Not too Early but just Right: Why Early Science Education is Key to Building a Foundation for High Quality Teaching & Lifelong Learning

2017 Buffett Institute PD for All: Children as Scientists

Daryl B. Greenfield, Ph.D., University of Miami, October 5, 2017

"Reaffirming and strengthening America's role as the world's engine of scientific discovery and technological innovation is essential to meeting the challenges of this century…That's why I am committed to making the improvement of STEM education over the next decade a national priority."

- President Obama
on the "Educate to Innovate Campaign" (2009)

White House Summit on STEM in Early Childhood, April 21, 2016

"Research indicates that as early as **infancy**, young children start **developing and testing hypotheses for how the world around them works.** They understand **probability** and make **predictions**. They take in information from trusted sources around them, and **use that information to guide their behavior.** And that all begins in the first year of life. As they progress through the preschool years, their **curiosity continues to grow**, and the **sophistication of their reasoning and inquiry skills, grow along with it.**"

Theories of Child Development: Applications to Early Education Practices

Jean Piaget Lev Vygotsky Michelle Chouinard

Piaget

- Child's development occurs internally through child's active engagement with his/her environment
- Role of a adult is to provide child with stimulating/novel environment to explore

Vygotsky

- Adults scaffold children into a “zone of proximal development,” carefully guiding each step in a hands-on apprenticeship fashion
- Must know sequence of steps children follow in learning a new skill
- Role of adult highly interactive, scaffolding the child into his/her zone of proximal development

Do Children Ask Questions & Why[1]?

Do young children ask questions?

- If yes, what is the content and focus of these questions

- Multiple studies with small and large groups of children to answer these questions

[1]Chouinard, M. 2007. Children's questions: A mechanism for cognitive development. *Monographs of the Society for Research in Child Development*, *72* (1):vii-ix, 1-136

Transcriptions of Naturally Occurring Parent-Child Spontaneous Questions for 4 children 1 – 5 years of age (total Qs & how many per hour)

Child	Age Range	Total Questions	Questions per hour
Abe	2:4 – 3:11	5219	69.6
Adam	2:3 – 4:10	10,905	198
Naomi	1:1 – 5:1	2321	77.4
Sarah	2:3 -5:1	6296	90.6
TOTAL		24,741	107.8

Data from: Chouinard, M. 2007. Children's questions: A mechanism for cognitive development. *Monographs of the Society for Research in Child Development, 72* (1):vii-ix, 1-136

Types of Questions Asked (Chouinard, M. 2007)

Information Seeking:

Factual (What's that?)

Explanatory (How do you make it go over there?)

Non-Information Seeking:

Attention Seeking (Hey Mom?)

Action (Can you fix this for me?)

Permission (Can I go outside?)

Information Seeking: 91% from 1.5 to 2 years of age; 71% from 2 – 5 year of age

Parents Responses (Chouinard, M. 2007)

How Often Do Parents Give Answers?

79% of questions are answered by parents for 1.5 to 2 year olds; 70% for 2 to 5 year olds

- What happens when parents do NOT answer children's questions?
  - Children persist until they get an answer
- Typically children start with factual question
  - Parents give answer versus parents engage in feedback loop

Chouinard

- Children ask questions when they have gaps, inconsistencies, problems in their knowledge
- Parents give answers, but when they don't children PERSIST
- Back and forth exchanges move from *fact* to *explanation*
- Young children's questions are powerful tools for gathering information and advancing cognitive development

All science inquiry starts with a question!

Why Science for Young Children - What the Research Says:

Children learn best when they are:

- Active (physically and mentally)

- Engaged in a goal-directed activity with meaningful to-be-learned concepts

- In a context where they can socially interact with others

Science provides all of these features, drawing upon young children's natural curiosity and motivation to make sense of their world

Implications for Learning

Taken together these theories and research tell us to:

Involve meaningful, active, & engaging materials that can be explored in socially interactive ways

Encourage children to ask questions

Guide exploration into "zone of proximal development"

