WHITE PAPER

IV. Scientific Thinking

Background and Criteria

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The Scientific Thinking domain is concerned with how children observe, record, describe, question, form explanations, and ultimately draw conclusions. The Work Sampling System, 5th Edition (WSS) includes four functional components of scientific investigation (1) inquiry skills and practices, (2) physical sciences, (3) life sciences, and (4) earth sciences. Within each of these areas processes of scientific investigation are emphasized because these skills are embedded and fundamental to all scientific inquiry, instruction, and content.

The development and revision of the WSS preschool performance indicators was guided primarily by research and by state early learning standards (e.g., Pennsylvania Department of Education and Department of Public Welfare, 2009; Georgia Early Learning and Development Standards [GELDS], 2013; New York State Early Childhood Advisory Council and the New York State Council on Children and Families, 2012; National Institute of Early Education Research [NIEER] “Math and Science in Preschool: Policies and Practice” [Brenneman, Stevenson-Boyd, & Frede, 2009]).

The WSS kindergarten through third grade performance indicators were based primarily on the research and guidelines compiled by the National Academy of Sciences report entitled *A Framework for K-12 Science Education Standards: Practices, Crosscutting Concepts, and Core Ideas* (*Framework;* National Research Council [NRC], 2012). This report was guided by extensive research published by the NRC, including:

- *How People Learn: Brain, Mind, Experience, and School* (NRC, 2000),
- *Systems for State Science Assessment* (NRC, 2005),
- *Taking Science to School: Learning and Teaching Science in Grades K-8* (NRC, 2007),
- *Learning Science in Informal Environments: People, Places, and Pursuits* (NRC, 2009),
- *Benchmarks for Science Literacy* published by the American Association for the Advancement of Science [AAAS] (AAAS, 1993),
- *National Science Education Standards* [NSES] (NRC, 1996),
- *Science Framework for the 2009 National Assessment of Educational Progress* (U.S. Department of Education, 2009),
- *Science College Board Standards for College Success* (College Board, 2010),
- National Science Teachers Association’s [NSTA] Science Anchors project (NSTA, 2009), and
- A variety of state and international science standards and curriculum specifications.

Based on the above research and guidelines, the NRC committee recommended that science education in grades K through 12 be built around three major dimensions:

1. Scientific and engineering practices
   a. Asking questions (for science) and defining problems (for engineering)
   b. Developing and using models
   c. Planning and carrying out investigations
   d. Analyzing and interpreting data
   e. Using mathematics and computational thinking
   f. Constructing explanations (for science) and designing solutions (for engineering)
   g. Engaging in argument from evidence
   h. Obtaining, evaluating, and communicating information

2. Crosscutting concepts that unify the study of science and engineering through their common application across fields
3. Core ideas in four disciplinary areas
   a. physical sciences
   b. life sciences
   c. earth and space sciences
   d. engineering, technology, and applications of science

The first WSS functional component (Inquiry Skills and Practices) was aligned around the scientific and engineering practices dimension, and the second through fourth WSS functional components (Physical Science, Life Science, and Earth Science) were aligned around their corresponding core ideas (e.g., Physical Science). Crosscutting concepts and engineering, technology, and applications of science were integrated throughout all functional components.

Note: Preschool-3 performance indicators are noted below unless the indicator starts at a higher grade. In those circumstances, the performance indicator is written starting at the lowest grade with the grade level noted in parentheses.

A Inquiry Skills and Practices

1. Asks questions that arise during explorations.

2. Uses senses and simple tools to explore.

3. Makes meaning from explorations, and generates ideas and solutions based on their own observations of the natural and human-made worlds.

4. Communicates experiences, observations, and ideas with others through conversations, representations, and/or behavior.

