YOUNG SCIENTISTS IN ACTION: SCIENCE IN THE KINDERGARTEN CLASSROOM

SCIENTIFIC Notebook

EVERY GREAT ADVANCE IN SCIENCE HAS ISSUED FROM A NEW AUDACITY OF IMAGINATION

-JOHN DEWEY

NOTES • THOUGHTS • SKETCHES • IDEAS • QUESTIONS • REFLECTIONS

THE IMPORTANT THING IS TO NOT STOP QUESTIONING

-ALBERT EINSTEIN

Kids are natural scientists

--Alan Alda

NOTES • THOUGHTS • SKETCHES • IDEAS • QUESTIONS • REFLECTIONS

Science
comes from the word SCIENTIA,
which means KNOWLEDGE

To raise a few new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science.

-Albert Einstein

We learn more by looking for the answer to a question and not finding it than we do from learning the answer itself.

--Lloyd Alexander

NOTES • THOUGHTS • SKETCHES • IDEAS • QUESTIONS • REFLECTIONS

QTIR

QUICK TIPS • INFORMATION • RESOURCES

Inquiry is a term with many meanings across a variety of contexts and subjects. Our focus is on inquiry as a method for teaching science, and a concept of how scientists work. It is important for children to be able to practice scientific inquiry skills, and also understand what inquiry is. In this way, inquiry is both content and process. According to the National Research Council (NRC),

"*Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations" (p. 23).*

In simpler terms, inquiry is a process of generating questions, investigating possible answers, analyzing data and developing and communicating explanations. Students at all levels can participate in scientific inquiry and develop an understanding of the scientific process. According to the National Academy of Sciences (NAS) there are five steps to the inquiry process, and each step has multiple levels of child input. (Table 2-6 p. 29)

WHAT IS INQUIRY?

According to NAS:

STEP ONE

GENERATING A RESEARCH QUESTIONS

This is any question that can be answered through research and investigation.

STEP TWO

EXPLORE AND GATHER EVIDENCE

Children think about what evidence they would like to collect and how.

STEP THREE

DEVELOP EXPLANATIONS

Children begin to develop their explanations for the evidence.

STEP FOUR

MAKING CONNECTIONS TO SCIENTIFIC IDEAS AND COMMUNICATING RESULTS

Children create connections between their individual learning and larger scientific ideas facilitated by the teacher.

STEP FIVE

PREPARING AND COMMUNICATING FINAL IDEAS

Children develop oral, visual and or written presentations of their ideas.

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LEVELS OF INQUIRY

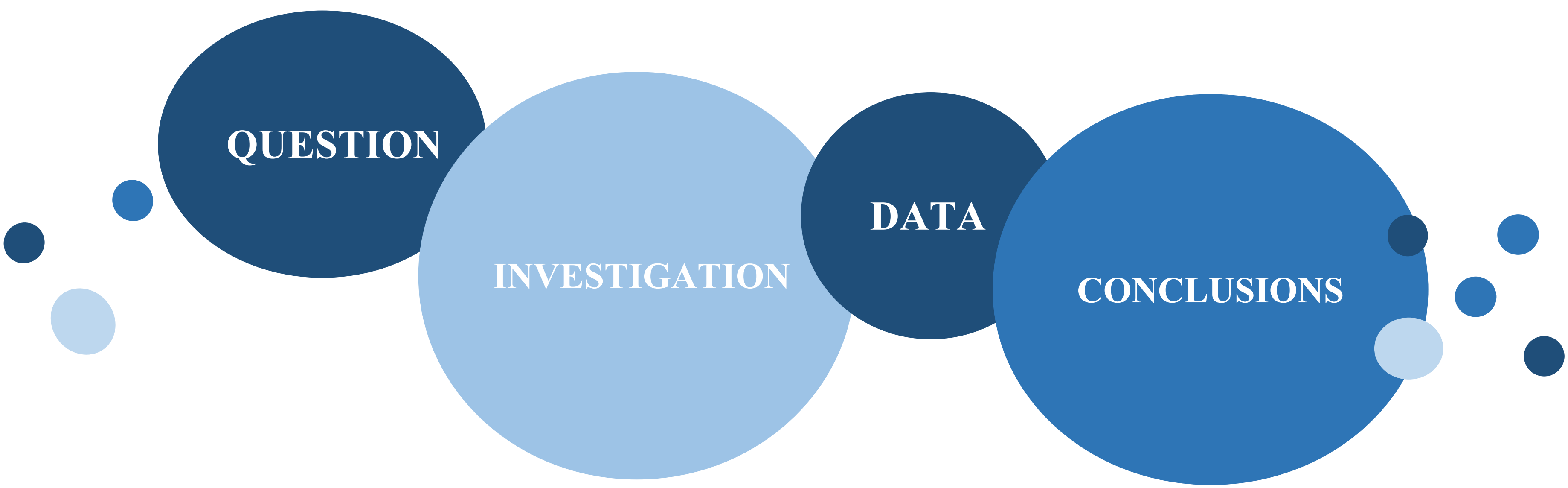
One common question about inquiry is how much influence the teacher should have over the process. The answer to this question is, it varies. Over the last half century, science education has shifted away from teacher-centered direct instruction to more child-centered inquiry instruction. As with many things, this transition has been slow and gradual. The same can be said for using inquiry instruction in your classroom. It is generally agreed that children, especially in the primary grades, should not be asked to complete an inquiry project on their own, on the first day of school. When we first introduce scientific inquiry to our students it is acceptable and recommended that teachers heavily guide the process.