Provide stimulating environments for active exploration

Move from factual knowledge to in-depth understanding

Provide goal-directed experiences that focus on concept development

All of these come naturally during SCIENCE experiences

Using Science as a Way of Integrating Multiple Learning Domains

Science is Integrative

- **Language and Literacy --** Scientists document their observations, predictions and outcomes in science journals; lots of books for preschoolers to read that have science as main content
- **Early Math --** Involves counting, measuring, comparing, making charts and other important math skills
- **Social & Emotional Development --** Science is done in groups and shared among participants, promoting social development
- **Physical Development and Health --** Activities develop find and gross motor skills; Science projects can be designed around health issues
- **Creative Arts --** Science involves lots of drawing; easy to add creative arts projects as part of each science activity
- **English Language Acquisition --** Science is fertile ground for learning new vocabulary, and communicating

Science learning involves all these areas while drawing upon young children's natural curiosity and motivation to make sense of their world

The Universal Language of Science

Science & Domain General Skills

- Domain general skills:
  - Support learning across domains
  - Are modifiable
  - Promote school readiness
  - Apply to lifelong learning
- Examples include:
  - Approaches to learning
  - Executive functioning

Science supports the development of these important skills!

Executive functioning

A set of higher-order thinking skills that help monitor and control thoughts and behavior

