Science and Engineering Practices: 1 of the 3 Dimensions of the AZ Science Standards

Who’s in the Room?

Complete the poll that will be on your screen.

Webinar Expectations

Microphones are disabled

Utilize the chat room for discussion/comments

If you have a question type in “stack” so you can share your question when time is appropriate

Objectives

- Recognize how science and engineering practices can be used by students for **making sense of the phenomena**.
- Describe how the science and engineering practices **progress through the grade bands to support student learning**.
- Explain how science and engineering practices are an **integral dimension to the Arizona Science Standards**.

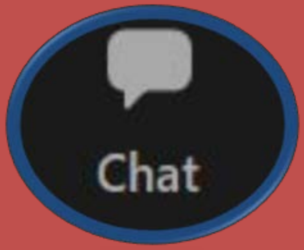
Norms

- **A**sk questions
- **E**mbrace mistakes
- **I**ntegrate new information
- **O**pen your mind to diverse views
- **U**tilize what you learn

The Washington Post

Do you agree?

Disagree?



https://www.washingtonpost.com/outlook/2020/04/23/scientific-method-cant-save-us-coronavirus/

The scientific method can't save us from the coronavirus

What we need is problem-solving — creativity, flexibility and teamwork

“The scientific method can’t save us — because it doesn’t exist.”

“Science is about staying flexible, trying out a variety of tools as the questions we try to answer change before our eyes. It is a process, not a product.”

How is this definition of science similar and different from what is currently in the science curriculum?

Science in Action

Wondering…

If this is how science is done…logical but **NOT** linear…how do we teach science?

Science and Engineering Practices (SEPs)

The idea of science as a set of practices has emerged from the work of historians, philosophers, psychologists, and sociologists over the past 60 years. This perspective is an improvement over previous approaches in several ways.

Science and Engineering Practices (SEPs)

1) SEPs minimizes the tendency to reduce scientific practices to a single set of procedures, such as identifying and controlling variables, classifying entities, and identifying sources of error.

2) A focus on **practices** avoids the mistaken impression that there is one distinctive approach common to all science—a single "scientific method"—or that uncertainty is a universal attribute of science.

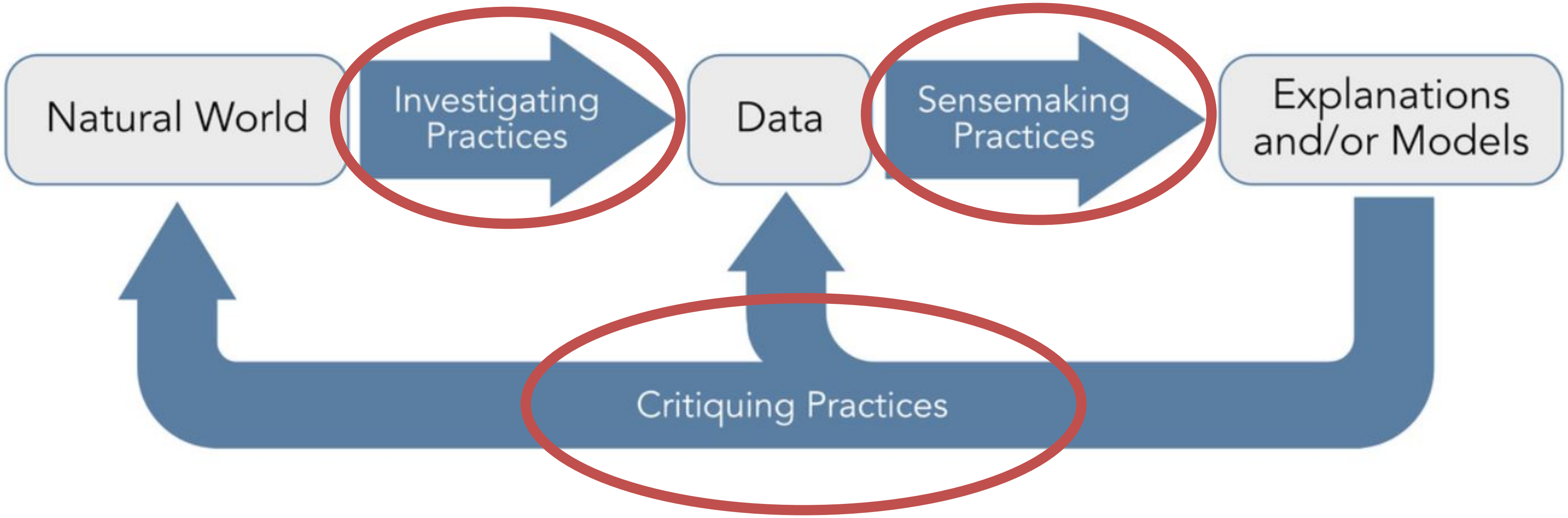
3) Attempts to develop the idea that science should be taught through a process of inquiry