One way to look at the amount of teacher input is to consider inquiry instruction on a continuum or sequence. On one end, the teacher is providing most of the information throughout the process. On the other end, the children are generating most or all of the steps and information. Teachers can think of this sequence in terms of the steps. How much information is provided by the teacher for each of the steps of the inquiry process? How much of the process is generated by the students? Table 1 indicates four levels of inquiry activities on this continuum. Notice that the four steps are always present, and children are always responsible for using evidence to create a conclusion or explanation.

TABLE 1 INQUIRY LEVEL CONTINUUM

Inquiry Level	**1**	**2**	**3**	**4**
Question	X	X	X	O
Investigation	X	X	O	O
Data	X	O	O	O
Conclusions	O	O	O	O

X – Teacher provided O – Child generated



According to Bell, Smetana & Binns (2005), the four levels of inquiry can be named as follows:

Level 1 - Confirmation
Level 2 - Structured Inquiry
Level 3 - Guided Inquiry
Level 4 - Open Inquiry

LEVEL ONE
CONFIRMATION

The teacher is providing the research question, the procedure for the investigation and the data. **Children** are examining the data and developing their own explanations and conclusions. This is the most basic form of inquiry and often serves as the foundation for the inquiry process.

LEVEL TWO
STRUCTURED
INQUIRY

The teacher is providing the question and procedure, but **the children** are producing the data and again completing the analysis and explanations. This opens the door for errors in the data, but that can be a valuable opportunity for discussing potential challenges that children and scientists both face.

LEVEL THREE
GUIDED
INQUIRY

The teacher is providing only the question. **The children** then develop a procedure for testing the question and producing data. The children analyze the data and develop their explanations. One of the challenges with Level 3 and Level 4 is making appropriate materials available for the children to use. When the teacher does not know what the procedures will be, the process can become more difficult. However, teachers can guide children toward procedures that use commonly available materials. Allowing children to direct the procedure can be daunting, but it can provide authentic learning experiences for children.

LEVEL FOUR
OPEN
INQUIRY

The teacher is guiding the children to develop questions that can be investigated. **The children** create the investigative procedure, produce the data and complete the analysis. Children work with their peers to develop their explanations and understanding of the inquiry topic.

It is very important to note that the levels of inquiry are indeed a continuum. Teachers should not expect children to be able to advance all the way to Level 4 inquiry without significant experience at the prior levels. It is entirely possible that children will only experience the first one or two levels in a single school year. Since kindergarten is most likely a child’s first experience with science inquiry it is certainly not a failing on the part of the teacher if children are not ready for Level 4 inquiry by the end of the year. Remember that science education is lifelong process, children do not need to be inquiry masters by the end of kindergarten. It is simply important for children to be exposed to the inquiry process so they can begin to develop the skills for exploring and explaining the world around them.

IN PRACTICE

GROWING PLANTS

TWO DIFFERENT APPROACHES

APPROACH #1

1. Children read a story about how plants grow
2. Children pick up materials set out by the teacher
    - A cup
    - Soil
    - Seeds
3. Children put half the pre-measured soil in the cup
4. Children add the seed
5. Children fill the cup with the remaining soil
6. Children add half a cup of water
7. Children place cups on the window sill
8. Children observe their cups over the next weeks and record observations
9. Children discuss what their observations mean

What level of inquiry is this?