Cognitive Flexibility

Shifting from one mindset to another

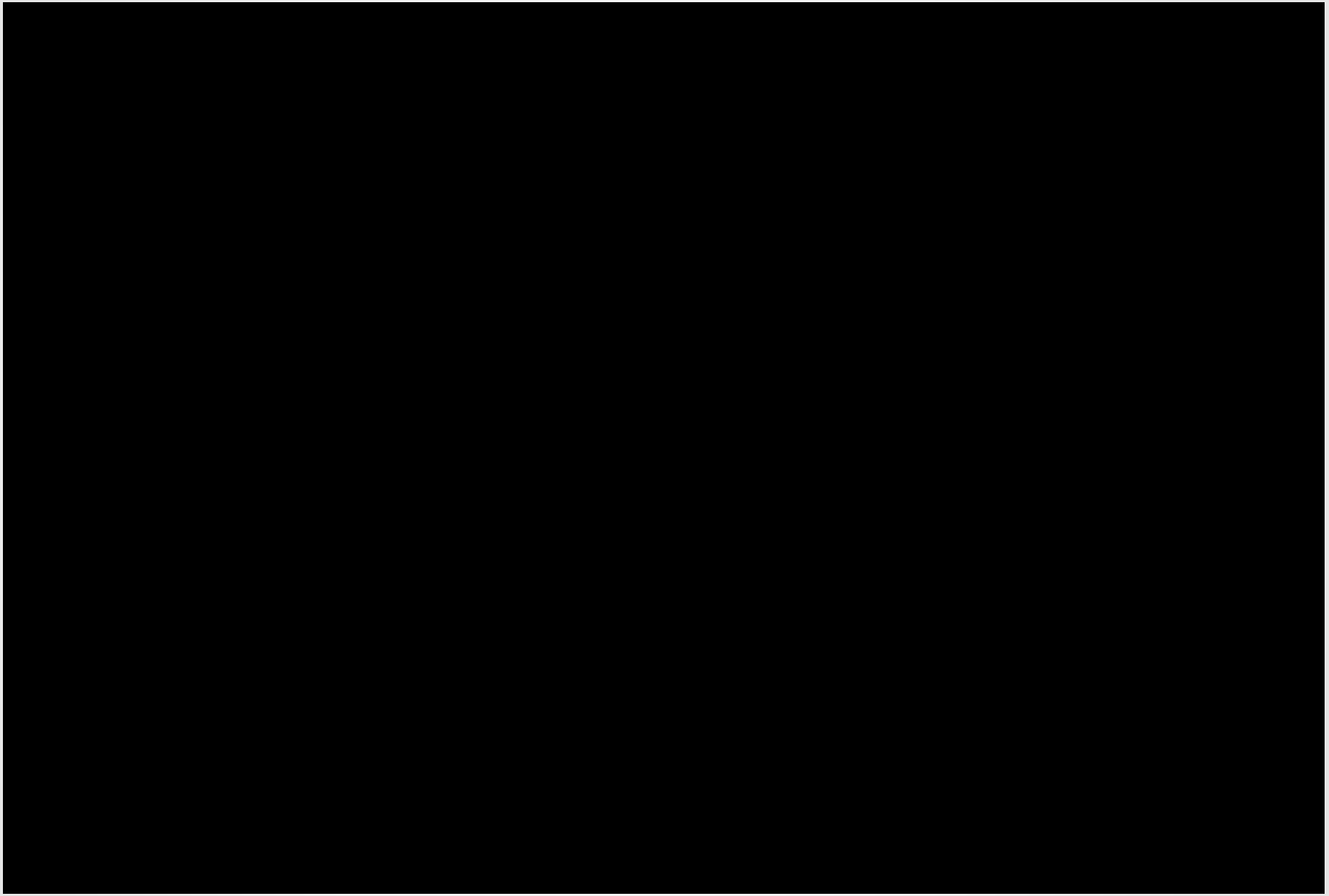
Inhibition

Inhibiting a dominant response in favor of a sub-dominant response

Working Memory

Maintaining and manipulating multiple pieces of information at once

Executive Function in the Moment



Executive Function in the Moment

Summary: Science Learning in Early Childhood

Provides a context for implementing best practices for teaching and learning

- About a child's immediate world
  - Draws upon their curiosity about how their world works
- "Doing" science involves a "hands-on/minds-on, goal-directed collaborative approach"
  - Produces high engagement, motivation and interest
- "Process" for answering questions
  - Promotes higher-order thinking skills
