CREATIVE INVESTIGATIONS IN EARLY SCIENCE

Angela Eckhoff, PhD

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Introduction

Inquiry-Based Learning in Early Science

Tommy and three of his classmates are sitting together in the art area working on paintings of imagined, mythical creatures known as zoomorphic animals. Zoomorphic creatures are fantastic creations consisting of various parts of real animals put together in novel ways. This class of five- and six-year-olds has been studying the characteristics and habits of animals for several weeks as part of the science curricula. Tommy's teacher, Mr. Brown, had recently shared a story that features zoomorphic animals, *If I Had a Gryphon* by Vikki VanSickle, and many of the children expressed an interest in developing their own mythical creatures. To support this exploration, Mr. Brown stocked the classroom's science center with pictures of various animals for the children to use to explore, as well as with paints, paper, colored pencils, and a variety of markers to use in the drawing and painting phases of the project. He encouraged the students to begin by sketching draft drawings and working to modify those drawings over the course of several days. Once they were satisfied with their sketches, the children were then encouraged to use the arts media to add color and definition to the images. The subject of Tommy's zoomorphic work is a combination of several of his favorite real-life animals and features the head of an elephant, the wings of an eagle, and the sharp spines of an iguana. Tommy's zoomorphic creature is a fantastic combination of animal characteristics that give his creature "super powers to be the strongest and fastest"—to be as strong as an elephant, to fly like an eagle, and to have the natural defenses of an iguana. As Mr. Brown comes over to talk about the boys' work, Tommy excitedly draws Mr. Brown's attention to his distinctive creature by pointing out its component parts. Mr. Brown and Tommy discuss the parts of the drawing that are associated with each animal that was used as inspiration. "Okay, Tommy," says Mr. Brown, "I have a challenge for you. If your creature has an elephant head but the body of an eagle, what does it eat?" Tommy

replies excitedly that his elephant head likes to eat peanuts, not dead animals or worms like eagles do. Mr. Brown laughs and asks Tommy, "Where will this creature sleep? Will it have a nest like an eagle?" Tommy quickly answers yes and says, "He is little like an eagle so he needs to sleep up high in a nest away from big animals."

Tommy's Zoomorphic creature.

Tommy's zoomorphic creature experience provided him with opportunities to bring together his understanding of the needs and characteristics of animals as well as his creative-thinking and visual art skills. Mr. Brown has created a learning environment that encourages and supports connections between science content and the children's desire to engage in creative experiences. The exploration of zoomorphic creatures provides unique opportunities for each child to develop his own interpretation and encourages the children to reflect and draw upon their knowledge of the physical characteristics of animals.

Mr. Brown enhanced this experience for his students by encouraging engagement with one another through the sketching and research experiences with the animal photographs. He also extended the children's individual work by asking prompting questions.

Young Children are Scientists

All children are scientists; during the early childhood years children naturally engage in the scientific processes of observation, manipulation, experimentation, and exploration. The natural curiosity of young students provides early childhood educators with an entry point from which to build classroom science experiences. Inquiry-based early childhood science education capitalizes on the interests young children demonstrate as they explore the world around them. Through creative, hands- and minds-on experiences, early childhood educators can encourage children to construct understanding of earth, life, and physical sciences in ways that are personally meaningful. The science experiences described in this book are based on the 5E inquiry model of instruction (engage, explore, explain, extend/elaborate, and evaluate) as well as the content recommendations from the *Next Generation Science Standards* (NGSS).

This book is designed to provide early childhood educators with pedagogical practices, science content knowledge, and lesson ideas that scaffold young children's experiences with earth, life, and physical science, while also building inquiry and creative-thinking skills. This book will broaden your understanding of the relationship between science content, the role of the learning environment, and supportive pedagogical practices in early childhood classrooms. When science experiences build on student interests and understanding and connect to other areas of content learning—literacy, technology, engineering, the arts, mathematics, and social studies—young children are able to experience meaningful, relevant connections among different content areas. This book stresses the importance of encouraging *minds-on* learning experiences in the early childhood classroom through guided and independent investigations, where every child is actively involved in meaningful ways. Early childhood educators have important roles in early science-focused experiences

and will act as both a guide and facilitator throughout the planning, implementation, and assessment of the creative, inquiry-based experiences presented throughout this book. For young children, science experiences involve using tools and a variety of materials, being creative and inventive, developing questions based on observations, exploring problems, and sharing their understanding with others.

