Ready To Learn

PBS KIDS Science Learning Framework

Science										
The study of the natural world, both living and nonliving, through a process of inquiry that includes observation, prediction, and experimentation leading to understanding/explanation.										
Science and Engineering Practices										
The practices that develop the skills, thinking, and language of Scientific Inquiry and Engineering Design.										
1. Asking questions (for science) and defining problems (for engineering) 2. Developing and using models 3. Planning and carrying out investigations 4. Analyzing and interpreting data 5. Using mathematics and computational thinking 6. Constructing explanations (for science) and designing solutions (for engineering) 7. Engaging in argument from evidence 8. Obtaining, evaluating, and communicating information										
Life Science				**Earth & Space Science**			**Physical Science**			
The study of the structure, behaviors, and relationships of living organisms.				*The study of processes that operate on Earth and of Earth's place in the solar system and the galaxy.*			*The study of the characteristics and properties of energy and nonliving matter.*			
From Molecules to Organisms: Structures and Processes	Ecosystems: Interactions, Energy, and Dynamics	Heredity: Inheritance and Variation of Traits	Biological Evolution: Unity and Diversity	Earth's Place in the Universe	Earth's Systems	Earth and Human Activity	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technologies for Information Transfer
Engineering & Technology										
The practice of design to find solutions to particular human problems (engineering) and the human-made tools, systems, and processes created to fulfill human needs and wants (technology).										

A Note about Science, Engineering and Technology

Welcome to the exciting, content-rich, and interdisciplinary world of Science, Engineering and Technology! Science can be defined as the study of the natural world, both living and nonliving, through a process of inquiry that includes observation, prediction, and experimentation leading to understanding/explanation. It encompasses many different areas of study including biology, ecology, geology, astronomy, chemistry, and physics. It is also integral to the fields of Engineering and Technology because our understanding of science shapes and constrains the tools, structures, and systems that people can design and build. The three disciplines should be approached in a way that serves to deepen the understanding of each other. Scientific knowledge is applied when engaged in engineering design with the goal of finding solutions to practical problems. Technologies are the product of engineering design and can be used to assist and aid in further scientific investigations or design processes, as well as in play or work. (*NGSS,* 2013)

Young children are natural scientists and engineers with a strong curiosity about how the world works. Through play and informal investigations as infants and toddlers, they begin to gather information and experiences about the living things and objects around them. As children develop socially and cognitively, the depth with which children engage in specific science concepts and the use of foundational inquiry practices changes. What children are capable of learning at a particular age is dependent on maturation, experience, and instruction (*Michaels et al.,* 2008, p. 2-3). But even at very early ages, children are sophisticated thinkers capable of understanding abstract concepts. By the time they enter Kindergarten, they have built a substantial knowledge base about the natural and human-designed world and can reason about the world in ways that provide the basis for scientific inquiry (*NRC,* 2007, p. 53). Once children enter school, they engage in more formal explorations of the natural and human-designed world, building on and amending the understandings acquired in infancy and as toddlers and preschoolers. PBS KIDS is uniquely positioned to leverage children's natural curiosity and build on children's existing understanding of science and engineering concepts and enrich their abilities to use science and engineering practices by providing a variety of rich, engaging, contextualized, and connected science- and engineering-focused media experiences.

Using the Science Learning Framework

This Framework will align with the content focus of many state standards for preschool and the early elementary years as established by the *Next Generation Science Standards* (2013). *NGSS* names four content domains: **Physical Science, Life Science, Earth and Space Sciences, and Engineering and Technology** and identifies Core Ideas within each. These Core Ideas, together with foundational Science and Engineering Practices and fundamental Crosscutting Concepts, form the core dimensions and thinking behind current science education as outlined by the *Framework for K-12 Science Education* (2012). Powerful learning occurs when children use the practices to engage in inquiry around meaningful content while highlighting related themes.

Like other PBS KIDS Learning Frameworks, the Science Framework includes a list of skills, sub-skills and knowledge for the major domains represented in the framework chart. These include the 4 content domains outlined above and the Science and Engineering Practices. Disciplinary core ideas in each domain have also been listed and represent the science topics that are appropriate for the target age group. Also provided are examples demonstrating how Crosscutting Concepts emerge from each of the four Core Ideas. Skills and knowledge are broken down by age range to highlight the developmental progression of scientific thinking and to provide examples of how children can appropriately engage with science content at each level. **It is very important to remember that most science concepts can be explored at multiple ages as long as the children are engaged at a developmentally appropriate level and that older children may continue to engage with content presented at earlier ages.** Whenever appropriate, connections will also be made between skills and practices in the Science Framework to related skills and practices in the PBS KIDS Literacy-ELA, Math, Social Studies, and Social Emotional Learning (SEL) Frameworks.

Key Components of the Framework

- **Inquiry and the Science and Engineering Practices –** At the foundation of science learning and engineering design are the Science and Engineering Practices. When children engage in these practices, they develop the skills, thinking, and language of inquiry. Young children's ability to engage in the inquiry process helps them gain understanding of the world around them by helping them find answers to their questions sparked by natural curiosity or when they try to solve a problem they encounter through the engineering design process. Children use these practices whenever they engage in science investigations and/or engineering design. It is also important to note the relationship between inquiry in science and inquiry in other subject areas. Children use similar thinking and reasoning skills when engaged in other academic areas including Math and Literacy. [See Appendix B] This Framework will provide examples of how children might engage in these fundamental practices in developmentally appropriate ways from age 2 through 8.
- **Disciplinary Core Ideas –** As mentioned, the Framework content aligns with the four content domains of Physical Science, Life Science, Earth and Space Sciences, and Engineering and Technology as presented in the *NGSS*. At early ages, children are just beginning to develop an understanding of core ideas within these content domains and are developing a foundation in experience to explain more complex phenomena as they progress through elementary school and beyond. These Core Ideas cover a broad range of content. This Framework will focus on appropriate core science ideas and topics within each of these domains for the PBS KIDS target audience of ages 2-8.
- **Crosscutting Concepts –** The *Framework for K-12 Science Education* (2012) outlines 7 crosscutting concepts to unite the core ideas of science and engineering: 1) Patterns, 2) Cause and Effect, 3) Systems and System Models, 4) Stability and Change, 5) Structure and Function, 6) Energy and Matter, and 7) Scale, Proportion and Quantity. These represent themes that emerge across all domains of science as well as in other subject areas including Literacy, Math, and Social Studies. Some of these concepts, including Patterns, Cause and Effect, Structure and Function, and Scale, Proportion, and Quantity, are most appropriate for the ages targeted in this Framework. Children should be guided to look for these embedded concepts to help them connect ideas across the science domains and better understand the core ideas of science and engineering. To do this, children should engage in authentic learning experiences that highlight the language of and ideas behind each concept. Children's depth of understanding of these concepts will increase in sophistication as children grow in their understanding of the science content domains. You will notice these concepts infused into the sub-skills of each content domain – these are better not taught directly, but should emerge in the language used in the context of the ideas. [See Appendix B for definitions and content domains for samples]
- **Connecting Science to Literacy, Math, and Social Emotional Learning –** Science is intimately connected to other academic disciplines including Literacy, Math, and Social Emotional Learning. As mentioned, the Science and Engineering practices align closely with the practices engaged in both Literacy and Math learning. [See Appendix B] Similarly, Crosscutting Concepts have applications across academic disciplines and can provide a common vocabulary for science and engineering utilized in other academic disciplines. When children ask questions, engage in argument, record results, make predictions, learn new science vocabulary, and communicate their findings, they are using foundational literacy skills. When children weigh and measure an object, record data in a chart, sort and classify organisms by attributes, and find patterns in the natural world, children are using mathematics and computational thinking. And when young scientists and engineers work together to solve problems, share ideas, listen to and respect the opinions of others, and demonstrate persistence and open-mindedness, they are strengthening important social emotional skills and demonstrating civic mindedness.
- **Universal Design for Learning (UDL) Considerations –** It is important to remember that the experiences and background knowledge children bring to science is influenced by their cultural, linguistic, and economic background (NRC, 2007, p. 186). In addition, many children have special needs for learning that need to be addressed. An important consideration when developing content for children, including science content, are the Universal Design for Learning (UDL) Guidelines as outlined by CAST (2011). These guidelines consider the means by which ALL children, including, but not limited to, those with disabilities, English Language Learners (ELLs), and gifted children, might best acquire information and demonstrate competence, providing children with equal opportunities to learn. There are three guiding principles for creating flexible, accessible and engaging content: 1) Multiple Means of Representation (the "What" of learning), 2) Multiple Means of Engagement (the "Why" of learning), and 3) Multiple Means of Action and Expression (the "How" of learning). The Framework embraces UDL by using language that allows children to meet learning goals in many different ways and by providing examples for applying these principles to broadcast, digital, and outreach content. [See Appendix C]

SCIENCE AND ENGINEERING PRACTICES

The practices that develop the skills, thinking and language of Scientific Inquiry and Engineering Design.

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

The Science and Engineering Practices are integral to children's development of the skills, thinking, and language of scientific inquiry and engineering design. By engaging in these practices while immersed in meaningful and relevant science content, children better learn how to explore and investigate in science and they deepen their understandings. For engineering, the practices focus on identifying real-world problems and designing solutions to the problem. These practices engage children in observing, comparing and contrasting, identifying patterns, measuring, predicting, checking, recording and reporting. Though all children can engage in these practices, the way in which they approach them and the depth in which they can participate in each varies with age and experience. Younger children are likely to ask simpler questions, build simpler models, and provide less abstract and detailed explanations than older children. It is also important to remember that children may engage in these practices in different ways at different times. **There is no one "scientific method" but rather multiple entry points and ways in which to engage in the inquiry and design process.** [See Inquiry Cycle graphic in Appendix A] Children might observe something in their everyday environment and ask a question which leads to an investigation. Or they may be looking at and evaluating a peer's investigative data which may lead them to a new related question and investigation. No matter what draws them in, a critical part of the process is when children collect evidence and record observations and data, describe and reflect on the observations/data, and draw conclusions about the collected evidence.