- Promotes learning across multiple domains

Why so little science in Early Childhood?

Why is science non-existent in infant and toddler classrooms, often avoided in preschool classrooms and not considered a critical academic area in early elementary grades?

Myth Busters

Won't my students find science hard and uninteresting?

Science draws on young children's natural curiosity about their world!

Isn't early childhood too early to start teaching science? Shouldn't it only be emphasized in upper grades and only for those students with aptitude for science?

Research shows that ALL young children are able to use scientific thinking as a model to guide learning!

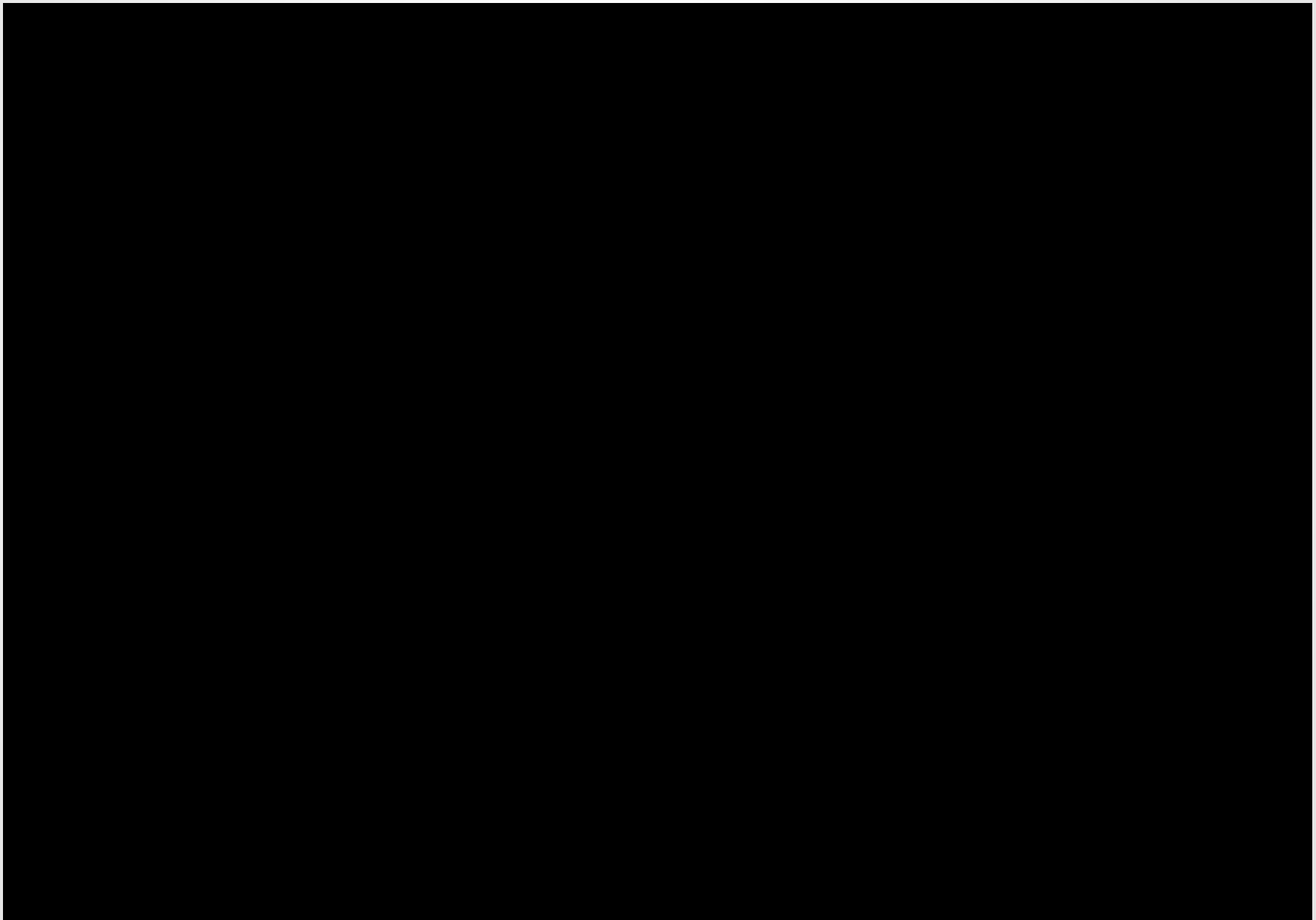
Don't I need to be an expert? Students might ask me lots of questions that I can't answer!