Science and Engineering Practices (SEPs)

- 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 arguments from evidence
- Obtaining, evaluating, and communicating information

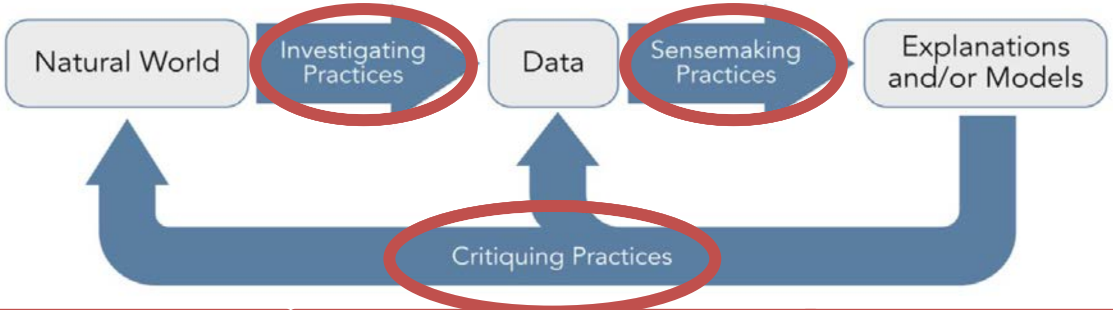
Chat

Grouping the Practices



McNeill, Katsh-Singer & Pelletier, 2015

Grouping the Practices



Investigating Practices	Sensemaking Practices	Critiquing Practices
Asking questions and defining problems	Developing and using models	Engaging in argument from evidence
Planning and carrying out investigations	Analyzing and interpreting data	Obtaining, evaluating, and communicating information
Using mathematical and computational thinking	Constructing explanations and designing solutions	

McNeill, Katsh-Singer & Pelletier, 2015

Investigative Practices

Asking Questions & Defining Problems

Scientific questions lead to explanations of how the natural world works and can be empirically tested using evidence

When students engage in this science practice they:

- Ask questions to develop or refine a model or explanations about the natural world
- Ask questions that can be answered using evidence from investigations or gathered by others

Investigative Practices

Planning & Carrying Out Investigations

A systematic way to gather data about the natural world, either in the field or in the laboratory setting

When students engage in this science practice they:

● Design investigations that will produce data that can be used to answer scientific questions.

● This process includes determining the goal of the investigation, developing predictions, and designing procedures (such as identifying experimental variables and controls)

Investigative Practices

Planning and Carrying Out Investigations

Using Mathematics & Computational Thinking

In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; solving equations exactly or approximately; and recognizing, expressing, and applying quantitative relationships.

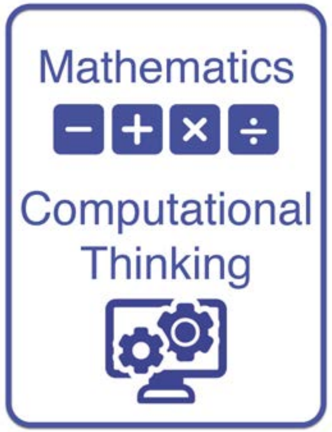
When students engage in this science practice they:

- Use numbers and measurements to describe the natural world; decide how to represent data; organize data in charts or graphs, apply or create mathematical algorithms or simulations to data.

ARIZONA Department of Education

and

Investigative Practices



- How do these 3 practices compare/contrast to the AZ 2004 standards?
- How do these relate to "the scientific method?"

Sensemaking Practices

Analyzing & Interpreting Data

…making sense of the data produced during investigations. Because patterns are not always obvious, this includes using a range of tools such as tables, graphs, and other visualization techniques.