The four WSS kindergarten through third grade performance indicators for Inquiry Skills and Practices were influenced by the eight scientific and engineering practices for K-12 science classrooms (see the *Framework,* NRC, 2012 for more information). These practices are also integrated in other WSS functional components (e.g., Physical Science) when applicable, as well as in the preschool performance indicators. However, those indicators were also guided by research and early learning state standards (e.g., New York State Early Childhood Advisory Council and the New York State Council on Children and Families, 2012).

Use of the term “inquiry skills and practices” reflects an underlying belief that scientific inquiry requires the integration of both knowledge and skill simultaneously through practice. The idea of science as a set of skills and practices has emerged from the work of historians, philosophers, psychologists, and sociologists over the past 60 years. According to the NRC committee, “Seeing science as a set of practices shows that theory development, reasoning, and testing are components of a larger system of activities that includes networks of participants and institutions (Latour, 1999; Longino, 2002), specialized ways of talking and writing (Bazerman, 1988; Latour, 1990; Lehrer & Schauble, 2006), the development of models to represent systems or phenomena (Nercessian, 2008), the making of predictive inferences, construction of appropriate instrumentation, and testing of hypotheses by experiment or observation (Giere, Bickle, & Maudlin, 2006).” p. 43 (NRC, 2012).

Research has increasingly demonstrated that preschoolers are capable of the basic reasoning skills required for scientific thinking (NRC, 2007). For example, preschoolers may persist in asking information-seeking questions of adults until they are given a satisfactory response (Chouinard, 2007). In addition, older preschoolers are able to interpret simple data patterns and show some understanding of how different patterns support different conclusions. (Khlar & Chen, 2003). Even well before three- and four years-old, children ask questions, generate explanations (Gopnik, Meltzoff, & Kuhl, 1999), engage in analogical reasoning (Goswami & Brown, 1990), and make inferences, such as when they infer a hidden causal mechanism to explain an observable event (Bullock & Gelman, 1979). Young children can think abstractly about various scientific concepts and have dispositions and thinking skills that support later, more sophisticated, scientific reasoning. For example, preschoolers are motivated to clarify ambiguous evidence. When they play with a jack-in-the-box-type toy, and the mechanism that causes the doll to spring from the box is clear, children stop playing with the jack-in-the-box as soon as a new toy is presented. When it is unclear exactly how the first toy works, they continue to explore it even when a new toy is available (Schultz & Bonawitz, 2007). This research has led quality preschool environments to increasingly provide children with opportunities to observe, explore, experiment with, question, and discuss a range of scientific phenomena as they learn key content and practices of science (National Association for the Education of Young Children [NAEYC], 2013). In addition, states have incorporated scientific inquiry and reasoning standards at the preschool level (GELDS, 2013; New York State Early Childhood Advisory Council and the New York State Council on Children and Families, 2012; Pennsylvania Department of Education and Department of Public Welfare, 2009).

Often, preschool children use advanced reasoning without being aware that they are doing so and without being able to describe their reasoning (NRC, 2007). Like people of all ages, children's use of logical thinking is constrained by a number of factors: (a) their knowledge of and experience with the domain they are reasoning about; (b) whether the problem being posed makes sense to them; and (c) whether they are comfortable in the assessment situation. One of the most important factors affecting children's reasoning ability is their knowledge of conceptual relations that promote deeper reasoning (i.e., reasoning based on causal, taxonomic relations rather than surface similarity or perceptual cues). Thus, rather than reasoning being independent of knowledge, there are deep interactions between domain knowledge and many forms of reasoning (Gotwals & Songer, 2006). For example, studies of young children's causal reasoning suggest an interaction of domain general reasoning processes and knowledge of the specific domain being investigated (Gopnik, Sobel, Schulz, & Glymour, 2001).