Ages 2-3	PreK-K	Grades 1-2
<u>Asking Questions/Defining Problems</u> (*See also Literacy-ELA Framework – Speaking and Listening: Comprehension and Collaboration*) • Demonstrate curiosity about their local environment • Ask "What?", "Why?" and "How?" questions to gain answers • Identify and communicate problems experienced firsthand **<u>Developing and Using Models</u>** • Use drawings, pictures, movement and 3D materials to	**<u>Asking Questions/Defining Problems</u>** (*See also Literacy-ELA Framework – Speaking and Listening: Comprehension and Collaboration*) • Demonstrate curiosity about the greater world outside of their local environment • Ask more complex questions about observable phenomena (objects, materials, organisms, or events) • Ask and/or identify cause and effect questions that can be answered by an investigation • Identify a simple problem that can be solved through the design	**<u>Asking Questions/Defining Problems</u>** (*See also Literacy-ELA Framework – Speaking and Listening: Comprehension and Collaboration*) • Ask more complex questions, based on curiosity and observations, to gain deeper information about the natural and/or designed world(s) • Ask new testable questions based on the results of other investigations • Identify a problem that can be solved through the design and construction of a new or improved object or tool (engineering)

represent ideas and make sense of everyday experiences (with support)
- Begin to distinguish between a simple model and the actual object, process, and/or events the model represents

Planning and Carrying Out Investigations

- Use the 5 senses (sight, hearing, taste, touch, smell) to observe objects, materials, organisms, or events
- Begin to identify and use (with support) tools for observation like hand lenses
- Begin to compare and contrast objects and events by describing basic similarities and differences (e.g., similarities and differences between leaves, plants, balls, blocks, etc.)
- Make simple predictions about what happens next (e.g., If I push the block tower, it will fall down; I think there will be a worm under this log.)
- Anticipate some cause and effects of own actions (e.g., If I push the block tower it will fall down; If I plant this seed it will grow.)
- With support, engage in simple investigations and experiments (e.g., Building a "bridge"; investigating "What will happen to this tree when it gets cold?")

Analyzing and Interpreting Data

(*See also Math Framework – Data Collection and Analysis* AND *Literacy-ELA Framework – Speaking and Listening and Expository Writing*)

- Provide verbal or signed descriptions of observations of objects and events in the environment
- With support, record observations in various ways including pictures, marks on a page, words (dictated to adults), charts, journals, models and photos, and movement (3 yr olds)
- Describe in different ways what happened during an investigation (science) or while building (engineering)

Using Mathematics and Computational Thinking

(*See also Math Framework – Numbers and Operations, Geometry, and Measurement and Data)*

- Use counting and numbers to make observations about observable phenomenon (e.g., cats have four legs)

and construction of a new or improved object or tool (engineering)

Developing and Using Models

- Represent observable, concrete objects, events, and findings in many different ways including drawing, clay model, collage, and dramatization (PreK with support)
- Distinguish between a model and the actual object, process, and/or events represented by the model
- Use simple models to support explanations (e.g., draw an arrow to show what direction a ball is rolling; build an indoor environment for a worm that reflects the natural environment)

Planning and Carrying Out Investigations

- Identify and use a greater variety of tools to extend the 5 senses for observing, measuring, and recording data about objects and events (e.g., magnifying glass, binoculars, microscope, stethoscope, thermometer)
- Compare and contrast objects and events and by describing similarities and differences in greater detail
- Demonstrate an increased ability to make and test predictions based on background knowledge and experiences
- With guidance, plan and conduct simple investigations using simple tools (i.e. articulate steps to be taken and materials to use for exploring testable questions)
- Design and build a solution to a simple problem (engineering)

Analyzing and Interpreting Data

(*See also Math Framework – Data Collection and Analysis* AND *Literacy-ELA Framework – Speaking and Listening and Expository Writing*)

- Collect, describe, and record observations in greater detail and in various ways including pictures, words, charts, journals, models, photos, or by tallying and graphing information (some adult support may still be needed)
- Use the 5 senses and simple tools to gather and record data
- Record observations to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems.
- Talk about and reflect on what happened during an investigation

Developing and Using Models

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

Planning and Carrying Out Investigations

- Evaluate different ways of observing and/or measuring and/or manipulating a phenomenon to determine which way can answer a question
- Make observations (firsthand or from media) to collect data that can be used to make comparisons and predictions and conclusions
- 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 (engineering)
- Make and test predictions based on background knowledge and prior experiences
- With guidance, plan and conduct an investigation together with peers to produce data as evidence to answer a question (*see also Social Emotional Learning Framework – Social Awareness and Relationship Skills*)

Analyzing and Interpreting Data

(*See also Math Framework – Data Collection and Analysis* AND *Literacy-ELA Framework – Speaking and Listening and Expository Writing*)

- Record information (observations, thoughts, and ideas)
- Use a journal to record and share pictures, drawings, and/or writings of observations and findings
- 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
- Compare predictions (based on prior experiences) to what occurred (observable events)
- Analyze data from tests of an object or tool to determine if it works as intended

- Sort objects into groups based on simple attributes like shape, size, color, texture, odor and sound (3 year olds)
- Use comparative measurement vocabulary to compare attributes of different objects and describe similarities and differences between objects and events (e.g.,, longer/shorter; faster/slower, heavy/light)

Constructing Explanations (science) and Designing Solutions (engineering)

- Provide a simple description of results (i.e. "What happened when we pushed on the block tower? It fell down!")
- Design a solution to a problem like making a block building stand up (engineering)

Engaging in Argument from Evidence
(*See also Literacy-ELA Framework – Speaking and Listening: Presentation of Knowledge and Ideas*)

- Make simple inferences and form basic generalizations based on evidence (e.g., Notice that you are hungry and say that you want to eat)

Obtaining, Evaluating, and Communicating Information
(*See also Literacy-ELA Framework – Comprehension of Informational Text, Vocabulary, and Speaking and Listening* AND *Social Emotional Learning Framework – Relationship Skills*)

- Use the 5 senses as a tool to gain information about the characteristics of people and the properties of objects and their uses
- Use adults as the primary resource for information to answer information questions
- Share findings and explanations (correct or incorrect) with or without adult prompting
- Begin to use common science and engineering process words and vocabulary (e.g., observe, tool, scientist, engineer, experiment, build)

or when solving a problem, and why it might have happened

Using Mathematics and Computational Thinking
(*See also Math Framework – Numbers and Operations, Geometry, and Measurement and Data)*

- Use counting and numbers to describe, measure, and/or compare quantitative attributes of different objects. (e.g., number of legs on a spider vs. number of legs on an ant)
- Sort and categorize observable phenomena based on attributes such as appearance, weight, function, ability, texture, odor and sound
- Use mathematical language and vocabulary to describe attributes such as position (over/under), motion (forward), speed (fast/slow), shape (sphere), and size (big/small)
- Use measurement tools (ruler, balance scale, eye dropper, unit blocks, thermometer, measuring cup) to measure and quantify properties of observable phenomena and objects
- Create a simple graph to show data (with support)

Constructing Explanations (science) and Designing Solutions (engineering)

- Use background knowledge experiences, and data to construct reasonable explanations and theories of natural phenomena (may not be scientifically correct, rather naïve theories) (science)
- Look for and describe patterns and relationships in natural phenomena (science)
- Use and apply productive science discourse to support an explanation (e.g., think out loud, revise and rethink)
- Use evidence to support a theory (science) or solution to a problem (engineering)

Engaging in Argument from Evidence
(*See also Literacy-ELA Framework – Speaking and Listening: Presentation of Knowledge and Ideas* AND *Social Emotional Learning Framework – Social Awareness and Relationship Skills*)

- Engage in discussions before, during, and after investigations
- Support thinking and argue ideas with evidence
- With support, distinguish between opinions and evidence (K only)
- Discuss why some evidence is useful for supporting a scientific question and why some is not (K only)
- With support, compare results of an investigation to an original

Using Mathematics and Computational Thinking
(*See also Math Framework – Numbers and Operations, Geometry, and Measurement and Data)*

- Use counting and numbers to identify and describe patterns in the natural and designed world(s). (e.g., looking at three or more temperatures and describing the trend (up or down), counting the number of bounces of different balls to determine bounciness, counting the number of seeds that sprouted in damp towels versus dry ones)
- Select and use appropriate measurement tools to describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs
- Decide when to use qualitative (observations) versus quantitative (numerical) data or both
- Use quantitative and/or qualitative data to compare two alternative solutions to a problem

Constructing Explanations (science) and Designing Solutions (engineering)

- Construct evidence-based explanations for natural phenomena (science)
- Use tools and/or materials to design and/or build a device that provides a solution to a specific problem (engineering)
- Generate and/or compare multiple solutions (brainstorm) to a problem (engineering)

Engaging in Argument from Evidence
(*See also Literacy-ELA Framework – Speaking and Listening: Presentation of Knowledge and Ideas* AND *Social Emotional Learning Framework – Social Awareness and Relationship Skills*)

- Engage in discussions before, during, and after investigations
- Identify arguments that are supported by evidence
- Distinguish between opinions and evidence in one's own explanations
- Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument
- Construct an argument with evidence to support a claim
- Make a claim about the effectiveness of an object, tool, or

	prediction and offer evidence as to why they do or do not match (K only) **<u>Obtaining, Evaluating, and Communicating Information</u>** (*See also Literacy-ELA Framework – Comprehension of Informational Text, Vocabulary, and Speaking and Listening* AND *Social Emotional Learning Framework – Relationship Skills*) • Obtain information through discussing prior knowledge and observations with experts including teachers or knowledgeable adults • Obtain information using various age-appropriate texts, text features, and other media to help answer a question and/or support an explanation • Describe observable phenomena using adjectives and labels (rocks feel rough, flowers smell sweet) • Use basic science and engineering practice vocabulary when engaged in investigations (e.g., observe, compare, contrast, describe, question, predict, experiment, reflect, cooperate) • Use basic science and engineering content vocabulary when investigating and describing observable phenomena (e.g., mammal, life cycle, ecosystem, force) • Share findings and explanations (correct or incorrect) with greater detail and through a variety of methods (e.g., telling an adult or peer, writing/drawing in a journal)	solution that is supported by relevant evidence (engineering) **<u>Obtaining, Evaluating, and Communicating Information</u>** (*See also Literacy-ELA Framework – Comprehension of Informational Text, Vocabulary, and Speaking and Listening* AND *Social Emotional Learning Framework – Relationship Skills*) • Use grade-appropriate texts and/or media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s) • Use more sophisticated vocabulary to describe science and engineering practices and specific science and engineering concepts • Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea • 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 • Share 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

LIFE SCIENCE

The study of the structure, behaviors, and relationships of living organisms.