When students engage in this science practice they:

- Make decision about how to analyze data (e.g. table or graph) and work with the data to create the representation.
- Consider limitations of data analysis
- Apply scientific principles to make sense of relationships in data

Sensemaking Practices

Developing & Using Models

"A model is an abstract representation of phenomena that is a tool used to predict or explain the world. Models can be represented as diagrams, 3-D objects, mathematical representations, analogies or computer simulations"

When students engage in this science practice they:

- Create or use model to describe, explain and/or predict scientific phenomena, processes, or relationships
- Evaluate the merits and/or limitations of models

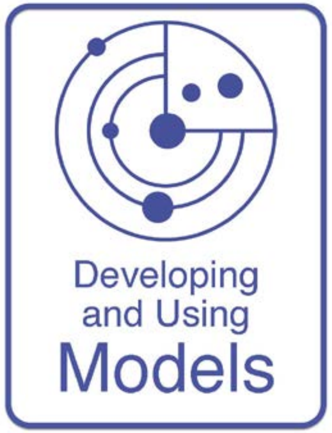
Sensemaking Practices

Constructing Explanations & Designing Solutions

Explanations focus on a specific question about a phenomenon and construct a how or way account for that phenomenon.

When students engage in this science practice they:

- Use evidence from personal set of core ideas, information from observations and/or investigations to construct an explanation about a specific phenomenon
- The explanations addresses the how or why account of the phenomenon and includes a claim, evidence, and reasoning.



Sensemaking Practices

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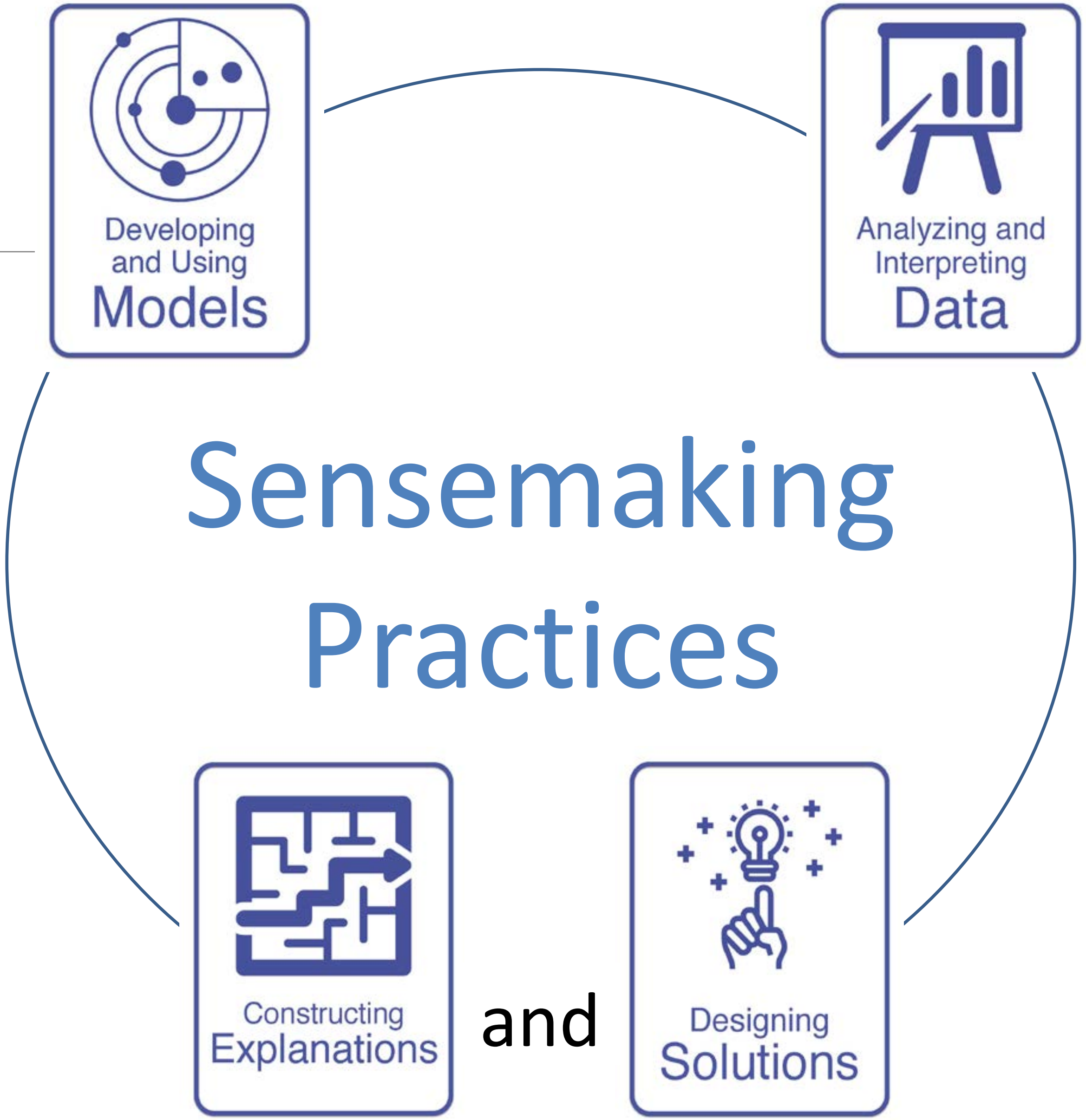
- Why do you think these 3 are in the sensemaking category rather than investigative or critiquing?
- Which one of these do you think will be most challenging for students? For teachers to facilitate?



