K – 12 Inquiry and Design (Science Practices)

The nature of science and technology is characterized by applying process knowledge that enables students to become independent learners. These skills include observing, classifying, inferring, predicting, measuring, computing, estimating, communicating, using space/time relationships, defining operationally, raising questions, formulating hypotheses, testing and experimenting, designing controlled experiments, recognizing variables, manipulating variables, interpreting data, formulating models, designing models, and producing solutions. Everyone can use them to solve real-life problems. These process skills are developed across the grade levels and differ in the degree of sophistication, quantitative nature and application to the content. Each competency is to be taught throughout the teaching of science. It is how students learn science and is not once and done. All competencies must be taught continuously within each grade level and high school science classes.

Each competency is aligned to the 2002 Academic Standards for Science and Technology, SAS Standards, Assessment Anchors and Eligible Content, and Next Generation Science Standards. This is a worksheet for each school/district to ensure each competency is integrated into the entire science curriculum. It is important to note that addressing the competencies is throughout each grade level as students are learning science. Students must always be utilizing these skills throughout the entire year.

Asking questions and defining problems in K–2 builds on prior experiences and progresses to simple descriptive questions that can be tested. Asking questions and defining problems in 3–4 builds on K–2 experiences and progresses to specifying qualitative relationships. Asking questions and defining problems in 5–8 builds on K–4 experiences and progresses to specifying relationships between variables, and clarifying arguments and models. Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

K – 2	3 – 5	6 – 8	9 – 12
Ask questions based on observations to find more information about the natural and/or designed world(s).	Ask questions about what would happen if a variable is changed.	Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.	Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
Ask and/or identify questions that can be answered by an investigation.	Identify scientific (testable) and non-scientific (non-testable) questions.	Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument.	Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
Define a simple problem that can be solved through the development of a new or improved object or tool.	Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.	Ask questions to determine relationships between independent and dependent variables and relationships in models.	Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.
	Use prior knowledge to describe problems that can be solved.	Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.	Ask questions to clarify and refine a model, an explanation, or an engineering problem.
	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.	Ask questions that require sufficient and appropriate empirical evidence to answer.	Evaluate a question to determine if it is testable and relevant.
		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 can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
		Ask questions that challenge the premise(s) of an	Ask and/or evaluate questions that challenge the

		argument or the interpretation of a data set.	premise(s) of an argument, the interpretation of a data set, or the suitability of a design.
		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.	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.

Developing and using models in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions. Modeling in 3–4 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. Modeling in 5–8 builds on K–4 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems. Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

K – 2	3 – 5	6 – 8	9 – 12
Distinguish between a model and the actual object, process, and/or events the model represents.	Identify limitations of models.	*Evaluate limitations of a model for a proposed object or tool.*	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.
Compare models to identify common features and differences.	Develop a simple model based on evidence to represent 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.	Design a test of a model to ascertain its reliability.
Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).	Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events.	Use and/or develop a model of simple systems with uncertain and less predictable factors.	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 a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.	Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.	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 and/or use models to describe and/or predict phenomena.	Develop and/or use a model to predict and/or describe phenomena.	Develop a complex model that allows for manipulation and testing of a proposed process or system.
	Develop a diagram or simple physical prototype to convey a proposed object, tool, or process.	Develop a model to describe unobservable mechanisms.	Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.
	Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.	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.	

Planning and Carrying Out Investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use

multiple variables and provide evidence to support explanations or solutions. Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

K – 2	3 – 5	6 – 8	9 – 12
With guidance, plan and conduct an investigation in collaboration with peers (for kindergarten).	Evaluate appropriate methods and/or tools for collecting data.	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.	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 variables are controlled.
Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.	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.	Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.	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 (e.g., number of trials, cost, risk, time), and refine the design accordingly.
Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question.	Make predictions about what would happen if a variable changes.	Evaluate the accuracy of various methods for collecting data.	Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
Make observations (first hand or from media) and/or measurements to collect data that can be used to make comparisons.	Test two different models of the same proposed object, tool, or process to design solutions under a range of conditions.	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.	Select appropriate tools to collect, record, analyze, and evaluate data.
Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal.	Collect data about the performance of a proposed object, tool, process or system under a range of conditions.	Collect data about the performance of a proposed object, tool, process or system under system under a range of conditions.	Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.
Make predictions based on prior experiences.			Manipulate variables 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.

Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions. Constructing explanations and designing solutions in 3–4 builds on K–2 experiences and 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. Constructing explanations and designing solutions in 5–8 builds on K–4 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

K – 2	3 – 5	6 – 8	9 – 12
Make observations (firsthand or from media) to construct an evidence-based account for natural	Construct an explanation of observed relationships (e.g., the distribution of plants in	Construct an explanation that includes qualitative or quantitative relationships between variables that	Make a quantitative and/or qualitative claim regarding the relationship between dependent

phenomena.	the back yard).	predict(s) and/or describe(s) phenomena.	and independent variables.
Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem.	Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.	Construct an explanation using models or representations.	Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) 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.
Generate and/or compare multiple solutions to a problem.	Identify the evidence that supports particular points in an explanation.	Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) 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 ideas to solve design problems.	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, 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.
	Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.	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.	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.
		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.	