Science is a "process" for answering questions – this can be done <u>together</u> with your students!

Won't spending time on science take away from more important readiness areas like language and math?

Other readiness areas can be included in meaningful, engaging, science activities!

Making Science Visible



Where to Start?

Making Science "Visible"

Defining Science: A New Conceptual Framework for K-12 Science Education: A Three Dimensional Approach that Provides a "Focused Lens" for Promoting High Quality Science Learning

Science Framework

- A coherent, consistent approach to science education – Designed for K-12 but applicable from birth through K as well
  - Active process
  - Consistent ideas that build in complexity across grade levels and development
- Science is three-dimensional
  - Practices
  - Crosscutting Concepts
  - Disciplinary Core Ideas

Science and Engineering Practices

…the behaviors that scientists engage in to explore and develop knowledge

- Making observations
- Asking questions and defining problems
- Making predictions
- Developing and using models
- Planning and carrying out investigations
- Using math and computational thinking
- Documenting, analyzing and interpreting data
- Constructing explanations and designing solutions
- Communicating information

Crosscutting Concepts

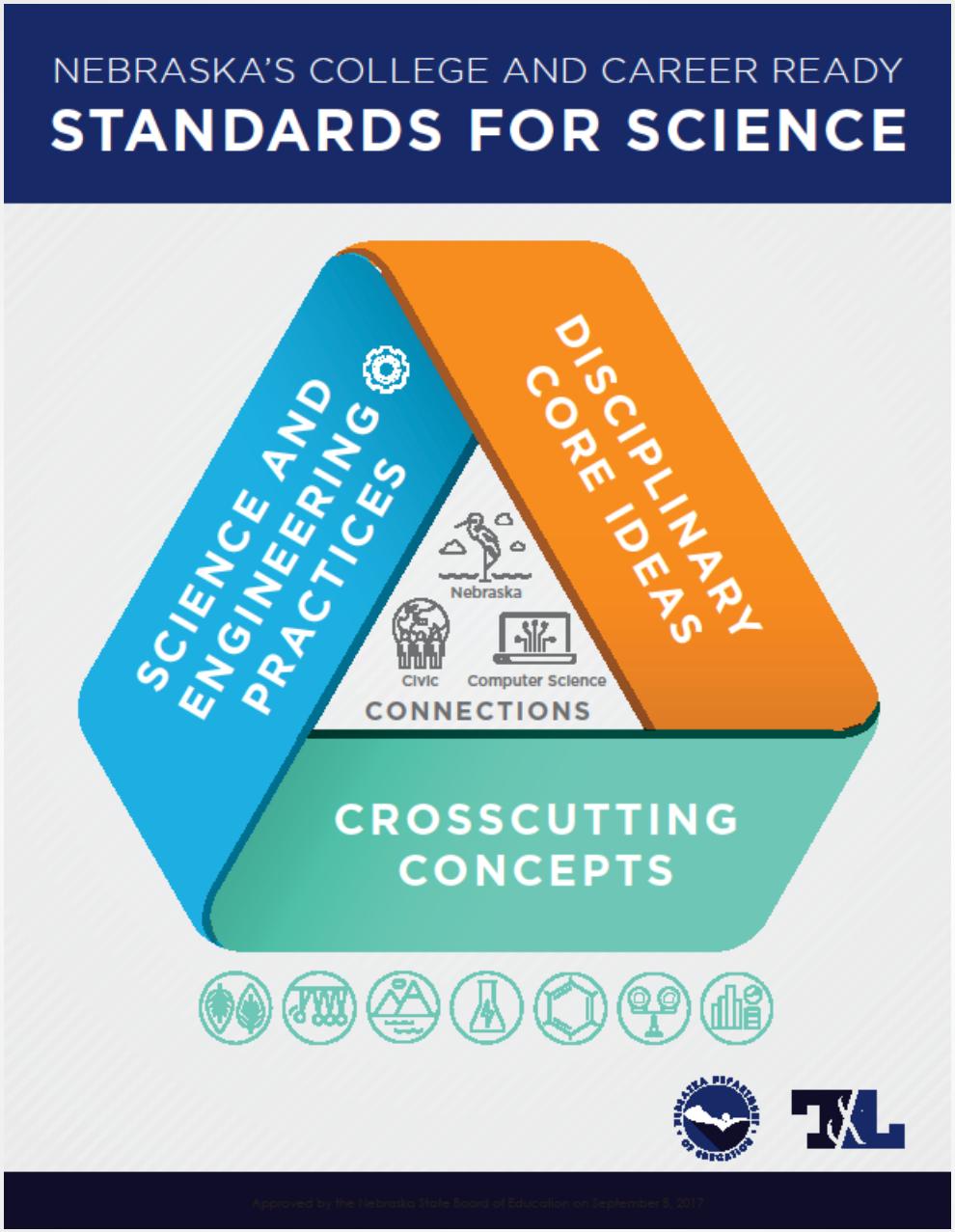
…the big ideas that help scientists connect knowledge from various experiences to draw conclusions and create a coherent view of the world

- Patterns
- Cause and effect
- Scale, proportion, and quantity
- Systems and system models
- Structure and function
- Stability and change
- Energy and Matter