Disciplinary Core Ideas: Properties and Characteristics of Living Things; Parts of Living Things and Their Function; Basic Needs of Living Things; Behavior of Living Things; Growth and Development of Living Things; People as Living Things; Relationship Between Living Things and Their Environment; Variation and Diversity of Living Things

Life Science is focused on the study living things including what they look like, how they live, and how they change. Young children have a great interest in plants and animals and even at 2 and 3 years-old have accumulated background knowledge and have some basic understandings about living things through observations made in their local environment. As they grow, they gain experiences with many different animals and plants, and understand that people are animals. Their understanding deepens into PreK as they grow cognitively and accumulate personal experiences and knowledge. They notice that animals (including humans) use body parts and senses to meet their needs and that plants grow and change. By Kindergarten, children are aware of the basic needs of living things – all plants and animals need food, water, and air to grow and survive. And they learn the differences in how plants and animals meet their unique needs. They also start to make connections between needs and the environment – how plants and animals (including humans) depend on other living things and nonliving things in the environment, like water, to survive. In early elementary school, children use the science practices in more sophisticated ways, helping them to observe, analyze and communicate similarities and differences they see between types of plants and animals and how different environments may better meet the needs of certain living things. They gain a deeper understanding of life cycles and how plants and animals grow and change over time. They also can examine and communicate with more detail about similarities between parents and their young and the role parents play in the young's survival.

2-3 Year Olds	PreK-K	Grades 1-2
<u>From Molecules to Organisms: Structures and Processes</u> • **Begin to understand that all living things have external parts** ○ Identify basic physical characteristics of familiar animals and plants (e.g., color, shape, and texture) ○ Observe and record the physical appearance of an animal or plant with a simple drawing ○ Begin to distinguish between different kinds of plants of animals solely on differences in appearance ○ Begin to understand that people are animals and have similar characteristics, behaviors and needs • **Begin to understand that animals (including humans) have different body parts that are used in different ways to meet their needs, and that plants have different parts that help them survive and grow** ○ Explore one's own body parts and the parts of other living things	**<u>From Molecules to Organisms: Structures and Processes</u>** • **Understand that all living things have external parts** ○ Identify and describe the physical characteristics of a variety of animals and plants (inside and out) including color, shape, size and texture ○ Record observations about an animal's or plant's physical appearance using a drawing, written description or other representation ○ Begin to categorize a variety of animals and plants based on their physical characteristics • **Understand that animals (including humans) have different body parts that are used in different ways to meet their needs, and that plants have different parts that help them survive and grow** ○ Identify body parts of animals, including humans, and their function (e.g. mouth for eating, legs for walking, nose for breathing)	**<u>From Molecules to Organisms: Structures and Processes</u>** • **Gain a deeper understanding about the external parts of living things and their purpose(s) and function(s) for growth and survival** ○ Identify and explain how different external features of an animal help it survive in its environment (e.g., polar bear's thick fur to protect it from freezing temperatures) ○ <u>Engineering Connection</u>: Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs (e.g., designing clothing or equipment for protection mimicking a turtle's shell or animal scales; keep out intruders by mimicking thorns on branches) • **Understand that animals (including humans) have body parts that convey different kinds of information helpful for survival and growth and that they respond to these inputs with**

- Begin to identify the 5 senses and the associated body parts (eyes=sight, nose=smell, ears=hearing, skin=touch, tongue=taste) and use them to gain information about the world
- Identify basic parts of plants and animals (e.g., flower, leaf, tail)
- Differentiate between and begin to articulate the difference between animate and inanimate objects (e.g., animate objects can initiate their own movement and have different insides than inanimate objects)

- **Begin to understand that living things have needs in order to live and grow**
  - Begin to understand one's own basic needs (e.g., food, water, home/shelter, clothing, sleep, care/love
  - Show awareness of the need to care for living things (e.g.,, water plants, feed pets, put food out for birds)

- **Begin to understand that all animals (including humans) and plants change and grow over time**
  - Observe and explore how familiar plants and animals (including humans) grow and change over time (e.g. plant seeds and observe the growing plant; measure one's own height at different times of the year to observe growth)

Ecosystems: Interactions, Energy, and Dynamics

- **Begin to understand that animals and plants depend on their environment to meet some of their needs**
  - Match animals to an aquatic (water) or terrestrial (land) habitat
  - Begin to explore how animals, including humans, rely on the environment to meet some of their needs (e.g., animals find plants or other animals to eat in their environment)

Heredity: Inheritance and Variation of Traits

- **Understand that individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways**
  - Begin to recognize how we may look alike or different from others (hair color, eye color, size, shape)
  - Identify the basic parts of plants (roots, stems, leaves, flowers, fruits) and their function
  - Compare, using descriptions and drawings, how the external body parts of animals and plants are the same and/or different (comparing animals to animals and plants to plants)
  - Begin to explore how different external features of an animal help it survive in its environment (e.g., thick fur to keep warm)

- **Understand that all animals (including humans) need food in order to live and grow, that they get their food from plants or from other animals, and that plants need water and light to live and grow**
  - Observe ways that animals (including humans) and plants get what they need to live and grow
  - Describe patterns of the basic needs of plants and animals (including humans) to better understand what they need to survive (e.g., all plants and animals need water)
  - Help care for living things at home or in the classroom (e.g., water plants, feed pets)

- **Understand that all animals (including humans) and plants have a life cycle, can reproduce, and change and grow over time**
  - Observe the life cycle of familiar plants and animals, including humans (i.e., Animals are born, develop and grow, reproduce and die; Plants start from seed, then seedling, grow and develop, reproduce through flower and fruit, and die)
  - Observe and document the growth in animals (including humans) and plants and begin to understand that living things grow and change over time
  - Use charts, graphs, and other methods to record data about animal or plant growth (*See also Math Learning Framework – Data Collection and Analysis*)
  - Observe and explore parts of different kinds of life cycles of plants and animals (e.g., caterpillar to butterfly, tadpole to frog, seed to plant, eggs to chicks, animals born live)

Ecosystems: Interactions, Energy, and Dynamics

- **Begin to understand that animals and plants depend on other living things and nonliving things in the environment to meet some of their needs**
  - Distinguish between living things and nonliving things based on background knowledge and evidence (e.g., a cat or tree is living, but a rock is nonliving)

behaviors that help them survive
  - Communicate that most animals have 5 senses that they use to gather information about the world around them and use that information to meet their needs

- **Understand that all animals (including humans) need food in order to live and grow, as well as air and shelter. Animals get their food from plants or from other animals. Plants need water and light to live and grow, and make their own food.**
  - Identify how behaviors of living things help them meet their basic needs (e.g., plants and animals grow and move, react to their environment)

- **Understand that in many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive**
  - Use firsthand observations and age-appropriate texts and media to determine patterns in the behavior of parents and offspring that help offspring survive (e.g., vocalizations that baby animals make to tell their parents they are hungry or in danger) (*see also Literacy-ELA Framework – Comprehension of Informational Text*)

Ecosystems: Interactions, Energy, and Dynamics

- **Understand that animals and plants depend on other living things and nonliving things in the environment to meet some of their needs**
  - Compare how plants and animals depend on their environment and other living things to meet their needs in the places they live (e.g., Animals need food, water, air, shelter, and favorable temperature; Plants need sufficient light, water, minerals, favorable temperature and animals or other mechanisms to disperse seeds)
  - Investigate further the consequences of how plants and animals (including humans) impact and change the environment

- **Understand that plants depend on water and light to grow**
  - Observe the effects of darkness and light on living green plants
  - Plan and conduct an experiment to determine if green plants need sunlight and water to grow (by testing one variable at a time)

○ Identify characteristics of animals from the same species. (e.g., color, size) • **Begin to understand that young animals (including humans) and young plants are very much, but not exactly like their parents** ○ Identify characteristics of own family (e.g., hair color, eye color, and height) ○ Match pictures of familiar parent animals with their offspring (e.g., kitten with cat, baby human with adult human)	○ Identify the habitats of familiar animals and plants in the environment ○ Recognize that each kind of living things has a habitat that has resources to meet its unique needs ○ Identify and observe the consequences of how plants and animals (including humans) impact and change the environment **Heredity: Inheritance and Variation of Traits** • **Understand that individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways** ○ Observe and describe similarities and differences between individuals of the same kinds of plant and animal (e.g., compare how two guinea pigs are the same as and/or different from each other) ○ Observe and recognize how we are the same and different from others (e.g., friends and family) • **Understand that young animals (including humans) and young plants are very much, but not exactly like their parents** ○ Understand that the young of a species are the same kind of animal or plant as the parents (e.g., kittens come from cats not dogs; apple trees come from apple seeds which come from apple trees, not tomato seeds (or cats!)) ○ Arrange and compare illustrations of humans and other animals in developmental sequence from infancy to adult **Biological Evolution: Unity and Diversity** • **Begin to understand that there are many different kinds of living things and how they may be the same or different** ○ Count the number of different plants or animals found within a specified area (e.g., count the number of different bugs and/or plants inside a hula hoop placed on the ground) ○ Observe and describe similarities and differences across different types of plants and animals (e.g., compare how a cat is the same as/or different from a dog) ○ Group different kinds of living things into categories based on basic similarities and differences (e.g., plants vs. animals; animals that live on the ground vs. animals that live in the air; plants that have flowers vs. plants that do not) ○ Begin to identify changes in physical characteristics or behaviors	• **Understand that plants depend on animals (or other means) for pollination or to move their seeds around** ○ Develop a simple model that illustrates how an animal might disperse seeds or pollinate plants **Heredity: Inheritance and Variation of Traits** • **Understand that young animals (including humans) and young plants are very much, but not exactly like their parents** ○ Observe and gather evidence to identify similarities and differences in parent animals and plants and their offspring **Biological Evolution: Unity and Diversity** • **Understand there are many different kinds of living things in any area, and they exist in different places on land and in water** ○ Use firsthand observations and age-appropriate texts and media to compare differences in the kinds of living things living in different habitats (e.g., compare animals that live in a desert habitat to those that live in an arctic habitat) (*see also Literacy-ELA Framework – Comprehension of Informational Text)* ○ Identify changes in physical characteristics or behaviors of animals that occur during different seasons as an adaptation to the environment for survival (e.g., bears hibernate in the winter) ○ Use firsthand observations and age-appropriate texts and/or media to compare how living things have adapted to survive in their habitat (e.g., some animals use camouflage to blend in with their surroundings for protection from predators) (*see also Literacy-ELA Framework – Comprehension of Informational Text)*

	of animals, including humans, that occur during different seasons as an adaptation to their environment for survival (e.g. bears hibernate in the winter; people wear coats to stay warm in cold climates)	