Creative Investigations in Early Science will support your development of creative early science experiences in the classroom by helping you to

- understand the links between science content, inquiry-based learning, and project-based learning;
- plan cooperative science lessons that will engage all children in your classroom as individuals or when working in small or whole groups;
- implement classroom experiences that support children's engagement with science content on a daily basis;
- recognize children's understanding, beliefs, and misconceptions of science concepts and utilize that information to support the growth of conceptual knowledge; and
- document children's knowledge development with authentic work samples and classroom artifacts.

Playful Learning

Play is an essential element of explorations of science in early childhood. Through play, young children learn about themselves, their environment, other people, and the world around them. Playful learning encourages children to explore and experiment in situations where they feel comfortable taking risks and delving into the unknown. Children's play in the early childhood classroom can take on many different forms and functions. When children explore, experiment, and cooperate through play, they learn about how the world works. Children need teachers who are supportive of this play and who work to carefully identify play situations where teacher guidance or involvement are welcome and needed.

Young children use their knowledge and understanding by bringing these ideas into their play to further experiment and clarify their understanding. This process is child-driven; the role of the adult is one of supporter, guide, and facilitator. The adult meets each child at his own stage of understanding with intentional pedagogical practices that promote questioning and exploration. Teachers can create early childhood classrooms that honor the ways in which children learn and explore by ensuring that young children have ample opportunities for playful learning and exploration. In the role of supporter, guide, and facilitator, the teacher carefully observes children's play and helps to encourage children's thinking through questioning, providing additional, supportive materials and opportunities for guided learning.

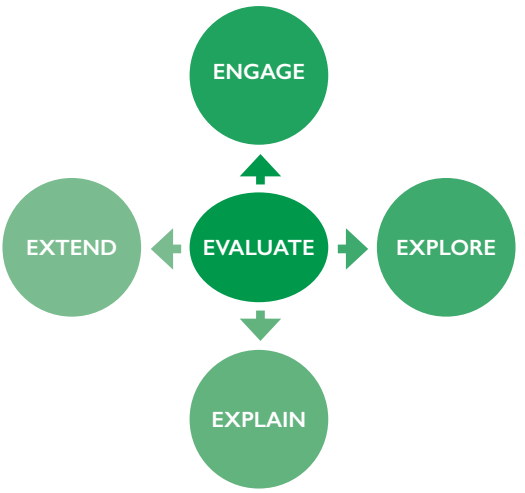
Guided Inquiry in Early Science Experiences

Inquiry-based learning can play a central role in the development of meaningful learning opportunities as children explore emerging skills in early science. Contrary to traditional notions of the teacher's role as a teller of information, teachers in inquiry classrooms perform the roles of guide, facilitator, and provocateur by asking questions and designing meaningful lessons built on student interests. A teacher's ability to listen to his students is a foundational component of the use of guided inquiry in science explorations. By carefully listening to students and reflecting on their ideas and interests, you will be able to plan and implement engaging and meaningful science explorations with your students that encourage individual expression.

Inquiry-based science experiences in early childhood classrooms are based on the 5E instructional model, where students are first engaged in the topic and then explore using materials and media, which is then followed by opportunities for explanation and elaboration. In the 5E model, both teachers and students work to evaluate ideas and understanding throughout the entire experience (Bybee, et al., 2006). Inquiry-based science learning requires planning and intensive engagement

on the part of the teacher as well as attentiveness and active engagement on the part of the children. It is recommended that early science experiences incorporate opportunities for exploring both content and inquiry skills. Inquiry-based learning requires these process skills: observation, exploration, questioning, making predictions, using simple tools and technologies, and conducting simple science investigations. In the introduction to each chapter of the book, you will find suggested ideas and practices for each phase of the 5E model based on the content covered in that chapter.

Bybee, Rodger W., et al. 2006. *The BCBS 5E Instructional Model: Origins and Effectiveness*. Colorado Springs, CO: BCBS.