- ❑ Level One
- ❑ Level Two
- ❑ Level Three
- ❑ Level Four

APPROACH #2

1. Children discuss what they think helps a plant grow
2. Children generate a list of materials that might help a plant grow
3. Teacher guides discussion toward available materials
4. Children generate questions that will use a variety of supplied materials
    - Various cups, multiple soils/sand/dirt/cotton balls, seeds
5. Children decide how their seed and "soil" will be added to the cup
6. Children decide how much water to add
    - Children record in pictures/words (with help as needed) their combination
7. Children decide where in the classroom they would like to have their seed grow
8. Children observe their cups over the next weeks and record observations
9. Children discuss what their observations mean

What level of inquiry is this?

- ❑ Level One
- ❑ Level Two
- ❑ Level Three
- ❑ Level Four

Approach #1, a hands-on activity is heavily directed by the teacher. The teacher generates questions for the children to answer. The teacher decides the precise materials and procedures that will be followed. The children make their own observations, collect data and develop explanations.

Based on these characteristics, this is a Level 2 inquiry activity. Level 2 activities are not "wrong" or "bad", they simply provide different opportunities for learners than the other levels.

Depending on how much help children need in generating their questions and procedures, **Approach #2** is a Level 3 or Level 4 inquiry activity. If the teacher finds the children are struggling to develop questions that can be explored, they might provide a list of possible questions. Similarly, if children are having a difficult time developing a procedure, the teacher is there to guide and help. This also acts as built-in differentiation. Children who require more guidance will receive it, while those who are ready to ask valid questions and develop feasible investigations on their own can grow and be challenged.

As a final note, inquiry can be messy! Children may come up with ideas that are clearly not going to work, but this is a great learning opportunity. Allowing children to "water" their seeds with milk because their parents said milk is healthy is fine. By collating class data and leading meaningful **discussions** of children's observations, genuine scientific **content** and **process skills** can be brought to light.

HOW TO DEVELOP AN INQUIRY LESSON

CHOOSING A TOPIC

The first step in developing an inquiry unit of study is to decide what topic the children will be investigating. There are multiple factors to consider when picking a topic. One of the most important considerations is determining children's interests and curiosities. Allowing the children to influence the topic increases their buy-in and allows for more connections to prior knowledge to be made. Any time new learning can be connected to children's prior knowledge, the learning is deeper and longer lasting.

This process also requires teacher guidance as there are other considerations that must be taken into account. There are specific science standards and learning objectives that need to be met over the course of the year. The ideal situation is bridging children's interests and the educational standards. Figure 5.1 has a list of questions to consider when selecting the topic of study.

RESEARCHING A TOPIC

Once a topic has been selected it is time for the teacher to assess their own understanding of the subject. This will direct the teacher to conduct research and develop a deeper understanding of the topic. In the past, this research would be useful so that the teacher could share the information with their class. In an inquiry unit, this background knowledge is not intended to be directly shared with the children. Rather, the teacher uses this information to prepare for children's questions and investigations

One important part of this research phase is discovering reliable sources of information for the children. This can be in the form of fiction and non-fiction books, magazine articles, video clips, internet sites and more. Additionally, this is the time to discover exciting guest speakers and field experiences.
Developing a thorough understanding of the research topic also allows the teacher to predict misconceptions and questions that children may develop during their investigations. This helps the teacher prepare appropriate materials and resources that will support children to maximize their learning.

ORGANIZE AND ELABORATE

Once a teacher has completed their research they will often find they have a large amount of disconnected information. This step is used to focus all of the research into important and concise concepts the teacher feels are most important. This process should be guided by the standards and learning objectives the teacher is trying to develop. These big ideas and questions can be organized using a graphic organizer, concept map or web.

This can help a teacher visualize how the information is connected, a big piece of the following step.

SET LEARNING GOALS

This phase of the process is closely connected to the prior step. Teachers are formalizing the outcomes they want children to reach by participating in the unit. This step is all about connecting the research that has been conducted with the investigations children will be carrying out. The big ideas that were developed in step 3 can be translated into essential or guiding questions for the unit. Ideally, the children will arrive at similar questions on their own, through guided discussions and pre-investigation activities.

Additionally, this is an opportunity for the teacher to consider the graphic organizer they developed in step 3. The teacher can identify the connections they want children to make between the big ideas of the unit. This is also a chance for the teacher to consider big ideas of science from outside of the unit that can be connected to the children's new experiences.