Sample of *Crosscutting Concepts in* Life Science*:*

Patterns – Patterns in plant and animal survival needs (all living things need water); Patterns in the inheritance of traits from parent to child; Patterns apparent in seasonal changes

Cause and Effect – Scrape a knee and feel pain; Stop watering a plant and the plant dies

Systems and System Models – Skeletal, digestive, and other body systems; Life cycle of a frog

Stability and Change – Some trees are always green, others lose leaves; As people grow, their bodies change size but other characteristics stay the same (e.g., number of arms, eyes, ears, etc.)

Structure and Function **–** Shape of a duck's foot for the purpose of swimming; Properties of a tree trunk that contribute to its stability

Energy and Matter - A food chain (one animal eats another, the matter from that animal helps another animal grow); Energy from the sun helps plants grow; Animals (including people) eat food to get energy

Scale, Proportion, and Quantity – Baby animals are smaller than adult animals; The size of a shelter must fit the animals that will live in it

EARTH & SPACE SCIENCES

The study of processes that operate on Earth and of Earth's place in the solar system and the galaxy.

Disciplinary Core Ideas: Characteristics and Properties of Earth Materials and Objects; Weather and Climate; The Universe and Its Stars (Sun, Moon, Stars); Earth and the Solar System; Changes in the Earth Over Time; Human Impacts on the Environment

Earth and Space Science focuses on understanding the structure of the Earth and its history, climate, meteorology, and the solar system and universe. For the youngest children, learning about Earth and Space is grounded in what children can experience with their senses, and their background knowledge and understanding of concepts of Life Science and Physical Science provide an important foundation for deeper understanding of the Earth and space. Their natural curiosity about and play with Earth materials in their own backyard leads them to look more closely at sand, rocks, water, and air and begin to describe the observable characteristics of each. They ask questions about and begin to document the patterns they observe regarding the presence of the sun, moon, and stars in the sky. They observe the weather in their local environment and think about how weather impacts their lives and the lives of other animals and plants. They also begin to think about how their decisions and actions, and those of other people, impact the environment. As they move through PreK and into early elementary school, the focus on these areas deepens and they engage in data collection and analysis to better understand and communicate about patterns like the apparent movement of the sun and moon across the sky. They explore changes in the Earth over time and how something like a volcanic eruption results in immediate change as opposed to other events that might cause change more slowly. They also become more active in solving problems related to their local environment, designing possible solutions to lessen negative impacts by humans.

2-3 Year Olds	PreK-K	Grades 1-2
Earth's Place in the Universe • **Begin to understand that the Earth is made up of a variety of natural materials** ○ Observe, play with, and explore various types of earth materials such as sand, rocks, soil, water, and air using the 5 senses and simple tools ○ Begin to draw pictures to record the physical characteristics of basic earth materials ○ Use simple scientific vocabulary to label earth materials (e.g., sand, rocks, soil, water, air) • **Begin to understand that patterns of the motion of the sun, moon, and stars in the sky can be observed, described and predicted** ○ Observe and describe natural objects in the sky including	**Earth's Place in the Universe** • **Understand that the Earth is made up of a variety of natural materials** ○ Explore and describe the characteristics of earth materials such as sand, rocks, soil, water, and air (e.g., size, weight, shape, color, texture, wind's effects on the local environment) ○ Explore water and other Earth materials during play using simple tools (e.g., funnels, tubes, measuring cups, containers of various sizes, balance scale) ○ Sort and classify natural materials found in one's local environment • **Understand that patterns of the motion of the sun, moon, and stars in the sky can be observed, described and predicted** ○ Observe and describe natural objects in the sky and how they	**Earth's Place in the Universe** • **Understand that patterns of the motion of the sun, moon, and stars in the sky can be observed, described and predicted** ○ Observe the sun, moon, and stars and describe predictable patterns (e.g., each appears to rise in one part of the sky, move across the sky, and appears to set) ○ Use age-appropriate texts and other media to gain knowledge and domain-specific vocabulary and labels for other aspects of space science (e.g., constellations, planets in Earth's solar system, comets) • **Understand that seasonal patterns, including sunrise and sunset, can be observed, described, and predicted** ○ Observe and compare the relative amount of daylight at different times of the year (e.g., there is more daylight in the

the sun, moon, stars and clouds
- Begin to notice the pattern of day and night and the presence (or lack thereof) of the sun and moon (e.g., the sun and moon are in the sky; sun is seen during the day; moon may or may not be seen at night and during the day)

Earth's Systems

- **Begin to understand that weather is the combination of sunlight, wind, snow, or rain and temperature in a particular region at a particular time and can be measured by people to describe and record the weather and to notice patterns over time**
  - Use basic vocabulary to describe the current, daily weather conditions (e.g., sunny, cloudy, windy, raining, snowing, hot, cold)
  - Describe how weather affects the decisions people make about clothing and activities (e.g., wear a coat, hat and mittens when it's cold and go swimming in the summer)
  - Name and describe the 4 seasons and observable conditions for each season

Earth and Human Activity

(*see also Social Studies Framework – Geography: Human-Environment Interactions*)

- **Begin to experience and engage in simple activities that care for the environment**
  - Begin to help with family and classroom activities that help take care of the environment like recycling trash and turning off lights to conserve energy

appear to move and change (sun, moon, stars, clouds)
- Observe and provide evidence to describe, the apparent movement of the sun throughout the day (i.e. the sun is in different positions in the sky at different times)
- Understand, based on observation, that the moon can be seen in the daytime and at night
- Recognize, through observation, that the moon appears to change shape over a month's time

Earth's Systems

- **Understand that water is found in the ocean, rivers, lakes, and ponds and can exist as solid ice and in liquid form**
  - Explore and describe different places where water is found in the local environment (e.g., puddles, rivers, lakes, ocean)

- **Understand that weather is the combination of sunlight, wind, snow, or rain and temperature in a particular region at a particular time and can be measured by people to describe and record the weather and to notice patterns over time**
  - Observe, describe, record and discuss patterns and changes in the weather and seasons
  - Use simple tools (thermometer, rain gauge, weather chart) to collect and record data about elements of daily weather including sun, clouds, wind, snow, rain, and high or low temperatures (*see also Math Framework: Measurement and Data Collection and Analysis*)
  - Use and share quantitative observations of local weather conditions to describe patterns over time (e.g., chart the number of sunny and cloudy days in a month) (*see also Math Learning Framework: Measurement and Data Collection and Analysis*)
  - Notice and describe the impact of weather and seasonal changes on living things (e.g., identify weather-appropriate clothing and activity choices; recognize that many animals find shelter when it rains or hibernate when it's cold)
  - Differentiate between typical (rain, sun, snow) and severe (hurricane, tornado) types of weather in the local community

- **Understand that plants and animals (including humans) can change their environment**
  - Construct an argument (using evidence) for how plants and animals (including humans) can change the environment to meet their needs (e.g., squirrel digging holes in the ground to

summer months than in the winter months)
  - Analyze provided data to identify relationships among seasonal patterns of change (e.g., sunrise and sunset time changes, seasonal temperature and rainfall or snowfall patterns, and seasonal changes to the environment including bird migration, foliage changes, and changes in insect activity)

- **Understand that some events happen very quickly and others occur very slowly, over a time period much longer than one can observe**
  - Use information from several sources to provide evidence that Earth events can occur quickly or slowly (e.g., erosion of rocks occurs slowly while earthquakes and volcanic eruptions can occur quickly) (Grade 2)

Earth's Systems

- **Understand that wind and water can change the shape of the land**
  - Observe how blowing wind and flowing water can move Earth materials from one place to another and change the shape of a landform (e.g., creation of a sand bar in the ocean by waves and currents) (Grade 2)
  - Engineering Connection: Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land to determine design effectiveness (e.g., dikes and windbreaks designed to hold back wind and water; designs using shrubs, grass, and trees to hold back land) (Grade 2)

- **Understand that maps show where things are located**
  (*see also Math Framework – Spatial Sense* AND *Social Studies Framework – Geography: Geographic Tools and Spatial Thinking*)
  - Develop a model (drawing, map, diorama, etc.) to represent the shapes and kinds of landforms (hills, valleys, river banks, dunes) and bodies of water (streams, lakes, ponds, rivers, oceans) in an area (Grade 2)

