model based on evidence to represent a proposed object or tool*

Grades 3-5

Progresses to building and revising simple models and using models to represent events and design solutions

- Identify limitations of models*
- Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events*
- Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution*
- Develop and/or use models to describe and/or predict phenomena*
- Develop a diagram or simple physical prototype to convey a proposed object, tool, or process*
- Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system*

Grades 6-8

Progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems

- Evaluate limitations of a model for a proposed object or tool*
- Develop or modify a model – based on evidence – to match what happens if a variable or component of a system is changed*
- Use and/or develop a model of simple systems with uncertain and less predictable factors*
- Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena*
- Develop a model to describe unobservable mechanisms*
- Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales*

Grades 9-12

Progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s)

- Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria*
- Design a test of a model to ascertain its reliability*
- Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system*
- Develop and/or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations*
- Develop a complex model that allows for manipulation and testing of a proposed process or system*
- Develop and/or use a model to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems*

SEP #3: Planning and carrying out investigations

Grades K-2.

Progresses to simple investigations which provide data to support explanations or design solutions.

- With guidance, plan and conduct an investigation in collaboration with peers (for K)*
- Plan and conduct a collaborative investigation to produce data to serve as the basis for evidence to answer a question*
- Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question*
- Make observations and/or measurements to collect data that can be used to make comparisons*
- Make observations and/or measurements of a proposed object or tool or solution to determine if solves a problem or meets a goal*
- Make predictions based on prior experiences*

Grades 3-5

Progresses to include investigations that control variables and provide evidence to support explanations or design solutions

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using a fair test in which variables are controlled and the number of trials considered*
- Evaluate appropriate methods and/or tools for collecting data*
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution*
- Make predictions about what would happen if a variable changes*
- Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success*

Grades 6-8

Progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim*
- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for the evidence that meet the goals of the investigation*
- Evaluate the accuracy of various methods for collecting data*
- Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions*
- Collect data about the performance of a proposed object, tool, process or system under a range of conditions*

Grades 9-12

Progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models

- Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variable are controlled*
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data and refine the design accordingly*
- Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts*
- Select appropriate tools to collect, record, analyze, and evaluate data*
- Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated*
- Manipulate variable and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables*

SEP #4: Analyzing and interpreting data

Grades K-2.

Progresses to collecting, recording, and sharing observations

- Record information*
- Use and share pictures, drawings, and/or writings of observations*
- Use observations to describe patterns and/or relationships in the natural and/or designed world(s) to answer scientific questions and solve problems*
- Compare predictions to what occurred*
- Analyze data from tests of an object or tool to determine if it works as intended*

Grades 3-5

Progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations (use digital tools when possible)

- Represent data in tables and/or various graphical displays to reveal patterns that indicate relationships*
- Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation*
- Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings*
- Analyze data to refine a problem statement or the design of a proposed object, tool, or process*
- Use data to evaluate and refine design solutions*

Grades 6-8

Progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis

- Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships*
- Use graphical displays of large data sets to identify temporal and special relationships*
- Distinguish between causal and correlational relationships in data*
- Analyze and interpret data to provide evidence for phenomena*
- Apply concepts of statistics and probability to analyze and characterize data, using digital tools when feasible*
- Consider limitations of data analysis and/or seek to improve precision and accuracy of data with better technological tools and methods*
- Analyze and interpret data to determine similarities and differences in findings*
- Analyze data to define an optimal operational range for a proposed object, tool, process or system that best meets criteria for success*

Grades 9-12

Progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data

- Analyze data using tools, technologies, and/or models in order to make valid and reliable scientific claims or determine and optimal design solution*
- Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible*
- Consider limitations of data analysis when analyzing and interpreting data*
- Compare and contrast various types of data sets to examine consistency of measurements and observations*
- Evaluate the impact of new data on a working explanation and/or model of a proposed process or system*
- Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success*

SEP #5: Using mathematics and computational thinking

Grades K-2.