DESIGN LEARNING ACTIVITIES

It might be hard to believe, but we are finally at the point where the actual activities are planned. One of the first steps in this process is to inventory what resources are available. This includes physical materials that can be used for investigations, informational resources mentioned in Step 2, identifying and scheduling your guest speakers and planning your field experiences.

This step should include opportunities for children to develop their thinking and participate in a variety of activities. Children should be allowed to work alone, in pairs or in small groups throughout the unit. One important piece of the learning activities is recognizing opportunities for assessment. One of the key tasks for a teacher who is acting as an inquiry facilitator is to offer children multiple and varied ways for children to show what they know. These opportunities should offer multiple opportunities to carry out formative assessments. Assessments serve to inform the teacher if children are making expected progress, what challenges they are facing and what questions they have. A few examples might be observing children's science journal entries including written or illustrated observations, listening to inter-child discussions and asking probing questions. These and many more activities allow teachers to take a snapshot of where their class has progressed to.
Another opportunity that is present when planning the learning activities is integration. Integration, in this context, is the inclusion of subjects other than science in your inquiry unit. Children can be reading and writing/illustrating about science concepts, they can use appropriate mathematics to help answer their science questions and they can examine how the topic relates to their lives outside of school. Integration supports multiple content areas simultaneously, encourages administration to provide more time for science and helps develop the whole child rather than thinking of them in the context of a single subject. The science activities can often be spread out across the school day and offered in many different locations. Consider how the inquiry exploration can be embedded into learning areas or workstations. Don't forget to consider opportunities for outdoor investigations.

The inquiry activities should involve data whenever possible. This data can be numerical, written descriptions, visual images and many other forms. The idea is to give children an opportunity to think about science data and develop explanations for what they are observing. Data might be in the form of observing different plants, trees or animals from the children's environment. These observations can be guided to explain important science concepts such as form and function or patterning. Guest speakers can provide valuable information and data for the children to consider as well as field trips/experiences. As you plan the activities consider the four key ideas from Figure 1, Question, Explore, Analyze Data and Explain. Where are children able to explore their questions and find or produce data? When and how are children able to explain their thinking? What products should children be able to produce to demonstrate their learning?

This last point, about child products, ties back in with assessment. In addition to ongoing formative assessments there should also be opportunities for children to complete authentic assessments. Authentic assessments relate the content being learned to real world experiences. This is critical for children to be able to understand that science doesn't stop when 'science time' is over or when they leave school. Provide children an opportunity to demonstrate their understanding of the content as it relates to their lives outside of school. This might be drawing comparisons between content observed in class and at home, in their backyard or their local park. This applies across all content areas within science. If children study trees, and specifically leaves, at school, how do their observations(data) compare to their experiences with trees elsewhere? Do any children have very different observations from other locations (children who moved, visited relatives, travelled abroad). By drawing out these experiences the children will demonstrate their ability to apply what they are learning in class to their daily lives. Additionally, this is a great opportunity to help children develop their social and emotional well-being at school. Children who are able to share stories that are valued by their peers are more likely to engage with the content and participate in class.

The emphasis on these science inquiry activities should be to being children's journey toward becoming scientifically literate individuals. This doesn't mean children should know science facts, memorize definitions and be able to recall discrete information. Rather, scientific literacy is the development of a child's understand that science is part of their lives and science is a way of learning and knowing about the world. The hope is that children will grow up to use scientific reasoning and evidence-based decision making in their daily lives.

DEVELOP A PLAN FOR IMPLEMENTATION

The final step in planning an inquiry unit is developing an actionable plan including a guiding schedule. Consider what specific materials will certainly be needed, you may also end up needing extra materials depending on children's questions. Contact the experts and guest speakers and determine when they are available to speak with the class. Technology, such as video chatting, has made this much more feasible. While having the expert in your room is preferable, technology allows a wider variety of experts to be included. Contact the local museums, science centers, zoos, aquariums, farms and others to determine the details for field experiences. These often have to be scheduled far in advance with school districts so it helps to plan them out early. Consider using a pacing guide but be prepared for it to change, it almost certainly will! Inquiry is intended to be an open-ended exploration and it may get messy or even a little chaotic, that's how it should be!