- **Understand that water is found in the ocean, rivers, lakes, and ponds and can exist as solid ice and in liquid form**
  - Use firsthand observations and age-appropriate texts and/or media to identify where water is found on Earth (ocean, rivers and streams, lakes, ponds, puddles, snow, ice) and that it can be a solid or liquid (*see also Literacy-ELA Framework: Comprehension of Informational Texts*) (Grade 2)

	hide nuts) **<u>Earth and Human Activity</u>** (*see also Social Studies Framework – Geography: Human-Environment Interactions*) • **Understand that things people do to live comfortably can affect the world around them, but they can make choices that reduce their impacts on the land, water, air, and other living things** ○ Ask questions about and discuss examples of how humans use Earth's resources (including soil and water) to meet their needs (e.g., water can be used for drinking, washing, watering plants, putting out fires, boating, and fishing) ○ Demonstrate an awareness of and the ability to discuss in simple terms the need for conservation, recycling, and respect for the environment (e.g., turning off lights and faucets, reusing materials for another activity, separating materials into recycling bins) ○ Participate in simple activities to care for the environment (e.g., pick up and throw away litter, recycle plastic bottles and containers)	• **Gain a deeper understanding of weather conditions and patterns and how people can record and respond to them** ○ Gather information about and communicate how weather forecasting helps people prepare for, and respond to, different types of local weather **<u>Earth and Human Activity</u>** (*see also Social Studies Framework – Geography: Human-Environment Interactions*) • **Gain a deeper understanding of how people can affect the world around them and how they can help reduce their impacts on the land, water, air, and other living things** ○ <u>Engineering Connection:</u> Develop a solution to reduce the impact of humans on the land, air, water, and/or other living things in the local environment

Sample of *Crosscutting Concepts In* Earth and Space Science*:*

<u>Patterns</u> – Pattern of apparent movement of sun and moon in the sky; Cycling of the seasons; Day/night cycle; Wave action in the ocean

<u>Cause and Effect</u> – Rainstorms wash away soil; Wind moves things (e.g., blows leaves); An earthquake causes cracks in the ground

<u>Systems and System Models</u> – The water cycle; Interconnected environmental systems (habitats)

<u>Stability and Change</u> – Volcanoes change the land quickly whereas the waves of an ocean slowly roll rocks against each other making larger rocks smaller until they turn to sand; Tidal change at the beach; Stability of day/night (light/dark) pattern but changes in the length of each through the year

<u>Structure and Function</u> **–** Certain earth materials have specific structures that make them good for certain uses (e.g., rocks make good stone walls because they stack and do not blow over easily)

<u>Energy and Matter</u> – Sun's energy warms; Sand was once large rocks that have broken down (the amount of matter didn't change only the size of the rocks)

<u>Scale, Proportion, and Quantity</u> – Use numbers to describe the number of rocks, sandy places, puddles, etc. encountered when exploring outside; Sand, gravel, pebbles, and boulders are all made of the same materials but we call them different things based on their size; 100million sand pieces fit the size of one boulder

PHYSICAL SCIENCE

The study of the characteristics and properties of energy and nonliving matter.

Disciplinary Core Ideas: Structure and Properties of Matter (solid, liquid, gas); Forces and Motion of Objects (pushes and pulls); Chemical Reactions (heating or cooling); Energy; Waves: Light and Sound

Physical Science involves the direct exploration of objects, materials and events of the nonliving world that can be encountered in children's everyday lives. Starting with the movement of their own bodies through space as they learn to crawl and walk, children naturally experiment with and gain understanding about the properties of energy and nonliving matter. Infants and toddlers begin to explore objects by chewing on and manipulating toys, and they experience the effects of gravity and force when they drop their spoon off the high chair or knock over block towers. As they enter the preschool years, children are given more opportunities to play with and investigate liquids and solids, shadow and light, the pitch and volume of sounds, and how things move. In PreK and Kindergarten they look more closely at the difference between an object and the material it is made of, how pushes and pulls of different strengths and direction can affect the movement of objects, and how changes in temperature can cause a solid to become a liquid or a liquid to become a solid. They also explore how energy from the sun can warm the materials (including themselves!) on Earth and in space. As they progress into 1st and 2nd grades, they investigate and classify human-made and natural objects and materials based on their physical characteristics and their uses, exploring how objects change (or do not) when broken apart or put together. They can observe and analyze how light changes when it passes through different types of materials and use their deeper knowledge of sound and light waves to plan, design, and build something to communicate with others over a distance.

2-3 Year Olds	PreK-K	Grades 1-2
Matter and Its Interactions • **Begin to understand that different kinds of matter exist and these can be described and classified by their observable properties** ○ Use the 5 senses to observe, play with, manipulate, and describe a variety of human-made and natural materials (solid and nonsolid) including water, sand, clay, paint, glue, blocks, simple household items, and objects made from wood, metal, or cloth • **Begin to understand that different kinds of matter can be solid or liquid depending on temperature** ○ Investigate, with support, the physical properties of solids and liquids (size, weight, shape, color, texture, and sound) • **Begin to understand that heating or cooling a substance may cause changes that can be observed (sometimes these**	**Matter and Its Interactions** • **Understand that different kinds of matter exist and these can be described and classified by their observable properties** ○ Demonstrate an increased ability to observe, manipulate, describe and ask questions about the characteristics and physical properties of familiar human-made and natural objects and liquids ○ Use tools to investigate familiar natural and human-made objects to describe, compare, sort and classify them based on observable characteristics • **Understand that different properties of materials are suited to different purposes** ○ Distinguish between an object and the material(s) from which it is made ○ Explore familiar objects to determine and describe how the materials of which they are made are related to the objects'	**Matter and Its Interactions** • **Deepen understanding of different kinds of matter, their observable properties, and their purposes** ○ Plan and conduct investigations to gather more information about different types of human-made and natural objects and materials, their properties, and their uses ○ Describe and classify different kinds of materials by their observable properties including color, strength, flexibility, hardness, texture, and absorbency ○ Engineering Connection: Observe and test different materials and analyze the qualitative data obtained to determine which materials have the properties that are best suited for an intended purpose (e.g., fabric is flexible to be worn as clothing; plastic is hard and non-porous to be used as containers that hold liquid) • **Understand that a great variety of objects can be built up from a**

changes are reversible and sometimes they are not)
- Observe and explore simple physical changes that can be observed firsthand (e.g., ice cube or snow melting, puddles disappearing)
- Combine materials to make a new substance. (e.g., mix water and soil to make mud)
- Observe and discuss changes in solid materials (e.g., ice cream melting, cookie crumbling)
- Observe and describe changes in food when participating in adult-led cooking activities

Motion and Stability: Forces and Interactions

- **Begin to understand that pushes and pulls can cause objects to move**
  - Recognize that objects can be moved and participate in activities involving moving objects
  - Observe and describe the motion of objects using basic vocabulary in terms of speed (fast/slow), direction (up/down/left/right), the way things move (rolling/sliding)
  - Explore and communicate the effect of one's own actions on how objects move (e.g., pushing, pulling, rolling, dropping)
  - Observe and describe factors involved when things stand or fall (e.g., building a block tower that can stand up)

Energy

The concept of Energy is abstract and difficult for children at this age to understand.

Waves and Their Applications in Technologies for Information Transfer

- **Begin to explore that vibrating matter can make sound**
  - Play with different objects and materials to make different types of sounds through banging, rubbing, plucking, etc. (e.g., musical instruments, pots and pans, plastic containers, kitchen utensils, blocks, sticks, rubber bands, string, beans in a container)

- **Begin to explore light and the idea that some materials block all the light creating a dark shadow on any surface beyond them, where the light cannot reach**

properties (e.g., a wooden block is hard, solid, and has smooth sides while a foam ball is soft, squishy, light, and has a rougher texture)
  - Determine whether an object is human-made or occurs in nature based on observable properties
  - Identify the uses of various natural or human-made objects based on their properties

- **Understand that different kinds of matter can be solid or liquid depending on temperature**
  - Identify and investigate the differences between solids and liquids
  - Recognize that matter takes on different shapes depending upon its state (e.g., solids have a definite shape, liquids take the shape of their container)
  - Engage in an experiences to investigate the idea that different kinds of materials can change and be a solid or liquid depending on temperature (PreK with support)

- **Begin to understand that heating or cooling a substance may cause changes that can be observed (sometimes these changes are reversible and sometimes they are not)**
  - Begin to understand the difference between a basic physical change (e.g., a liquid can become a solid and vice versa) and chemical changes (e.g., cooking an egg cannot be reversed)
  - Investigate physical objects and materials to understand that they can change under different circumstances (e.g., building up or breaking apart, mixing, dissolving, or changing state like when ice melts to liquid in warm temperatures)

Motion and Stability: Forces and Interactions

- **Understand that pushes and pulls can cause objects to move**
  - Explore and describe the effects of simple forces that push or pull in nature, such as wind and gravity
  - Observe and discuss ideas, based in evidence, about what makes something move and how movements can be controlled and changed (PreK with support)
  - Make and record observations about the motion of objects to explore the effects of pushes and pulls
  - Plan and conduct an investigation to compare different types of pushes and pulls (e.g., a string pulling an object, person pushing an object, person stopping a rolling ball, objects colliding)

small set of pieces
  - Investigate what happens when materials are broken into smaller pieces or when materials are put together
  - Understand, after considering evidence, that when a chunk of material is cut or broken into pieces, each piece is still the same material (e.g., when a piece of wood is cut into smaller pieces, the smaller pieces are still wood)
  - Observe and understand that when a chunk of material is broken or cut from a larger piece, the smaller piece has weight (e.g., a small piece of wood, cut from a larger piece, can be weighed but will weigh less than the original piece of wood)
  - Observe and explain how the material properties of a small set of pieces do not change when the pieces are used to build other objects (e.g., wooden bricks remain wooden bricks even when stacked together or with other materials)

- **Understand that heating or cooling a substance may cause changes that can be observed (sometimes these changes are reversible and sometimes they are not)**
  - Argue with evidence that some changes to materials caused by heating of cooling can be reversed and some cannot (e.g., solid ice can be heated to melt into water and can be cooled and refrozen into solid ice; an egg that is heated and cooked cannot be returned to its pre-heated state)