The 5E Model

Engage

Students come to learning situations with prior knowledge, incomplete understanding, and even misconceptions. The *engage* phase of the model provides opportunities for teachers to find out what students already know or believe about the concept under exploration. This phase also gives the children an opportunity to think about and discuss their thoughts about the concept. The engage phase is important because it offers an opportunity to capture student interest and inspires young children to want to find out more.

Explore

The *explore* phase of the inquiry cycle involves the hands-on, minds-on engagement of students. During the explore phase students will be actively working as individuals or as part of a group investigating materials, ideas, and questions. Time and space are important elements to exploration, so in this phase you will need to provide children with ample time and physical space to conduct their investigations. The explore phase can take place over several days or even weeks depending on the concept under investigation and the children's interest in further exploration.

Explain

The *explain* phase of the inquiry model provides opportunities for students to connect their prior understanding with their current experiences. Through both oral (discussion) and physical explanations (drawings, journals, models), the explain phase helps students develop their conceptual understanding of the science content. Because of the emphasis on sharing understanding, this phase also provides opportunities for you to introduce science language and terms to help support students' explanations. Prompting questions you can pose during this phase may include the following: What did you notice? How can you show us what you know or experienced? Can you tell us more about why you think that happened?

Elaborate

The *elaboration* phase of the inquiry model provides opportunities for children to apply or extend previously introduced concepts and experiences to new situations. In early childhood classrooms, opportunities for elaboration can begin through follow-up experiences in the science center or during paired or small group experiences. In the elaboration phase it is important for students to have opportunities to discuss and compare their ideas with others.

Evaluate

In early childhood science experiences, informal observations and interactions with students throughout all phases of the inquiry model

are the most appropriate ways to gather information on student understanding. The *evaluation* phase should always be directly connected to students' in-process work rather than the end product of an experience. You can engage your students in the evaluation phase by encouraging them to share their experiences and understanding with others and to also listen and respond to the ideas of their peers.

Moving beyond Misconceptions in Science

Misconceptions are ideas that a child or an adult may have that are not aligned with accepted scientific views. We all have science misconceptions; many are formed about concepts that are frequently misunderstood. A common misconception you have probably heard more than once is that humans only use 10 percent of their brains. Cognitive scientists have worked for years to change this misconception by stating that there is no scientific evidence to suggest that we use only 10 percent of our brains. In fact, brain imagining demonstrates that when we move, speak, or think about a particular object, brain activity is widely noted in many regions. However, once many of us hear this myth, it stays with us and we may repeat it to others. Like adults, young children frequently have misconceptions. A few common misconceptions they may hold are the following:

- Rain comes from holes in clouds.
- It rains because we need or want it.
- Leaves pick the color they want to change to in the fall.
- Humans are not animals.
- The moon can only be seen during the night.
- There are four separate moons.

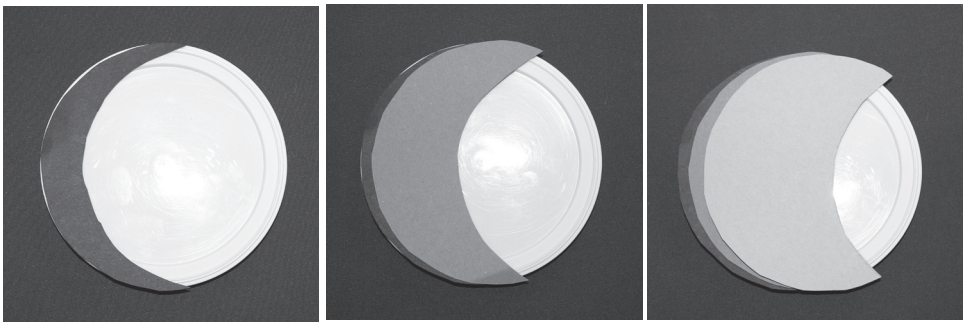
If we spend some time thinking about these misconceptions, we can begin to understand how children develop these ideas. When children

look at the sky on a rainy day, they may see clouds that appear to have holes, which would let rain leak out. They also hear adults say things such as, "The tree makes such beautiful colors in the fall." We point out the moon at night to children and read books that connect the moon and nighttime, but we may not take advantage of a clear sky during the day when we could point out the moon. The misconception that there are four different moons could be developed as children view the moon intermittently, where they only view the moon on occasion and note that it looks different from the time before. Without intending to, we also help to create misconceptions in the classroom when we do activities that might serve to reinforce their incomplete understanding. For example, a common phase of the moon lesson involves children using cookies or paper cutouts with small portions removed to represent each phase. As this activity requires students to create and display linearly four separate moons, we can understand how they arrive at a misconception.