Another important component of scientific inquiry and reasoning is children's ability to change their conceptions about how the world works. Children, as well as adults, often have perspectives and opinions that are difficult to change. How does a new conceptual system become strengthened and gain dominance over one's initial ideas? Many conceptual change researchers suggest that engaging in argument may be a central part of this process (e.g., Chinn & Brewer, 1993; Strike & Posner, 1985; Thagard, 1992). More specifically, students are asked to evaluate (or debate) the adequacy of the new system with known competitors. For example, the new system will gain ascendancy if it seems more plausible (consistent with prior knowledge and existing data), *fruitful* (generative of further questions) (Strike & Posner, 1985), or *coherent* (Thagard, 1992). Elementary school students are sensitive to many of these features in judging rival accounts. For example, Samarapungavan (1992) found that children prefer accounts that explain more, are not ad hoc, are internally consistent, and fit the empirical data.

Argumentation and repeated application of new ideas are both important and may involve complementary and interactive processes. Argumentation is a higher level, meta-cognitive process, whereas repeated practice in application involves gaining lower level associative strength. However, argumentation from evidence involves practice in application, and repeated application can also provide additional opportunities for meta-cognitive involvement. Indeed, many educators in science believe that the key to promoting conceptual change is to create a classroom discourse that revolves around argumentation (Hennessey, 2003; Herrenkohl & Guerra, 1998; van Zee & Minstrell, 1997). In addition, longitudinal studies of conceptual change highlight the importance of elaboration and depth of coverage (Clark & Linn, 2003), opportunities to revisit key ideas introduced in lessons (Minstrell, 1982; Minstrell & Kraus, 2005; Roth, Peasley, & Hazelwood, 1992), and further elaboration of key ideas in later courses (Arzi, 1988).

B Physical Science

1. **Explores the properties of objects and materials, and how they change.**
2. **Explores how objects and materials move.**
3. **Explores and describes light and sound.**

The *Framework's* focus for Physical Science (as well as other core ideas) is geared toward framing a curriculum around the questions that children naturally pose at different ages to communicate the relevance and important of science to children. Such questions as "Where do we come from?" "Why is the sky blue?" and "What is the smallest piece of matter?" are interesting concepts that engage young people. For the physical sciences, the committee developed four core ideas —three of which parallel those identified in previous documents, including the *National Science Education Standards* [NSES] (NRC, 1996) and *Benchmarks for Science Literacy* (AAAS, 1993). The three core ideas are PS1: Matter and Its Interactions, PS2: Motion and

Stability: Forces and Interactions, and PS3: Energy. A fourth core idea was also introduced as PS4: Waves and Their Applications in Technologies for Information Transfer—which introduces students to the ways in which advances in the physical sciences during the past century underlie all modern technologies available today. The committee included this fourth idea to stress the interplay of physical science and technology, as well as to expand students' understanding of light and sound as mechanisms of both energy transfer (see LS3) and transfer of information between objects that are not in contact. The WSS narrowed down these concepts into three performance indicators pertinent to young children as properties of objects and how they change; movement (force, motion, and stability); and properties of light, sound, and heat.

The first three core ideas answer two fundamental questions: "What is everything made of?" and "Why do things happen?" These are not unlike the questions that students themselves ask. These core ideas can be applied to explain and predict a number of occurrences in people's everyday lives, such as the evaporation of a puddle of water, the tarnishing of metals, and photosynthesis. Because such explanations and predictions rely on a basic understanding of matter and energy, students' abilities to conceive of the interactions of matter and energy are central to their science education.

In contrast to very young children who tend to identify material by their perceptual properties, children in elementary school increasingly trace the identity of materials through their transformational history (e.g., sawdust comes from grinding up wood, so it must still be the same kind of stuff with some of its properties). As children begin to think in this new way, they show a tendency (called *hyperconservation*) to believe that the identity of material is generally preserved. Hyperconservation prevents them from being able to consider chemical change. For example, they may see chemical changes as the mixture of substances whose identities are maintained during the process. Teaching these children about the transformation of matter can lead to insights in other contexts by allowing them to think of materials as underlying constituents that maintain some core elements. This move may be quite helpful to them in constructing an initial understanding of density as an intensive characteristic of materials (NRC, 2007).