Progresses to recognizing that mathematics can be used to describe the natural and designed world(s)

- Decide when to use qualitative vs. quantitative data*
- Use counting and numbers to identify and describe patterns in the natural and designed world(s)*
- Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs*
- Use quantitative data to compare two alternative solutions to a problem*

Grades 3-5

Progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions

- Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success*
- Organize simple data sets to reveal patterns that suggest relationships*
- Describe, measure, estimate, and/or graph quantities to address scientific and engineering questions and problems*
- Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem*

Grades 6-8

Progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions

- Use digital tools to analyze very large data sets for patterns and trends*
- Use mathematical representations to describe and/or support scientific conclusions and design solutions*
- Create algorithms to solve a problem*
- Apply mathematical concepts and/or processes to scientific and engineering questions and problems*
- Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem*

Grades 9-12

Progresses to using algebraic thinking and analysis, a range of linear and non-linear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions

- Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system*
- Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations*
- Apply techniques of algebra and functions to represent and solve scientific and engineering problems*
- Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model 'makes sense' by comparing the outcomes with what is known about the real world*
- Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units*

SEP #6: Constructing explanations and designing solutions

Grades K-2.

Progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions

- Make observations to construct an evidence-based account for natural phenomena*
- Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem*
- Generate and/or compare multiple solutions to a problem*

Grades 3-5

Progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems

- Construct an explanation of observed relationships*
- Use evidence to construct or support an explanation or design a solution to a problem*
- Identify the evidence that supports particular points in an explanation*
- Apply scientific ideas to solve design problems*
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution*

Grades 6-8

Progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena*
- Construct an explanation using models or representations*
- Construct a scientific explanation based on valid and reliable evidence obtained from sources and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future*
- Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real world phenomena, examples, or events*
- Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion*
- Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process, or system*
- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints*
- Optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing*

Grades 9-12

Progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories

- Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables*
- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future*
- Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects*
- Apply scientific reasoning theory and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion*
- Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations*

SEP #7: Engaging in argument from evidence

Grades K-2.

Progresses to comparing ideas and representations about the natural and designed world(s)

- Identify arguments supported by evidence*
- Distinguish between explanations that account for all gathered evidence and those that do not*
- Analyze why some evidence is relevant to a scientific question and some is not*
- Distinguish between opinions and evidence in one's own explanations*
- Listen actively to arguments to indicate agreement or disagreement based on evidence and/or retell the main points*
- Construct an argument with evidence to support a claim*
- Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence*

Grades 3-5

Progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s)

- Compare and refine arguments based on an evaluation of the evidence presented*
- Distinguish among facts, reasoned judgement based on research findings, and speculation in an explanation*
- Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions*
- Construct and/or support an argument with evidence, data, and/or model*
- Use data to evaluate claims about cause and effect*
- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem*

Grades 6-8

Progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s)

- Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts*
- Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail*
- Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem*
- Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system based on empirical evidence concerning whether or not the technology meets relevant criteria and constraints*
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria*

Grades 9-12

Progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science

- Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations, constraints, and ethical issues*
- Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments*
- Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions*
- Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence*
- Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence*
- Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors*

SEP #8: Obtaining, evaluating, and communicating information

Grades K-2.

Uses observations and texts to communicate new information

- Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s)*
- Describe how specific images support a scientific or engineering idea*
- Obtain info using various texts, text features, and other media that will be useful in answering a scientific question and/or supporting a scientific claim*
- Communicate info or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas*

Grades 3-5

Progresses to evaluating the merit and accuracy of ideas and methods

- Read and comprehend grade-appropriate complex texts and/or other reliable media to summarize and obtain scientific and technical ideas and describe how they are supported by evidence*
- Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices*
- Combine information in written text with that contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices*
- Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem*
- Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts*

Grades 6-8

Progresses to evaluating the merit and validity of ideas and methods

- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s)*
- Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings*
- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence*
- Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts*
- Communicate scientific and/or technical information in writing and/or through oral presentations*

Grades 9-12

Progresses to evaluating the validity and reliability of the claims, methods, and designs

- Critically read scientific literature adapted for classroom use to determine the central ideas of conclusions and/or obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms*
- Compare, integrate and evaluate sources of information presented in different media or formats as well as in words in order to address a scientific question or solve a problem*
- Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source*
- Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible*
- Communicate scientific and/or technical information or ideas in multiple formats*