Phases of the Moon: Cookie Experience

An activity that would better reinforce the idea of one moon moving through phases would be one in which the four phase cutouts could be laid on top of a single moon. Children can visualize that we can only see a part of the moon in each phase and can learn how the full moon is blocked, preventing us from seeing it in its entirety. This activity will also allow the children to see how each phase relates to the previous phase. You may want to follow up this experience by inviting children and families to complete a month-long moon journal in the evenings, which will further deepen the children's understanding. If children have

the opportunity to view the moon every evening (or when possible) and draw what they see for a month, they will begin to understand how the moon goes through the phases gradually. Providing young children with experiences that intentionally build on each other will help to avoid instances of reinforcing or developing misconceptions.



Phases of the Moon Cutouts

We can work to identify misconceptions by taking the time to talk and listen to students' thoughts and conversations during all phases of the inquiry cycle. In particular, asking children what they already know or understand about concepts during the *explore* phase of the cycle will help you to decide how best to proceed in your instruction. It's challenging to change misconceptions because they are based on our held beliefs, and we don't readily shed beliefs without prompting. Fortunately, we can work with young children and provide them with many opportunities to challenge their thinking. Having lessons in which students are interested will help support their willingness to think deeply. The concepts that you are teaching need to be appropriate and at a level that children can understand. For example, the concept of seasonal change is very complex. When we break it down into conceptual knowledge that is appropriate for young learners, we can focus on experiences where children observe and describe the characteristics of living things, compare the growth of a person to the growth of a plant and an animal, and describe the basic needs and the basic life processes of each. This foundational knowledge will help them understand why we experience seasonal change in later grades. Building conceptual knowledge in science is a long-term endeavor and the early childhood years are the time where we can help to develop children's initial understanding, skills, and dispositions.

Building Creative Science Experiences in the Classroom

Early childhood educators have essential roles in the development of children's creative thinking skills because they can create supportive classroom environments or classrooms in which children's creative skills are stifled. To incorporate creative learning experiences in the classroom, teachers must design lessons that include opportunities for critical thinking and reflection while also maintaining a focus on student interest. In addition, teachers must recognize that creativity is a learning process that encourages social interaction and promotes individual ownership of ideas. In the classroom, creativity is part of the learning process based on children's interests and it involves reflection and interaction with other children and adults, and it requires children to document and report on their thinking and experiences. When young children are provided opportunities to personally engage with challenging, reflective learning experiences, they are building critical and creative thinking skills.

The lesson ideas and classroom vignettes shared throughout this book incorporate opportunities to build children's inquiry process skills and their understanding of earth, life, and physical science while also promoting children's creative thinking skills. Each lesson includes critical elements of inquiry and creative thinking—open-ended tasks, opportunities for social interaction, and opportunities for reflection and elaboration. Open-ended tasks provide young learners with opportunities to experiment with new ideas and engage in inquiry. Because open-ended tasks promote idea experimentation, they encourage children to focus on the processes of learning rather than the need to arrive at a solitary correct answer. Gaining experience with idea experimentation will help support children's acceptance of ambiguity and the willingness to make mistakes, allowing them to gain confidence in their problem-solving abilities. Likewise, providing opportunities for small group works and social interaction is a crucial component of creative thinking. Working in pairs or small groups will help to promote brainstorming and allow children to learn from and with each other. Such tasks will also support

children's experiences with reflection and idea elaboration. These skills are important cognitive tools that allow children to learn from their own experiences and examine their own learning process.