Scientists follow the schedule of their experiments, they follow the data that is produced, neither of these things can be complete controlled or scheduled. Sometimes the best learning opportunities occur far from your original

OPEN-ENDED QUESTIONING THAT SUPPORT YOUNG SCIENTISTS TO USE CRITICAL THINKING SKILLS

- How did you figure that out?
- What do you think will happen next?
- What steps did you take?
- I'm wondering what you might be thinking.
- When you __________ , what happened?
- How will you approach it this time?
- Have you ever had this experience before?
- Do you remember when we_______________. How is this the same or different?
- What do you think is missing? Are there other tools that might be helpful?
- What do you see? Let's observe carefully.

Let's capture your observations!

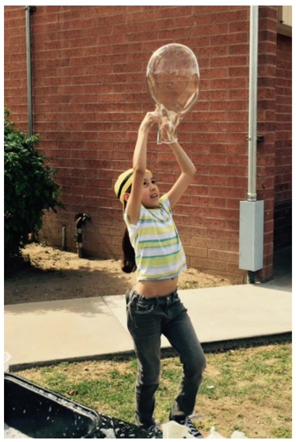
How might this information be helpful to us?

What might YOUNG SCIENTISTS DO?

Where might we find the answer to that question?

Supporting The Whole Child

SCIENCE IN THE KINDER CLASSROOM



10 KEY ATTRIBUTES IN SCIENTIST LEADERS –

Scientists who are making their science matter:

1. They have a vision – and can articulate it.
2. They are passionate. But don't necessarily wear it on their sleeve.
3. They work hard at communication… even if they make it look deceptively easy.
4. They are generous and think beyond their own work to support others.
5. They take risks and are willing to fail – sometimes publicly.
6. They are resilient. And pick themselves up and keep on going when they fall.
7. They are self-examining and adaptive.
8. They seek solutions. And address the "so what" so people care.
9. They have a fun factor or some kind of charisma – but are not necessarily extroverted.
10. They are persistent. Patience eventually pays off.

-Nancy Baron, Director of Science Outreach, COMPASS

WHOLE CHILD CONNECTION

The development of these attributes are supported when there is strong social and emotional support in early childhood classrooms. When teachers intentionally provide opportunities for children to explore their interests, work collaboratively with others, practice effective communication skills, learn skills for self-reflection, and practice persistence, it supports the development of foundational leadership skills—skills scientist leaders need.

Science Learning Area with science tools, materials, and open-ended activities easily accessible to children

Water table with tubing structure (top)
Provocation: Intentionally designed experience-worm exploration (bottom)

Intentional display of dried artichokes with classmade book and magnifying glsses (left)
Light table, magnetic board, and water table ready for children's use (right)

The Science Learning Area

BASIC RECOMMENDED MATERIALS

Open-ended Materials

- Blocks
- Sand/water table
- Light table
- Pulleys
- Gears
- Magnets
- Pipettes/droppers
- String/rope/clothes line
- Containers/jars
- Trays
- Tweezers of varying sizes
- Building/connecting materials
- Safety glasses
- Cars, balls, marbles

Tools for Observations & Documentation

- Magnifying glasses, hand lenses, loupes
- Camera for still shots (old cell phones work well)
- Device to capture videos and audio recordings
- Science journals
- Informational texts
- Array of writing tools
- Microscope/handheld digital microscope
- Binoculars
- Clipboards

Natural Materials

- Bark, twigs, cross sections of wood
- Nests
- Pine cones
- Seeds
- Plants
- Shells
- Stones/rocks

Tools for Measurement and Comparisons

- Balance
- Rulers/measuring tapes
- Scales
- Thermometer
- Graduated cylinders
- Stopwatch/timer
- Measuring cups/spoons