Analyzing and Interpreting data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations. Analyzing data in 3–4 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. Analyzing data in 5–8 builds on K–4 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

K – 2	**3 – 5**	**6 – 8**	**9 – 12**
Record information (observations, thoughts, and	When possible and feasible, digital tools should	Construct, analyze, and/or interpret graphical	Analyze data using tools, technologies, and/or

ideas).	be used.	displays of data and/or large data sets to identify linear and nonlinear relationships.	models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
Use and share pictures, drawings, and/or writings of observations.	Represent data in tables and/or various graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.	Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.	Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.
Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems.	Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.	Distinguish between causal and correlational relationships in data.	Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.
Compare predictions (based on prior experiences) to what occurred (observable events).	Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.	Analyze and interpret data to provide evidence for phenomena.	Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
Analyze data from tests of an object or tool to determine if it works as intended.	Analyze data to refine a problem statement or the design of a proposed object, tool, or process.	Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.	Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.
	Use data to evaluate and refine design solutions	Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).	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.
		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.	

Using mathematics and computational thinking in K–2 builds on prior experience and progresses to recognizing that mathematics can be used to describe the natural and designed world(s). Mathematical and computational thinking in 3–5 builds on K–2 experiences and progresses to extending quantitative measurements to a variety of physical properties and using computation and mathematics to analyze data and compare alternative design solutions. Mathematical and computational thinking in 6–8 builds on K–5 experiences and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments. Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear 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.

K – 2	**3 – 5**	**6 – 8**	**9 – 12**
Decide when to use qualitative vs. quantitative	Decide if qualitative or quantitative data are best	Use digital tools (e.g., computers) to analyze very	Create and/or revise a computational model or

data.	to determine whether a proposed object or tool meets criteria for success.	large data sets for patterns and trends.	simulation of a phenomenon, designed device, process, or system.
Use counting and numbers to identify and describe patterns in the natural and designed world(s).	Organize simple data sets to reveal patterns that suggest relationships.	Use mathematical representations to describe and/or support scientific conclusions and design solutions.	Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.	Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.	Create algorithms (a series of ordered steps) to solve a problem.	Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
Use quantitative data to compare two alternative solutions to a problem.	Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.	Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and 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.
		Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.	Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, etc.).

Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s). Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s). Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s). Engaging in argument from evidence in 9–12 builds on K–8 experiences and 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.

K – 2	**3 – 5**	**6 – 8**	**9 – 12**
Identify arguments that are supported by evidence.	Compare and refine arguments based on an evaluation of the evidence presented.	Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.	Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
Distinguish between explanations that account for all gathered evidence and those that do not.	Distinguish among facts, reasoned judgment based on research findings, and speculation in an explanation.	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.	Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
Analyze why some evidence is relevant to a	Respectfully provide and receive critiques from	Construct, use, and/or present an oral and written	Respectfully provide and/or receive critiques on

scientific question and some is not.	peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.	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.	scientific arguments by probing reasoning and evidence, challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining additional information required to resolve contradictions.
Distinguish between opinions and evidence in one's own explanations.	Construct and/or support an argument with evidence, data, and/or a model.	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.	Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument.	Use data to evaluate claims about cause and effect.	Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.	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.
Construct an argument with evidence to support a claim.	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.		Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).
Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.			

Obtaining, evaluating, and communicating information in K–2 builds on prior experiences and uses observations and texts to communicate new information. Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and 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. Obtaining, evaluating, and communicating information in 6–8 builds on K–5 experiences and progresses to evaluating the merit and validity of ideas and methods. Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

K – 2	3 – 5	6 – 8	9 – 12
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).	Compare and/or combine across complex texts and/or other reliable media to support the engagement in other scientific and/or engineering practices.	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).	Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to 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.
Describe how specific images (e.g., a diagram	Combine information in written text with that	Integrate qualitative and/or quantitative scientific	Compare, integrate and evaluate sources of

showing how a machine works) support a scientific or engineering idea.	contained in corresponding tables, diagrams, and/or charts to support the engagement in other scientific and/or engineering practices.	and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.	information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.
Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim.	Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.	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.	Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.
Communicate information 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.	Communicate scientific and/or technical information orally and/or in written formats, including various forms of media as well as tables, diagrams, and charts.	Evaluate data, hypotheses, and/or conclusions in scientific and technical texts in light of competing information or accounts.	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 (e.g. about a proposed object, tool, process, system) in writing and/or through oral presentations.	Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).