Young elementary school children also learn to develop a macroscopic conception of chemical substances (as characterized by its properties such as boiling and melting points, etc.) that allows them to identify and track the ways substances can go in and out of existence during a chemical change (Johnson, 2000, 2002). Ultimately, students need to reconsider the relation between properties that characterize entities at macro and micro levels, and consider how entities at the micro level can be used to explain observable phenomena. For example, although some macro-level properties are explained in *decompositional* terms (e.g., the weight and mass of an object is a function of the weight and mass of the atoms or molecules of which it is composed), whereas other macro-level properties are emergent characteristics explained in terms of *interactions* among entities at the micro level (e.g., objects are solid not because they have solid atoms, but because of bonding patterns among atoms and molecules). Elementary school children often have difficulty seeing how micro-level entities are related to macro-level ones, sometimes thinking that everything must appear the same at all levels of analysis (Nakhleh & Samarapungavan, 1999).

Early learning state standards were developed for preschoolers based on the research just described. For example, exploring and describing objects according to size, shape, and properties of matter, and the experimentation of what happens with matter in different environments is natural and fun for preschoolers (GELDS, 2013; New York State Early Childhood Advisory Council and the New York State Council on Children and Families, 2012; Pennsylvania Department of Education and Department of Public Welfare, 2009). Young children often describe matter according to touch ("These cotton balls feel soft!"), appearance ("These blocks are big!"), and state ("This ice cube is turning into water!"), but they especially enjoy exploring materials (e.g., sand and water) that move and flow in response to their actions. Children also investigate common interactions between matter and energy (e.g., butter melting, cream turning to butter, peanuts becoming peanut butter, etc.) (New York State Early Childhood Advisory Council and the New York State Council on Children and Families, 2012).

Preschoolers also enjoy exploring and describing the movement of toys and objects as well as investigating how fast or slow these objects can go (GELDS, 2013; New York State Early Childhood Advisory Council and the New York State Council on Children and Families, 2012; Pennsylvania Department of Education and Department of Public Welfare, 2009). They can begin to describe how they caused a reaction or force to occur (e.g., "I made the ramp steeper so the cars would go down faster."). For example, they might explore and compare how different balls and other objects slide, spin, and roll on different surfaces and inclines, and in response to their own pushing and pulling. Using different cars and trucks, they watch how fast/slow each goes down the slide.

In terms of light and sound, preschoolers enjoy making sounds (e.g., clapping, stomping, playing instruments) as well as determining where those sounds are coming from (e.g., outside, inside, near or far) (Pennsylvania Department of Education and Department of Public Welfare, 2009). They also enjoy experimenting with light such as trying to separate from their shadow or coordinate its movements with a friend's shadow. They also begin to construct relationships about how shadows change as a result of their actions (e.g., when the object casting the shadow moves closer to the light, the shadow gets bigger).

The NRC committee (2012) recommends the following 11 goals for children, beginning in kindergarten. The WSS guidelines and performance indicators were based on these goals, particularly for grades kindergarten through third grade. For more information, please see *A Framework for K-12 Science Education Standards: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012).