THE ENVIRONMENT

WHAT THE STUDENT DOES

Stage of the Instructional Model	The BSCS 5E Instructional Model: What the Student Does	
	That Is Consistent with This Model	That Is Inconsistent with This Model
Engagement	• Asks questions such as, "Why did this happen?" • "What do I already know about this?" • "What can I find out about this?" • Shows interest in the topic	• Asks for the "right" answer Offers the "right" answer • Seeks one solution
Exploration	• Thinks freely, within the limits of the activity • Tests predictions and hypotheses • Forms new predictions and hypotheses • Tries alternatives and discusses them with others • Records observations and ideas • Asks related questions • Suspends judgment	• Lets others do the thinking and exploring (passive involvement) • "Plays around" indiscriminately with no goal in mind • Stops with one solution
Explanation	• Explains possible solutions or answers to others • Listens critically to others' explanations • Questions others' explanations • Listens to and tries to comprehend explanations that the teacher offers • Refers to previous activities • Uses recorded observations in explanations • Assesses own understanding	• Proposes explanations from "thin air" with no relationship to previous experiences • Brings up irrelevant experiences and examples • Accepts explanations without justification • Does not attend to other plausible explanations
Elaboration	• Applies new labels, definitions, explanations, and skills in new but similar situations • Uses previous information to ask questions, propose solutions, make decisions, and design experiments • Draws reasonable conclusions from evidence • Records observations and explanations • Checks for understanding among peers	• Plays around with no goal in mind • Ignores previous information or evidence • Draws conclusions from thin air • In discussion, uses only those labels that the teacher provided
Evaluation	• Answers open-ended questions by using observations, evidence, and previously accepted explanations • Demonstrates an understanding or knowledge of the concept or skill • Evaluates his or her own progress and knowledge • Asks related questions that would encourage future investigations	• Draws conclusions, not using evidence or previously accepted explanations • Offers only yes-or-no answers and memorized definitions or explanations as answers • Fails to express satisfactory explanations in his or her own words

The BSCS 5E Instructional Model

WHAT THE TEACHER DOES

The BSCS 5E Instructional Model

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Stage of the Instructional Model	The BSCS 5E Instructional Model: What the Teacher Does That Is Consistent with This Model	That Is Inconsistent with This Model
Engagement	• Creates interest Generates curiosity Raises questions Elicits responses that uncover what the students know or think about the concept or topic	• Explains concepts Provides definitions and answers States conclusions Provides closure Lectures
Exploration	• Encourages the students to work together without direct instruction from the teacher • Observes and listens to the students as they interact • Asks probing questions to redirect the students' investigations when necessary • Provides time for the students to puzzle through problems • Acts as a consultant for students • Creates a "need to know" setting	• Provides answers • Tells or explains how to work through the problem • Provides closure • Directly tells the students that they are wrong • Gives information or facts that solve the problem • Leads the students step by step to a solution
Explanation	• Encourages the students to explain concepts and definitions in their own words • Asks for justification (evidence) and clarification from students • Formally clarifies definitions, explanations, and new labels when needed • Uses students' previous experiences as the basis for explaining concepts • Assesses students' growing understanding	• Accepts explanations that have no justification • Neglects to solicit the students' explanations • Introduces unrelated concepts or skills
Elaboration	• Expects the students to use formal labels, definitions, and explanations provided previously • Encourages the students to apply or extend the concepts and skills in new situations • Reminds the students of alternate explanations • Refers the students to existing data and evidence and asks, "What do you already know?" "Why do you think …?" (Strategies from exploration also apply here.)	• Provides definitive answers • Directly tells the students that they are wrong • Lectures • Leads students step by step to a solution • Explains how to work through the problem
Evaluation	• Observes the students as they apply new concepts and skills • Assesses students' knowledge and skills • Looks for evidence that the students have changed their thinking or behaviors • Allows students to assess their own learning and group-process skills • Asks open-ended questions such as, "Why do you think …?" "What evidence do you have?" "What do you know about *x*?" "How would you explain *x*?"	• Tests vocabulary words, terms, and isolated facts • Introduces new ideas or concepts • Creates ambiguity • Promotes open-ended discussion unrelated to the concept or skill