Disciplinary Areas: Core Ideas

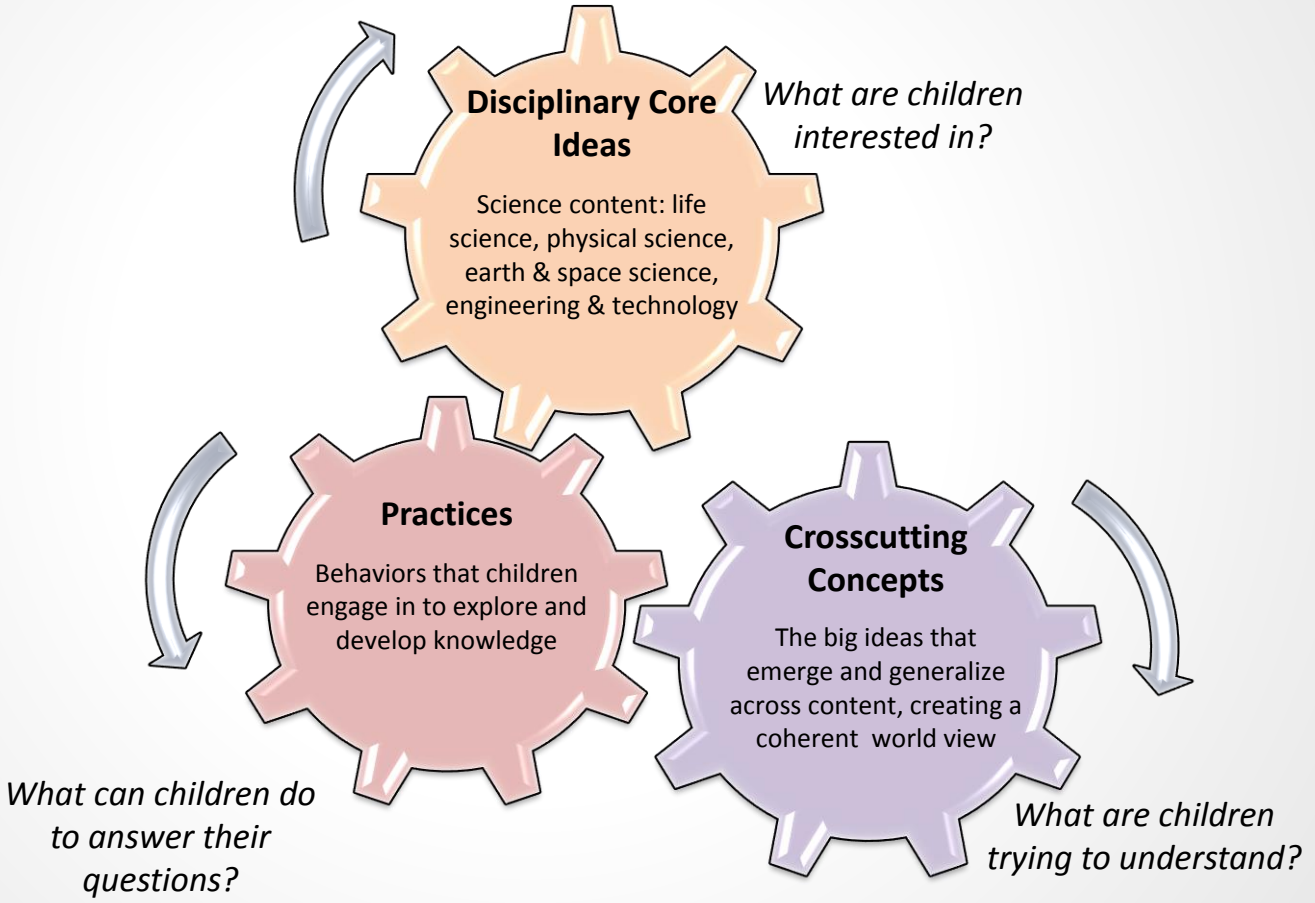
…the content that provide a context for engaging in practices and developing an understanding of crosscutting concepts.

- **Physical Science**
  - *What things are made of and how they move*
- **Life Science**
  - *Needs and characteristics of living things*
- **Earth and Space Science**
  - *Environment, weather, and human interaction*
- **Engineering and Technology**
  - *How things are designed and used to answer questions and solve problems*



Approved September 8 , 2017

The K-12 Framework for Science Education For Early Childhood (Birth to Age 8)