Motion and Stability: Forces and Interactions

- **Deepen understanding of the motion and stability of objects**
  - Understand that the shape and or weight of a structure effects its stability (i.e., a wider base makes a structure more stable)
  - Understand the concept of balance (i.e., an object that is not moving is balanced and properties like symmetry, weight, size, shape can effect balance)
  - Explore how weight affects the movement of objects (e.g., the heavier the object, the harder it is to push and pull it)
  - Design and conduct an experiment to show the effects of different conditions (including weight, ramp height, and friction) on the speed and direction of objects (e.g., rolling a ball down a high ramp makes the ball roll faster than a lower ramp; sliding an object on a rough surface makes the object slower than when the same object slides across a smooth surface)

○ Observe one's own shadows and shadows of other things (both indoors and outdoors), noticing that shadows are observable when there is a light (sun or moon is shining, flashlight) but not observable on a cloudy or dark day or indoors when the lights are out	• **Understand that pushes and pulls can have different strengths and directions** ○ Compare the effects of different strengths or different directions of pushes and pulls • **Understand that pushing on an object can change the speed or direction of its motion and can start or stop it** ○ Observe and communicate the effect of one's own actions on the motion of objects including changes in speed and direction ○ Engineering Connection: Analyze data to decide if a design solution works (as intended) to change the speed or direction of an object • **Understand that when objects touch or collide, they push on one another and can change motion** ○ Observe and communicate the cause and effect when objects touch and collide **Energy** • **Understand that sunlight warms Earth's surface** ○ Make and record observations of the warming effect of sunlight on materials found on Earth's surface including sand, rocks, soil and water ○ Engineering Connection: Use tools and materials to design and build a model of a structure that will reduce the warming effect of sunlight on an area (e.g. umbrellas, canopies, and tents) (K only) • **Understand that a bigger push or pull makes things go faster or slow down more quickly (relationship between energy and forces)** ○ Plan and conduct an investigation to compare the effects of different strengths of pushes and pulls on the motion of an object (K only) **Waves and Their Applications in Technologies for Information Transfer** • **Begin to understand that sound can make matter vibrate, and vibrating matter can make sound** ○ Investigate sounds made by different objects and materials ○ Discuss possible explanations for what causes sounds made by different objects and materials	**Energy** *Children at this age should continue to deepen their understanding of the PreK/K Energy concepts through further investigation.* **Waves and Their Applications in Technologies for Information Transfer** • **Understand that sound can make matter vibrate, and vibrating matter can make sound** ○ Plan and conduct an investigation to provide evidence that vibrating materials can make sound (e.g., plucking a stretched string, striking a tuning fork) ○ Plan and conduct an investigation to provide evidence that sound can make materials vibrate (e.g., a paper placed near a speaker will vibrate, a tuning fork that has been struck and placed in water will cause the water to move/ripple) • **Understand that objects can only be seen if light is available to illuminate them or if they give off their own light** ○ Observe and explain, based on evidence, that objects in darkness can be seen only when illuminated ○ Investigate light and its properties and uses • **Understand that some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach** ○ Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light including materials that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror) • **Understand that people use a variety of devices to communicate (send and receive information) over long distances** ○ Engineering Connection: Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance. (e.g., paper cups connected by string to make a "telephone")

	○ Through play and investigations, identify ways to manipulate and change different objects and materials to change the volume (loud/soft) and pitch (high/low) • **Begin to understanding that some materials block all the light creating a dark shadow on any surface beyond them, where the light cannot reach** ○ Observe and investigate relationships between the size and shape of shadows by exploring a light source and a variety of objects to create the shadows	

Sample of *Crosscutting Concepts in* Physical Science:

Patterns – Smaller musical instruments can produce higher-pitched sounds while larger instruments can produce lower-pitched sounds

Cause and Effect – Applying force causes objects to move; Plucking a string on a guitar (to make it vibrate) produces a sound; A dropped the object falls to the ground; The larger ball rolls farther off the ramp

Systems and System Models – A swing set is a system made of different parts that work together ; Shadows are created when a light source is blocked (it's a system, not an object)

Stability and Change – Changes in the state of matter due to heating or cooling (increased temperature causes solid ice to melt to liquid); A sand castle washes away when a wave comes but a stone wall can last a long time

Structure and Function **–** Solid, non-porous materials like metal or plastic are good materials for use as plates and bowls; Round objects like balls move by rolling

Energy and Matter – Most objects don't change shape unless energy is added (e.g., you can't change the shape of Playdoh unless you push or pull it); You can take it Playdoh apart and change its shape, but it is still the same amount of matter; Pouring liquid in different shape/size containers looks different but it is still the same amount

Scale, Proportion, and Quantity – Hottest and coolest states of water; Heaviest and lightest objects; Pitch of a sound is related to the size of the instrument

ENGINEERING & TECHNOLOGY

The practice of design to find solutions to particular human problems (engineering) and the human-made tools, systems, and processes created to fulfill human needs and wants (technology).

Disciplinary Core Ideas: Defining and Understanding Engineering Problems; Developing Possible Solutions to Problems; Comparing and Testing Solutions to Problems; Low- Tech and High-Tech Tools and their Uses

Science, Engineering and Technology connect to and greatly influence each other. Scientists "use the technologies that engineers create (such as microscopes, monitors, and meters) to conduct their research. And when engineers start to design a new technology, they call on the knowledge of the natural world developed by scientists (for example, the law of gravity or how fluid flows)." (*Engineering Is Elementary*, 2015) In addition, human needs and desires help shape what questions scientists investigate and what problems engineers work to solve. Children are natural engineers. Their early design and building skills can be seen in their play as they use simple tools and a variety of materials to create and build creations including block towers and sand castles. As they learn more about the world and can identify simple problems that people may have, they can start to engage in the Engineering Design Process, an iterative process that involves asking questions to identify a problem, imagining, planning, and creating solutions to the problem, and working to improve upon the designed solution. [See Appendix A] New or improved tools and technologies are the result of this process, and children at all ages can and should be using a variety of both high- and low-tech tools and technologies when engaged in scientific investigations and engineering design. In fact, children use simple tools and technology everyday when they use a pencil to write, a spoon to eat, and a computer to gain and share information.

2-3 Year Olds	PreK-K	Grades 1-2
Engineering Design and Technology Applications • **Begin to explore engineering design through play** ○ Play and build with blocks and other materials to experience elements of the engineering design process (Ask, Imagine, Plan, Create, Improve) • **Use a variety of technologies and tools for a variety of purposes** ○ Use different types of low-tech and high-tech technologies and tools (e.g. writing or drawing utensils, magnifying glasses, ramps, screwdrivers, measuring cups, computers and appropriate software, tablets) ○ Play with simple machines (e.g., ramps, levers, etc.)	**Engineering Design and Technology Applications** • **Begin to understand that asking questions, making observations, and gathering information are helpful in thinking about problems, and that it is important to clearly understand the problem before beginning to design a solution** ○ Begin to use the five elements of the Engineering Design Process: Ask, Imagine, Plan, Create, and Improve ○ Define a simple problem that can be solved through the design of a new or improved tool or technology • **Begin to understand that people depend on various technologies in their lives and that human life would be very different without technology** ○ Begin to use a variety of technologies (high-tech and low-tech) for a variety of purposes including to make observations, conduct investigations, and solve problems related to scientific investigations and engineering design ○ Use a variety of low-tech tools including writing, drawing	**Engineering Design and Technology Applications** • **Understand that a situation that people want to change or create can be approached as a problem to be solved through engineering and that such problems may have many acceptable solutions** • **Understand that asking questions, making observations, and gathering information are helpful in thinking about problems, and that it is important to clearly understand the problem before beginning to design a solution** ○ Use the engineering design process to ask questions, make observations, and gather information about a situation people want to change and define a simple problem that can be solved through the development of a new or improved object or tool • **Understand that every human-made product is designed by applying some knowledge of the natural world and is built using**

	and painting utensils, scissors, magnifiers, balance scales, ramps, pulleys, hammers, screwdrivers, sieves, tubing, binoculars, whisks, measuring cups ○ Use a variety of high-tech tools including computers and appropriate software, tablets and apps, website information, video and audio recordings, digital cameras, tape recorders ○ Explore, through play, the function of simple machines to solve a problem (e.g., pulley, wheel, lever, inclined plane, wedge, and screw)	**materials derived from the natural world** ○ Give examples of how living things in the real world inspire engineering designs (natural design) • **Understand that designs can be conveyed through sketches, drawings, or physical models to communicate ideas for a problem's solutions to other people** ○ Analyze a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function to solve a given problem • **Understand that because there is always more than one possible solution to a problem, it is useful to compare and test designs** ○ Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs • **Understand that people depend on various technologies in their lives and that human life would be very different without technology** ○ Use a variety of technologies (high-tech and low-tech) for a variety of purposes including to make observations, conduct investigations, and solve problems related to scientific investigations and engineering design

Sample of *Crosscutting Concepts in* Engineering and Technology:

Patterns – Patterns can be discovered in design features that make them good designs (e.g., children might notice that the paper bridges that could hold more pennies all had triangle folds in them)

Cause and Effect – Changing the height of a ramp effects how far and fast a ball rolls

Systems and System Models – Model of how a simple machine (like a pulley) works; Model how human joints, such as an elbow or knee, works