5Es IN PRACTICE

AN INVESTIGATION INTO SOIL

Stage of the Instructional Model	Model Description	Intentional opportunities for learning
Engagement	**To capture attention, activate prior knowledge, and raise questions about soil** *(PO 1. Identify rocks, soils and water as basic Earth materials)*	• Take a walk around the school and notice the soil. • If permitted, dig soil samples from several locations. • Ask families to bring in soil samples from their homes. • Chart children's experiences with soil, what they have noticed and what they wonder about soil.
Exploration	**This is a time to observe, record, experiment, and organize ideas.** *(PO 2. Compare physical properties ((e.g. color, texture, capacity to retain water)) of basic Earth materials, PO 3. Classify a variety of objects as being natural or man-made, PO 1. Identify the following aspects of weather (wind, precipitation)*	• **Look closely at soil**: Working in small groups, children pour soil onto white paper (on table or a cookie sheet). Using paint brushes and tweezers, children sort through the soil. What do they see? • **Take a closer look**: Add a variety of magnifying glasses, and if possible, a microscope to look take a closer look at the soils and what it is in. • **Sift through the soil:** Add sieves and strainers with different size openings • **Observe with our hands**: What happens when soil is pushed together. Does it hold its shape? Do all the samples act the same way? Can it be rolled into a ball? Does it break easily? • **Wind and Rain on Soil:** Provide straws, eye droppers, and/or watering cans to create the effects of wind and rain on soil. • **Percolate through the Soil:** Funnel water through different types of soil (some with lots of sand, some with lots of clay, some top soil). What differences are noted?
Explanation	**During this phase, children share their initial findings. ideas, questions, and new understandings are recorded. Scientific vocabulary is introduced and experiences support understanding of explorations.**	• **Pick a Path**: Children act out the flow of water through sand, silt, and clay. • **Soil as a Filter:** Extending the previous percolation activity, different soils are used to filter "polluted" water. • **Extracting Clay:** Clay is removed from the soil and has many uses. • **The Three Little Pigs**: To further demonstrate the effects of weather on soil, children create three types of structure and model the effects of rain and wind.
Elaborate	**These are opportunities to o apply new knowledge, ask new questions, and continue to explore.** *PO 4. Identify ways some natural or man-made materials can be reused or recycled*	• Make soil by crushing small rocks into fine particles. • Create a worm farm and watch the role of worms in composting. • Making Adobe Bricks • Paint with Soil • Sculpt with Clay • Look for effects of weather on soil when outdoors.
Evaluation	Formative assessment takes place throughout the lesson	• Photos of children's engagement and exploration are taken • Teachers uses questioning that encourages children to share their thinking • Teachers document observations, conversations, reflections, etc. • Teachers take audio recordings of conversations • Teachers video children engaging, conversing, sharing

Intentionally infuse vocabulary words:
Soil, Sand, Silt, Clay, Loam, Erosion

Suggested books for Soil Investigation:
***Dirt: The Scoop** on Soil*, Natalie M. Rosinsky and Sheree Boyd
Soil Basics, Mari Schuh

NSTA Position Statement:
Early Childhood Science Education

Introduction

At an early age, all children have the capacity and propensity to observe, explore, and discover the world around them (NRC 2012). These are basic abilities for science learning that can and should be encouraged and supported among children in the earliest years of their lives. The National Science Teachers Association (NSTA) affirms that learning science and engineering practices in the early years can foster children's curiosity and enjoyment in exploring the world around them and lay the foundation for a progression of science learning in K–12 settings and throughout their entire lives.

This statement focuses primarily on children from age 3 through preschool. NSTA recognizes, however, the importance of exploratory play and other forms of active engagement for younger children from birth to age 3 as they come to explore and understand the world around them. This document complements NSTA's position statement on elementary school science (NSTA 2002) that focuses on science learning from kindergarten until students enter middle or junior high.

Current research indicates that young children have the capacity for constructing conceptual learning and the ability to use the practices of reasoning and inquiry (NRC 2007, 2012). Many adults, including educators, tend to underestimate children's capacity to learn science core ideas and practices in the early years and fail to provide the opportunities and experiences for them to foster science skills and build conceptual understanding (NRC 2007, p. vii). Also underestimated is the length of time that young children are able to focus on science explorations. Effective science investigations can deeply engage young children for extended periods of time, beyond a single activity or session.

NSTA supports the learning of science among young children that will create a seamless transition for learning in elementary school.

Young Children and Science Learning

NSTA identifies the following key principles to guide the learning of science among young children.

- **Children have the capacity to engage in scientific practices and develop understanding at a conceptual level.**
  Current research shows that young children have the capacity for conceptual learning and the ability to use the skills of reasoning and inquiry as they investigate how the world works (NRC 2007, NRC 2012). For example, their play with blocks, water, and sand shares some science-relevant characteristics. Young children also can learn to organize and communicate what they learn, and know the difference between concrete and abstract ideas (Carey 1985). Adults who engage children in science inquiry through the process of asking questions, investigating, and constructing explanations can provide developmentally appropriate environments that take advantage of what children do as part of their everyday life prior to entering formal school settings (NAEYC 2013, p. 17; NRC 2007).These skills and abilities can provide helpful starting points for developing scientific reasoning (NRC 2007, p. 82).