Recommended Practices and Content Coverage in Early Science Experiences

The content of the lessons presented in each chapter of this book are based on the guiding recommendations in the *Next Generation Science Standards* from National Academies Press. While these standards do not speak directly to young children in the preschool years, you can use these guidelines to help determine the types of experiences that you can develop in your classroom so that your students have a solid foundation in both content understanding as well as experiences and are engaged in creative thinking processes and inquiry-based learning. Every lesson presented in this book is designed to encourage you to explore and implement the types of inquiry-based science experiences that will build children's thinking, exploration, questioning, and documentation skills in addition to curricular content knowledge. Every lesson you encounter in this book will ask you to carefully consider your interactions with young children as well as the classroom environment. The interplay among children, teachers, and the classroom environment are all central to the process of learning. The concept of *possibility thinking* encourages teachers to consider the effect that asking questions, play, supportive classrooms, imagination, innovation, and risk-taking have on the processes of thinking and learning.

Possibility thinking—A dynamic interplay between children and teachers (Craft, et al., 2012)

Posing questions—questions from children are acknowledged and celebrated by teachers; teachers' questions encourage inquiry

Play—opportunities for extended play periods

Immersion—immersion in a "benign environment" free from criticism and mockery

Innovation—teachers closely observe innovations in student thinking in order to prompt and encourage

Being imaginative—ample opportunities to meld imagination and curriculum content

Self-determination and risk taking—deep involvement and risk-taking are encouraged by both children and teachers

Source: Craft, Anna, Linda McConnon, and Alice Matthews. 2012. "Child-Initiated Play and Professional Creativity: Enabling Four-Year-Olds' Possibility Thinking." *Thinking Skills and Creativity* 7(1):48–61.

Promoting Creative, Inquiry-Based Learning in Science

Classroom Components	*Supportive Approaches in the Early Childhood Classroom*
Physical Environment	• Flexible spaces with moveable furnishings that provide space for exploration, display, and storage, and spaces that can accommodate and adapt for small and large groups
Role of the Teacher	• Provide opportunities for children to document their thinking through drawing, writing, and verbal means • Encourage students to share their thoughts with a large/small group • Ask questions to promote deep thinking and problem solving • Provide materials that can support student inquiry • Closely monitor student thinking and exploration in order to scaffold experiences

Classroom Components	*Supportive Approaches in the Early Childhood Classroom*
Peer-to-Peer Relationships	• Provide opportunities for children to share their problem-solving experiences and encourage and support children's use of inquiry-based and creative thinking • Provide opportunities for children to ask questions, design experiments/ plans, work in pairs/small groups, test ideas, and document their experiences
Structure of Technology and Engineering Experiences	• Provide opportunities for children to connect science to other content areas, work on problems and projects for extended periods of time, and revisit previous experiences and lessons multiple times to encourage mastery and promote confidence
Parent and Community Engagement	• Provide opportunities to connect science experiences into the community and the children's daily lives • Engage families throughout the learning process through regular documentation of children's experiences

Creating Engaging Science Centers

In addition to planning and implementing science experiences in the classroom, it is important to create learning spaces where your students are able to further their own explorations. A science learning center is a good place to invite your students to work individually or in small groups; these centers can be permanent or moveable, depending on the interests and needs of your students at any given time. Many science concepts are a natural extension to preschoolers' play in outdoor spaces where children may freely explore life and earth science content.

Classroom Components	*Teacher Actions*
The Physical Environment	• Include a variety of natural materials, content-focused books, posters or colorful photos, and child-friendly science equipment (magnifying glasses, scales, rulers)
The Role of the Teacher	• Develop a supportive environment for playful learning, experimentation, and risk-taking • Closely observe children's play and exploration (formative assessment) • Ask thoughtful questions and provide opportunities to expand and clarify children's thinking
Peer-to-Peer Relationships	• Plan opportunities for collaborative experiences • Demonstrate respect for students' work and ideas • Provide opportunities for play and exploration
Structure of Science Lessons and Experiences	• Plan opportunities for individual and group experiences • Keep a flexible schedule for lesson lengths based on children's responses and interests • Develop extended, project-based science experiences for complex content • Plan opportunities for children to make their thinking visible (exploratory, hands-on experiences; science journals; digital photography) • Extend familiar lessons and concepts to deepen and encourage flexibility of student understanding

Organization of the Book

This book is based on broad categories for early science explorations: matter and physical properties, physical and chemical changes, growth and change, conservation and sustainability, and earth and space systems.