Goal 1: Matter

Goal 2: Chemical Reactions

Goal 3: Forces and Motion

Goal 4: Types of Interactions

Goal 5: Stability and Instability in Physical Systems

Goal 6: Conservation of Energy and Energy Transfer

Goal 7: Relationship Between Energy and Forces

Goal 8: Energy in Chemical Processes of Everyday Life

Goal 9: Wave Properties

Goal 10: Electromagnetic Radiation

Goal 11: Information Technologies and Instrumentation

C Life Science

1. Explores the characteristics of living things.

2. Explores the needs of living things.

3. Explores variation and diversity of living things. (Kindergarten)

According to the *Framework*, "The life sciences focus on patterns, processes, and relationships of living organisms. Life is self-contained, self-sustaining, self-replicating, and evolving, operating according to laws of the physical world, as well as genetic programming. Life scientists use observations, experiments, hypotheses, tests, models, theory, and technology to explore how life works. The study of life ranges over scales from single molecules, through organisms and ecosystems, to the entire biosphere, that is all life on Earth. It examines processes that occur on time scales from the blink of an eye to those that happen over billions of years. Living systems are interconnected and interacting. Although living organisms respond to the physical environment or geosphere, they have also fundamentally changed Earth over evolutionary time. Rapid advances in life sciences are helping to provide biological solutions to societal problems related to food, energy, health, and environment" (NRC, 2012, p. 139).

The WSS organized the Life Sciences functional component around the following four core ideas developed by the NRC committee (2012):

1. The first core idea focuses on organisms, their many processes and structures, and at scales ranging from microscopic individual atoms to organ systems that are necessary for life to be sustained.
2. Next, the idea broadens to consider organisms and how they interact and adapt in their environment.
3. A discussion about how organisms reproduce and how these mechanisms lead to variability and diversity within species is then discussed.
4. Finally, the core ideas in the life sciences culminate around evolution and how it can explain the diversity observed within and across species and how this

occurred through a process of descent with adaptive modification. Interestingly, evolution also accounts for the remarkable similarity of the core characteristics of all species.

Preschoolers know the differences between animate (living) and inanimate (nonliving) objects (Gelman & Opfer, 2002). When shown photographs of novel objects, they accurately predict that animate objects can move by themselves but inanimate objects cannot (Massey & Gelman, 1988) and that the insides of an unfamiliar machine are different from those of an unfamiliar animal (Gottfried & Gelman, 2005). Young children distinguish between living and nonliving things on a number of critical features. They seem aware that animals and plants can grow and heal but that artifacts cannot, and they understand some aspects of the life cycle of plants and animals (Backsheider, Shatz, & Gelman, 1993). Finally, with educational intervention, they can form a beginning notion of genes and inheritance (Soloman & Johnson, 2000).

Early learning state standards emphasize that preschoolers should learn why plants and animals need food, water, and sunlight to survive, and learn to discriminate between plants and animals by recognizing they have different parts. They should also begin learning about how organisms interact with, rely on, and respond to the environment. For example, they learn that people have to wear different types of clothing at different times of the year in order to adapt. Similarly, they should begin to learn that plants only grow when the temperature is warm enough. (GELDS, 2013; New York State Early Childhood Advisory Council and the New York State Council on Children and Families, 2012; Pennsylvania Department of Education and Department of Public Welfare, 2009).

During the elementary years, children gain in their understanding of the living world. Children have opportunities to observe particular animals or plants (through caretaking or school activities) and learn more about what they do, what their parts are, what their insides are like, etc. Between preschool and fifth grade, children are able to list more and more internal body parts (Gellert, 1962). They also gain a better understanding of the function of those parts. Children also learn about many more types of plants and animals through reading, visits to the zoo, etc. There is also an increasing appreciation of the diversity and depth of biological taxonomies, including the different subclasses of species (e.g., breeds of dogs) (NRC, 2007).

Children in the elementary school years not only accumulate facts, but they also begin to restructure knowledge. They may reclassify some kinds of plants from nonliving to living (Hatano et al., 1993). Interestingly, these shifts seem to be linked to cultural practices as well. For example, in a cross-national study of U.S., Japanese, and Israeli children, only 60% of Israeli fourth graders thought that plants were alive compared with over 90% of U.S. and Japanese children. While children may shift their beliefs in the living nature of plants without direct instruction or experience with gardening, it appears these forms of exposure may accelerate the process (NRC, 2007).

During these years, there is growth in children's understanding of the human body's internal organs and how they function and interact (Carey, 1985, 1995; Crider, 1981). Although their ideas are still simplistic, they represent a maturing idea of both the structure and function of parts. For example, they begin to see the heart as a pump consisting of interconnecting tubes that transport nutrients to different body parts (Arnaudin & Mintzes, 1985). And while children may understand that food is broken down physically, they can miss that it is also broken down chemically (NRC, 2007).