- **Adults play a central and important role in helping young children learn science.**
  Everyday life is rich with science experiences, but these experiences can best contribute to science learning when an adult prepares the environment for science exploration, focuses children's observations, and provides time to talk about what was done and seen (NAEYC 2013, p. 18). It is important that adults support children's play and also direct their attention, structure their experiences, support their learning attempts, and regulate the complexity and difficulty of levels of information (NRC 2007, p. 3). It's equally important for adults to look for signs from children and adjust the learning experiences to support their curiosity, learning, and understanding.

- **Young children need multiple and varied opportunities to engage in science exploration and discovery** (NAEYC 2013).
  Young children develop science understanding best when given multiple opportunities to engage in science exploration and experiences through inquiry (Bosse, Jacobs, and Anderson 2009; Gelman, Brenneman, Macdonald, and Roman 2010). The range of experiences gives them the basis for seeing patterns, forming theories, considering alternate explanations, and building their knowledge. For example, engaging with natural environments in an outdoor learning center can provide opportunities for children to examine and duplicate the habitats of animals and insects, explore how things move, investigate the flow of water, recognize different textures that exist, make predictions about things they see, and test their knowledge.

- **Young children develop science skills and knowledge in both formal and informal settings.**
  Opportunities to explore, inquire, discover, and construct within the natural environment and with materials that are there need to be provided in formal education settings, such as preschool and early care and education programs through intentional lessons planned by knowledgeable adults. In addition, children need to have opportunities to engage in

science learning in informal settings, such as at home with cooking activities and outdoor play or in the community exploring and observing the environment.

- **Young children develop science skills and knowledge over time.**
  To effectively build science understanding, young children need opportunities for sustained engagement with materials and conversations that focus on the same set of ideas over weeks, months, and years (NRC 2007, p. 3). For example, investigating the concept of light and shadows over several weeks indoors and out with a variety of materials and multiple activities will allow children to re-visit and re-engage over time, building on observations and predictions from day to day.

- **Young children develop science skills and learning by engaging in experiential learning.**
  Young children engage in science activities when an adult intentionally prepares the environment and the experiences to allow children to fully engage with materials. The activities allow children to question, explore, investigate, make meaning, and construct explanations and organize knowledge by manipulating materials.

Declarations

NSTA recommends that teachers and other education providers who support children's learning in any early childhood setting should

- recognize the value and importance of nurturing young children's curiosity and provide experiences in the early years that focus on the content and practices of science with an understanding of how these experiences connect to the science content defined in the *Next Generation Science Standards (NGSS)* (NGSS Lead States 2013);

- understand that science experiences are already a part of what young children encounter every day through play and interactions with others, but that teachers and other education providers need to provide a learning environment that encourages children to ask questions, plan investigations, and record and discuss findings;

- tap into, guide, and focus children's natural interests and abilities through carefully planned open-ended, inquiry-based explorations;

- provide numerous opportunities every day for young children to engage in science inquiry and learning by intentionally designing a rich, positive, and safe environment for exploration and discovery;

- emphasize the learning of science and engineering practices, including asking questions and defining problems; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using mathematics and computational thinking; constructing explanations and designing solutions; engaging in argument from evidence; and obtaining, evaluating, and communicating information (NRC 2012, NGSS Lead States 2013);

- recognize that science provides a purposeful context for developing literacy skills and concepts, including speaking, listening, vocabulary development, and many others; and

- recognize that science provides a purposeful context for use of math skills and concepts.

NSTA recommends that teachers and other providers who support the learning of science in young children be given professional development experiences that

- engage them in learning science principles in an interactive, hands-on approach, enabling them to teach about science principles appropriately and knowledgeably;
- are ongoing and science-specific;
- help them understand how children learn science and engineering practices (NRC 2012, NGSS Lead States 2013);
- inform them about a range of strategies for teaching science effectively; and
- include the use of mentors to provide ongoing support for educators for the application of new learning.

NSTA recommends that those in a position to provide financial, policy, and other support for early childhood education should

- provide appropriate resources for teachers and children;
- ensure a positive and safe environment for exploration and discovery;
- ensure teachers receive sustained science-specific professional development that includes how children learn and how to teach science;
- provide mentoring; and
- establish a coherent system of science standards, instruction, appropriate assessment, and curriculum.

Parents and other caregivers can nurture children's natural curiosity about the world around them, creating a positive and safe environment at home for exploration and discovery. These recommendations can be found in NSTA's position statement, Parent Involvement in Science Learning (NSTA 2009), found at *www.nsta.org.*

—Adopted by the NSTA Board of Directors
January 2014

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