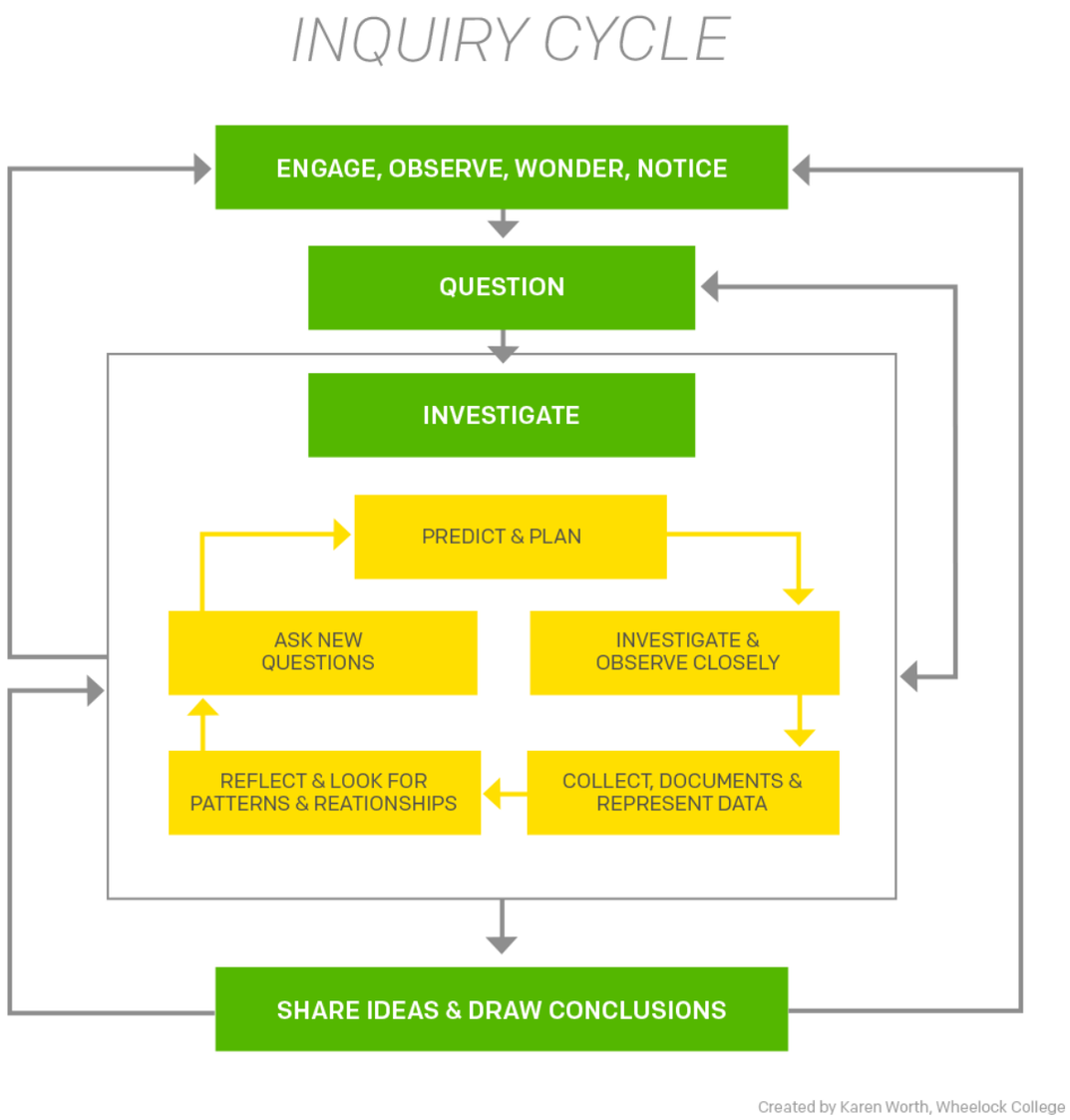
Stability and Change – Using different shaped blocks in different orientations to create a stable foundation for a building; Some technology has been around a long time (the wheel, building blocks) and has not changed much, while other technology (the computer, LeapPad) has changed a lot; New technology creates change in our life systems (cars, cell phones, etc.)

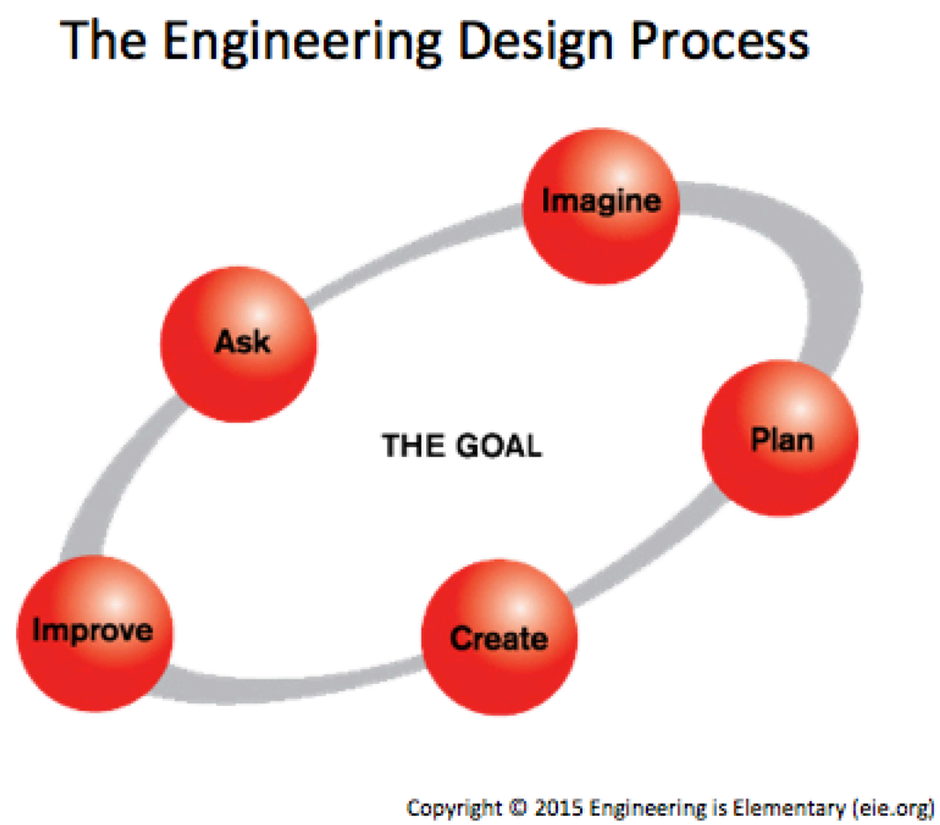
Structure and Function – Design of a building for better stability; Shape of a fork for the purpose of eating

Energy and Matter - Designing tools that use natural resources (sun energy, wind mills) for power

Scale, Proportion, and Quantity – Developing scale diagrams and models

APPENDIX A: The Inquiry Cycle (© Karen Worth) and The Engineering Design Process (retrieved from *Engineering is Elementary,* eie.org)





APPENDIX B: Crosscutting Concepts; Connections between Science, Math, and Literacy-ELA Practices (retrieved from http://nstahosted.org/pdfs/ngss/PracticesVennDiagram.pdf)

Crosscutting Concepts

1. **Patterns:** By noticing, observing, classifying and recording patterns in the natural and human designed world, children can recognize that patterns can be used to describe phenomena and used as justification for predictions or evidence for conclusions**.**

2. **Cause and Effect:** By identifying and observing events, relationships, and patterns in the natural and human designed world, children can learn that events have causes that generate observable patterns and they can design simple tests to gather evidence to support or refute their own ideas about causes.

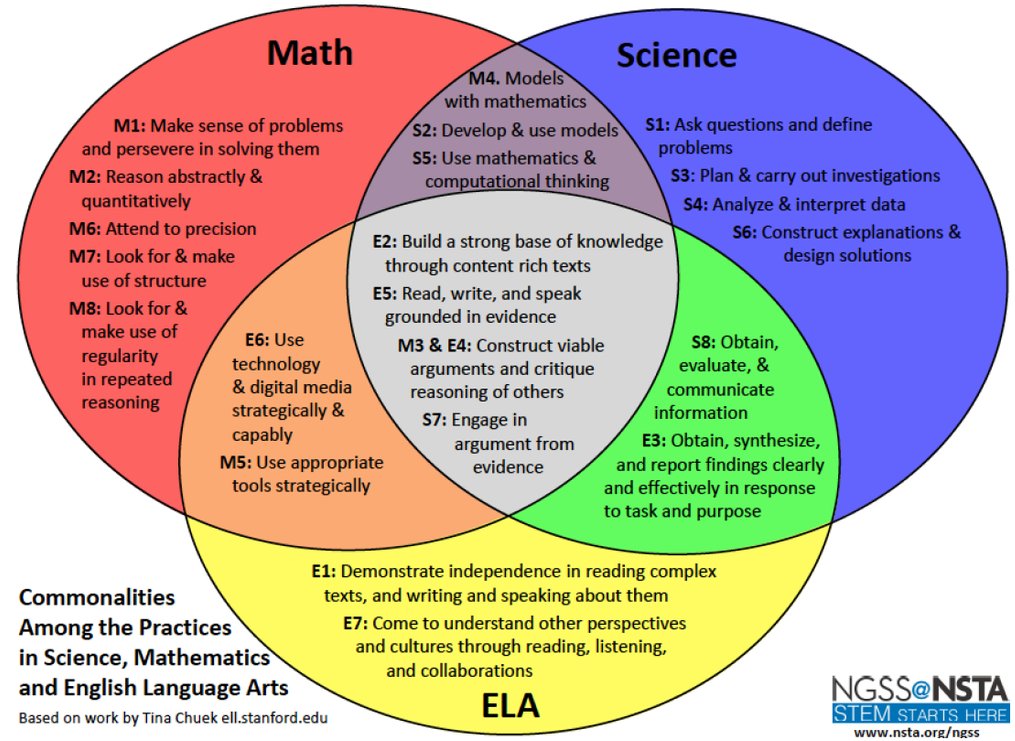
3. **Systems and System Models:** By investigating accessible and visible systems in the natural and human designed world, children can understand that objects and organisms can be described in terms of their parts. By describing things in terms of parts, roles of parts, and relationship among parts, children understand that systems have parts that work together and that if a part of the system breaks, is removed, or is altered, the working of the system can change.

4. **Stability and Change:** By exploring and reflecting on various events and phenomenon in the natural and human designed world, children can observe that some things stay the same while other things change, and that things may change slowly or rapidly.

5. **Structure and Function:** By investigating how things work and reflecting on characteristic parts and what they do in both nature and the human designed world, children can observe that the shape, material, and parts of an object or system are related to the function(s) of the object or system.

6. **Energy and Matter – Flows, Cycles and Conservation:** By observing various objects in the natural and human designed world, children can understand that objects may break into smaller pieces, can be put together into larger pieces, or can change shapes.

7. **Scale, Proportion and Quantity:** By using relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects and standard units to measure length, children can compare and describe objects and events in the natural and human-made world.