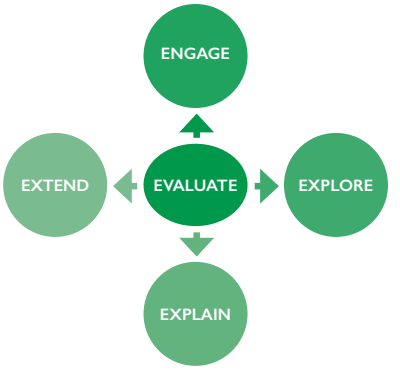
Each chapter begins with a section where you can find background information on physical, life or earth science content and the processes of inquiry related to each content area. Each chapter also features classroom vignettes to help bring the information on content and pedagogical information to life. Woven throughout the book are science lessons for preschoolers that are built on pedagogical practices for creative, inquiry-based thinking. You will also find children's book recommendations related to each chapter's content.

1
Physical Science: Understanding Matter and Physical Properties

Young children explore their world using their five senses to take in information about the physical properties of objects. These explorations serve as a foundation to understanding objects and the behaviors of those objects under various conditions. A young child licking a frozen treat outside on a warm summer day quickly learns that it can melt before she is finished! These direct, informal experiences allow children to make inferences about the reasonable and sometimes unreasonable explanations of consequences.

Matter is anything that has mass and takes up space. Mass is the amount of matter in an object and differs from weight which is a measurement of the gravitational pull on an object. Young children can readily explore the physical properties of matter including size, shape, color, texture, hardness, melting point, magnetism, and whether an object sinks or floats. Explorations with the physical properties of matter provide creative opportunities for inquiry-based learning by allowing numerous opportunities to make observations, develop predictions, and conduct simple experiments.

The Cycle of Inquiry: Matter and Physical Properties



Engage

Questions to Engage: Matter and Physical Properties

Ask these types of questions to engage young learners' interests:

- Which of these objects do you think is heavier? What makes you think that?
- What do you think will happen if we put this ice cube in the sun and put this one in the shade?
- Why will it melt faster/slower?
- What do you think this object will feel like in your hand?
- Can you describe this object with one word?

Explore

Engaged Exploration: Matter and Physical Properties

To assist children as they work to explore the world around them, provide a space in the classroom that allows them to do the following:

- Sort, compare, and classify objects by their physical properties (color, shape, texture, size, weight, and phase of matter (solid or liquid)
- Explore water and objects (sink or float)
- Touch objects of varying textures and materials

Explain

Explanation Opportunities: Matter and Physical Properties

Use the following suggestions to help children understand and explore class lessons on a deeper level:

- Display properties charts in the classroom
- Display photographs of experiments with student quotes
- Plan whole group debriefings that discuss observed changes in matter
- Encourage students to draw, write, and comment in their science journals
- Develop whole class exploration charts with objects that sink or float, objects that are magnetic or non-magnetic, and objects that are hard or soft

Elaborate

Science Center Elaborations: Matter and Physical Properties

Engage your students with the following ideas to continue their learning:

- Plan water play indoors or outdoors with a variety of natural and man-made objects to test the sink or float property
- Test magnets and a variety of materials to learn about the magnetism property
- Classify a variety of materials to explore the size, shape, color, texture, or hardness properties

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RESEARCH, question, ANALYZE, and discover... START EXPERIMENTING!

Young children are born scientists with an innate desire to analyze and investigate the world around them. Expand their learning and encourage their inquisitive nature as you explore the physical, life, and earth sciences together! *Creative Investigations in Early Science* will help you to guide preschoolers' learning as they study seasonal transitions, explore basic chemical changes, and learn about matter and physical properties. Children will develop an early love for the sciences as you help them research, question, experiment, analyze, and discover through open-ended explorations. You'll feed their curiosity while enhancing their STEM skills!

Teachers and parents alike will learn practical and approachable ways to intentionally foster their young scientists' hands-on, minds-on explorations in the following areas:

- Matter and physical properties
- Physical and chemical changes
- Conservation and sustainability
- Earth and space systems

Guide your young STEM learners as they explore both on their own and collaboratively to grow their knowledge about the world around them.

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