Children in elementary school continue to have misconceptions about core ideas in the life sciences. For example, as children come to recognize that plants are living things, they begin to overgeneralize that plants eat, sleep, etc. A powerful revelation for young elementary school children is learning that plants take in their food through their roots, rather than through their leaves (Roth, 1984). More specifically, there are many reasons why understanding photosynthesis is difficult, including limitations in their understanding of matter and atomic-molecular levels. Limitations in their conceptions of matter also affect their understanding of growth and decay. These sorts of patterns further demonstrate how domain knowledge interacts; that is, limitations in knowledge in one domain (e.g., matter) can constrain the understanding of another (e.g., metabolism) (NRC, 2007).

The NRC committee (2012) recommends the following 13 goals for children, beginning in kindergarten. For more information, please see A Framework for K-12 Science

Education Standards: Practices, Crosscutting Concepts, and Core Ideas (NRC, 2012).

Goal 1: Structure and Function

Goal 2: Growth and Development of Organisms

Goal 3: Organization for Matter and Energy Flow in Organisms

Goal 4: Information Processing

Goal 5: Interdependent Relationships in Ecosystems

Goal 6: Cycles of Matter and Energy Transfer in Ecosystems

Goal 7: Ecosystem Dynamics, Functioning, and Resistance

Goal 8: Social Interactions and Group Behavior

Goal 9: Inheritance of Traits

Goal 10: Variation of Traits

Goal 11: Evidence of Common Ancestry and Diversity

Goal 12: Adaptation

Goal 13: Biodiversity and Humans

D Earth Science

1. **Observes the sky and the natural and human-made objects in it.**
2. **Explores rocks, water, soil, and sand.**
3. **Observes weather and seasonal changes.**
4. **Observes and describes characteristics of earth and space.**

According to the *Framework* (NRC, 2012), Earth and space sciences (ESS) investigate processes that operate on Earth as well as the Earth's place in the solar system and the galaxy. Thus, ESS involves phenomena that range in scale from the unimaginably large to the invisibly small. There is significant overlap between the ESS and the other core sciences. For this reason, the majority of research in ESS is interdisciplinary in nature and falls under the categories of astrophysics, geophysics, geochemistry, and geobiology. For example, the physical sciences (e.g., forces, energy, gravity, magnetism) originally sought to understand the size, age, structure, composition, and behavior of the Earth, sun, and moon. Physics and chemistry later developed as separate disciplines. Similarly, the life sciences overlap with Earth science. Earth remains the only example of a biologically active planet, and the fossils found in the geological record of rocks are of interest to both life scientists and Earth scientists. However, the underlying traditional discipline of geology, involving the identification, analysis, and mapping of rocks, remains the core theme of ESS.

Earth consists of a set of systems (e.g., atmosphere, hydrosphere, geosphere, and biosphere) that are all interconnected. Small changes in one part of one system can have large and sudden consequences in parts of other systems, or they can have no effect at all. Understanding the different processes that cause Earth to change over time (i.e., how it "works") requires knowledge of the multiple systems' interconnections and feedbacks. In addition, Earth is part of a broader system—the solar system—which is itself a small part of one of the many galaxies in the universe.

The *Framework* begins at the largest parts of the universe and moves toward increasingly smaller scales. Thus, the first core idea, ESS1: Earth's Place in the Universe, describes the universe as a whole and addresses its grand scale in both space and time. Topics include the overall structure, composition, and history of the universe and Earth, and the forces and processes by which the solar system operates.

The second core idea, ESS2: Earth's Systems, discusses the Earth's structure and composition, and the processes that drive Earth's conditions and evolution. It also focuses on the vital role that water plays in all of the planet's systems and surface processes.