Practices in Mathematics, Science, and English Language Arts*

Math	Science	English Language Arts
M1. Make sense of problems and persevere in solving them.	**S1.** Asking questions (for science) and defining problems (for engineering).	**E1.** They demonstrate independence.
M2. Reason abstractly and quantitatively.	**S2.** Developing and using models.	**E2.** They build strong content knowledge.
M3. Construct viable arguments and critique the reasoning of others.	**S3.** Planning and carrying out investigations.	**E3.** They respond to the varying demands of audience, task, purpose, and discipline.
M4. Model with mathematics.	**S4.** Analyzing and interpreting data.	**E4.** They comprehend as well as critique.
M5. Use appropriate tools strategically.	**S5.** Using mathematics, information and computer technology, and computational thinking.	**E5.** They value evidence.
M6. Attend to precision.	**S6.** Constructing explanations (for science) and designing solutions (for engineering).	**E6.** They use technology and digital media strategically and capably.
M7. Look for and make use of structure.	**S7.** Engaging in argument from evidence.	**E7.** They come to understanding other perspectives and cultures.
M8. Look for and express regularity in repeated reasoning.	**S8.** Obtaining, evaluating, and communicating information.	

* The Common Core English Language Arts uses the term "student capacities" rather than the term "practices" used in Common Core Mathematics and the Next Generation Science Standards.

NGSS@NSTA
STEM STARTS HERE

APPENDIX C: UDL Guideline Applications

Applying Universal Design for Learning (UDL) Guidelines to Science Content (pg 23-24)

UDL Guidelines		Suggestions for Television Content	Suggestions for Game and Activity Content
I. Provide Multiple Means of **Representation** ↓ **Resourceful, knowledgeable learners**	1. Provide options for perception	Provide options for visual and auditory perception by following federal standards (Section 508 and FCC guidelines) to ensure that critical information is fully accessible to children who have perceptual limitations - blind, low vision, deaf, hard of hearing – e.g. closed captions, auditory descriptions. In addition to captions, provide words on screen when characters are talking about new science vocabulary so that children have both a visual and auditory reference for the new word.	Provide options for perception by following international web-accessibility standards (WCAG2) and educational media developer guidelines (including the National Center on Accessible Educational Materials: http://aem.cast.org/creating/accessibility-standards-specifications-guidelines.html#.VmyxE-ODGko) to ensure that critical instructional elements are perceivable by all students (e.g., text equivalents for images, captions for video, etc.).
	2. Provide options for language, mathematical expressions, and symbols	Provide options to ensure that students with differing linguistic and cultural backgrounds have equal access to key science information and symbols on screen (e.g. closed-captions in multiple languages, visual and narrative cues that provide context and support for science vocabulary or symbols).	Provide spoken and written language options in activities, games, etc. to ensure that science vocabulary is equally accessible for all students: e.g. options for translations into multiple languages, embedded links to science-specific vocabulary definitions, options for text-to-speech decoding with highlighting, links to explanations of symbols, etc. Also, include supports for parents and teachers to assist children with relevant vocabulary and concepts.
	3. Provide options for comprehension	Provide options to support comprehension of science concepts including on-screen character dialogues and discussions that model scientific thinking, provide key background knowledge about science, and highlight crosscutting concepts, like patterns and cause and effect relationships that they observe while conducting scientific investigations.	Provide options in activities, games, etc. to support the learning of science concepts by students with differing cognitive and cultural backgrounds. For example, include options that link to critical background knowledge (help buttons, etc.), that highlight critical features and main points, that provide concept maps, and that present questions about text content or literacy skills before interacting with the text so that children can consider them and better attend to relevant information while reading or listening.
II. Provide Multiple Means of **Action and Expression** ↓ **Strategic, goal-directed**	4. Provide options for physical action	Ensure that diversity in physical ability is evident in on-screen characters so that they can model alternative means of interacting physically with key science activities (both online and off), and can provide inclusive role models of scientists who are physically limited (get Stephen Hawking, Janice Brunstrum, to guest!).	Provide options in activities, games, etc. for navigation and physical interaction so that learners with motor limitations can participate fully by thinking and acting like scientists. For example, ensure that navigation and interactions can be conducted using voice commands, common AT devices, or alternatives to mouse, etc. When recording observations in a science journal in a game format, for example, provide dictation capabilities and/or stamps and appropriate icons and graphics to use. See guidelines for physical access at National Center on Accessible Educational Materials: (http://aem.cast.org/creating/accessibility-standards-specifications-guidelines.html#.VmyxE-ODGko.
	5. Provide options for expression and communication	Characters on-screen should model different materials and tools to use when conducting science investigations, when engaging in engineering design, and when communicating results and designs to others	Digital games and on- and off-line experiences should include options and supports for meeting the needs of users with differing skills in acting and communicating like a scientist, including supports and scaffolds that can be gradually released with growing skills.

learners	6. Provide options for executive function	Characters on-screen should model age-appropriate planning and organizing of resources when developing science investigations and designing solutions to problems in engineering. Characters should model the use of appropriate scaffolds for planning and organizing (e.g., using check-lists, templates, etc.).	Games and activities should provide access to scaffolds that guide and support learners in planning and organizing their investigations and engineering designs (e.g., access to step-by-step guidelines or prompts, process checklists, advanced organizers, etc. to help children structure their thinking).
III. Provide Multiple Means of **Engagement**	7. Provide options for recruiting interest	Story topics should reflect relevant and meaningful science and engineering experiences that are diverse enough to engage the full spectrum of learners with experiences relevant in their everyday life. For example, characters might build with blocks or observe plants and animals in the backyard or in the streetyard.	As with TV, content should reflect relevant and meaningful science and engineering experiences that are diverse enough to engage the full spectrum of learners with experiences relevant in their everyday life. Offer game players a choice in the science and engineering content they wish to explore, the activity type they engage with, and the tools they can use to explore the content.
	8. Provide options for sustaining effort and persistence	When conducting science investigations or engaged in engineering design, characters should model collaboration and teamwork, asking questions, and the sharing and support of all ideas.	Provide reminders throughout different levels and steps of game play about the goal and purpose of the science or engineering activity. Also should provide appropriate and adaptable game-play to match individual user level. Finally, should provide opportunities for teamwork and collaborative investigation and design.
Purposeful, motivated learners	9. Provide options for self-regulation	Characters on-screen should model strategies for appropriately handling problems or mistakes when conducting investigations or engaged in engineering design and building (e.g., modeling persistence when not able to immediately solve a problem or complete a task while other characters /adults offer words of encouragement) In addition, while main characters may model age-appropriate planning strategies, other characters can model less complex skills/knowledge to sustain the interest of viewers with developmental delays (i.e., each “lesson” targets 2-3 levels of learning).	Allow children the chance to reflect on and share their experience with a science or engineering game or activity through discussion, journaling, graphic feedback or other method. In particular, encourage self-reflection on such things as how to monitor frustration, handle failure, and set motivating goals (e.g., younger children and children with developmental delays can use faces/symbols to self-assess difficulty and persistence).

SCIENCE ADVISORS:

Kim Brenneman, Program Officer for Early Mathematics, Heising-Simons Foundation
Bryan Brown, Associate Professor and Associate Dean for Student Affairs, Stanford Graduate School of Education
Sara Sweetman, Assistant Professor and Director of Guiding Education in Math and Science Network (GEMS-Net), University of Rhode Island
Karen Worth, Professor of Elementary Education and Science Education, Wheelock College

UDL ADVISORS:

Michael Conn-Powers, Center Director, Indiana Institute on Disability and Community's Early Childhood Center
David Rose, Chief Education Officer for CAST

CLASSROOM EDUCATOR ADVISORS:
Allison DePrizio Frometa, Kindergarten Teacher, Chelsea Public Schools (MA)
Flor Retamal, Head Start/Pre-K Teacher, Chicago Public Schools

PRIMARY SOURCES:

Bowman, B., Donovan, M.S., & Burns, M.S. (Eds.). (2001). *Eager to learn: Educating our preschoolers*. Washington, DC: National Academies Press.

CAST (2011). *Universal Design for Learning Guidelines version 2.0.* Wakefield, MA: Author.

California Department of Education. (2008). California Preschool Learning Foundations, Volume 3: Foundations in Science.

Gelman, R., K. Brenneman, G. Macdonald, and M. Roman. (2010). *Preschool pathways to science: Ways of doing, thinking, communicating and knowing about science*. Baltimore, MD: Brookes Publishing.

Head Start Early Learning Outcomes Framework: Ages Birth to Five (2015). HHS/ACF/OHS. Retrieved from http://eclkc.ohs.acf.hhs.gov/hslc/hs/sr/approach/pdf/ohs-framework.pdf

Michaels, S., Shouse, A.W., & Schweingruber, H.A. (2008). *Ready, Set, Science! Putting research to work in K-8 science classrooms.* Washington, DC: National Academy Press.

Massachusetts Draft Revised Science and Technology/Engineering Standards, December 2013. Available at www.doe.mass.edu/STEM/review.html

Museum of Science, Boston. *Engineering is Elementary.* (2015). Retrieved from http://www.eie.org/.

National Research Council (NRC). (2007). *Taking science to school: Learning and teaching science in grades K–8.* Washington, DC: National Academies Press.

National Research Council (NRC). (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

National Science Teachers Association (NSTA). 2002. *NSTA Position Statement: Elementary School Science.*
2004. *NSTA Position Statement: Scientific Inquiry.*
2014. *NSTA Position Statement: Early Childhood Science Education.*

New Jersey State Department of Education. (2014). Preschool Teaching and Learning Standards: Science.

NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states.* Washington, DC: National Academies Press.

Pennsylvania Office of Child Development and Early Learning. (2014). Learning Standards for Early Childhood: Infants and Toddlers and Pre-Kindergarten (2014).

Worth, K., & Grollman, S.. (2003). *Worms, shadows, and whirlpools*; *Science in the early childhood classroom.* Portsmouth, NH: Heinemann, and Washington, DC: NAEYC.