Where to start: Science Opportunities are Everywhere

Infants Exploring their World

Infants Exploring their World

Infants Exploring their World

Infants Exploring their World

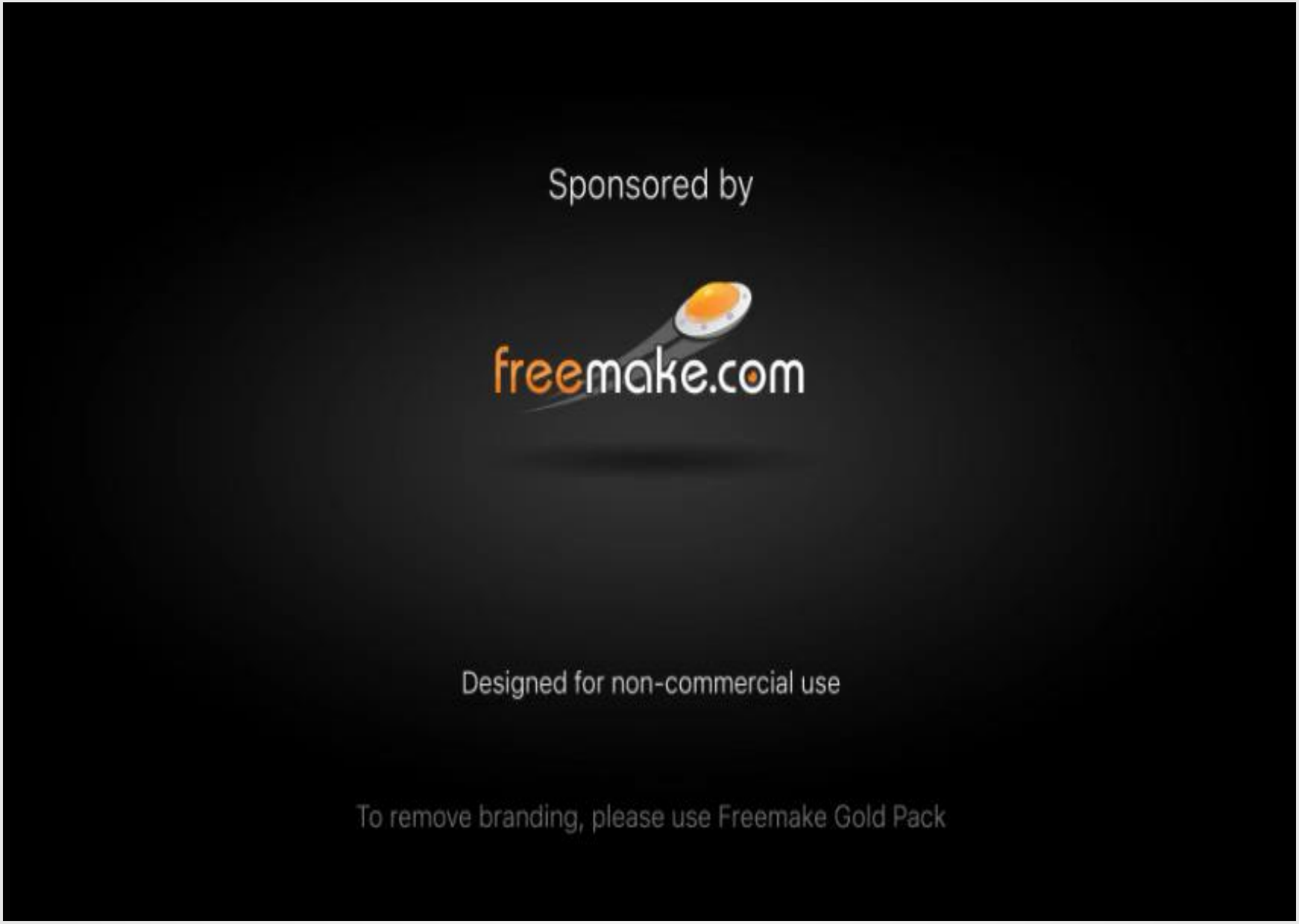
Looking for Learning

Practices	Crosscutting	Other Domains
		Language & Literacy, Math, Social & Emotional Skills, Effective Teaching Practices

- Making observation
- Asking questions and defining problems
- Making predictions
- Developing and using models
- Planning and carrying out investigations
- Using math and computational thinking
- Documenting, analyzing and interpreting data
- Constructing explanations and designing solutions
- Communicating information

- Patterns
- Cause and effect
- Scale, proportion, and quantity
- Systems and system models
- Structure and function
- Stability and change
- Energy and Matter

Ice on the Playground



Taking Further Advantage of a Science Opportunity

How could “Miss Heida” take further advantage of children’s interest in ice found on the playground?

- *Additional activities/experiences to:*
  - *<u>Deepen</u> their understanding*
  - *<u>Extend</u> their understanding to other relevant and related concepts*
  - *<u>Connect</u> it to their everyday lives*

Your Inquiry and the Science Framework

What is relevant?

e.g. Student Interests, Questions & Abilities
Time of year/events/local context/cultural relevance

Disciplinary Areas

What content area fits?

Crosscutting Concepts

What will children *understand*?

Practices

What should children *do*?

Local Context

Local Context

Thought Questions for the Day

When you think of your “inquiry,” what connections do you see between what you are already doing and the science framework?

How can you deepen, extend and connect this experience to move your students from “factual” to greater “conceptual understanding?”

Hard Work Pays Off!