The third core idea, ESS3: Earth and Human Activity, addresses society's interactions with the planet. Specifically, this idea explains how Earth's processes affect people through natural resources and natural hazards, and it describes some of the ways in which humanity in turn affects Earth's processes.

Views of the nature of the heavens and of heavenly bodies have varied enormously over the years and from society to society. It might therefore seem that views of the earth, the heavens, extraterrestrial bodies, and the interactions between them would show markedly different developmental patterns depending on the culture involved. However, research suggests there may be a considerable common ground to early views of the Earth and the heavens, with divergence tending to emerge later on. One view sees preschool children as developing a coarse set of beliefs or "framework theory" (Wellman, 1990) that helps guide the emergence of later more culture-specific views (Nussbaum, 1979; Nussbaum & Novak, 1976; Nussbaum & Sharoni-Dagan, 1983; Vosniadou, 1994; Vosniadou & Brewer, 1990, 1992, 1994; Vosniadou & Ioannides, 1998). By this account, young children become convinced of two very salient "facts" about their external world: 1) it is essentially flat, and 2) unsupported objects fall down. As they grow older and become immersed in their culture, they strive to fit these two universal framing beliefs with what the culture tells them about the Earth, the moon, and the stars. This process of fitting these strong early beliefs with what their culture tells them often results in distortions as they either attempt to reconcile the two or simply develop compartmentalized and internally contradictory beliefs. In sum, even most adults through most of history have held views that are radically different from those held by scientists today. Errors and mistakes are, in that sense, the norm for individuals of all ages and not merely during a period of development (NRC, 2007).

Until fourth grade, it is very difficult for students to fully grasp the concept of a spherical Earth with gravity pulling objects toward Earth's center. According to Agan and Sneider (2003) "achieving conceptual change at such a deep level requires clarification of current ideas (even if those ideas may be wrong), listening to the ideas of others, thinking through the logical implications of different models, and then applying conceptual models to explain previously observed phenomena." A deep knowledge about the Earth is important for many reasons. First, it provides a foundation for explaining important phenomena that connect to children's daily lives such as the reasons for day and night and the causes of the seasons. Second, it provides a great opportunity for engaging in model-based reasoning and understanding during the elementary school years (NRC, 2007).

Based on this research, early learning state standards focus on the following earth science goals for preschoolers:

1. Identify Earth forms in pictures,
2. Observe water in solid and liquid states,
3. Identify the use of water,
4. Examine how weather affects daily life, and
5. Identify the characteristics of the sun, moon, stars, and clouds (GELDS, 2013; Pennsylvania Department of Education and Department of Public Welfare, 2009).

They also learn to compare the daytime/nighttime cycle; explore the different properties of rocks, soil, sand, and mud; and use appropriate vocabulary to describe the weather (GELDS, 2013; New York State Early Childhood Advisory Council and the New York State Council on Children and Families, 2012). After learning about all the Earth's characteristics, preschoolers begin to learn how many of the Earth's natural substances can be used as resources (e.g., wood for lumber to build shelter, water for drinking) (New York State Early Childhood Advisory Council and the New York State Council on Children and Families, 2012). As with the other core sciences, Earth science preschool standards are focused on what young children can see, feel, hear, and touch. In other words, while children's abstract reasoning skills are still emerging, the content they learn needs to be a part of their everyday experience and lives.

The NRC committee (2012) recommends the following 11 goals for children, beginning in kindergarten. For more information, please see *A Framework for K-12 Science Education Standards: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012).

Goal 1: Earth's Place in the Universe

Goal 2: Earth and the Solar System

Goal 3: The History of Planet Earth

Goal 4: Earth's Systems

Goal 5: Plate Tectonics and Large-Scale System Interactions

Goal 6: The Roles of Water in Earth's Surface Processes

Goal 7: Weather and Climate

Goal 8: Biogeology

Goal 9: Natural Resources

Goal 10: Natural Hazards

Goal 11: Human Impacts on Earth Systems

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