Critiquing Practices

Engaging in Argument from Evidence

Argumentation is a process for reaching agreements about explanations and design solutions. In science, reasoning and argument based on evidence are essential in identifying the best explanation for a natural phenomenon.

When students engage in this science practice they:

- Listen to, compare, and evaluate competing ideas or solutions
- Identify the best explanation or solution
- Use evidence to support their claim

Critiquing Practices

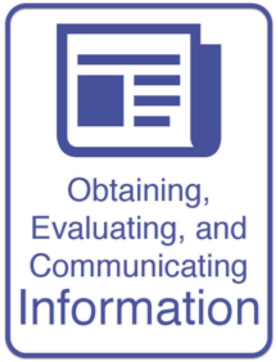
Obtaining, Evaluating, & Communicating Information

"…gathering, critically examining, and using resources to further their collective investigations an sense-making about the natural and designed world"

When students engage in this science practice they:

● Read and evaluate text to obtain scientific information

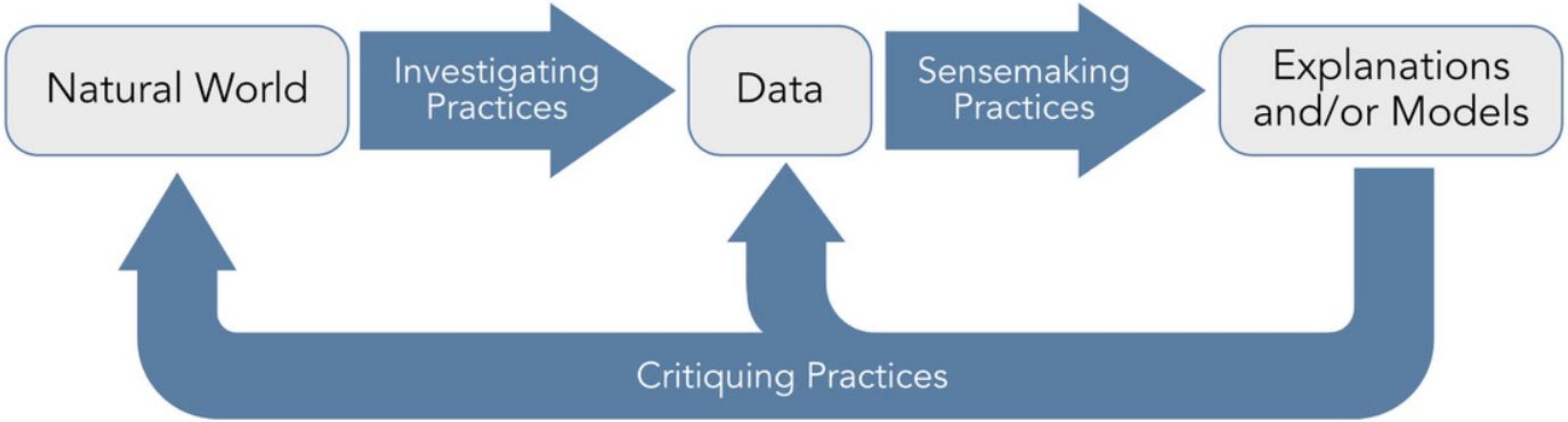
● Compare and combine information from multiple texts considering the strengths of the information and sources



Critiquing Practices

- Why do you think critiquing practices are often left out of the curriculum?
- If the critiquing practices are more emphasized in the curriculum, how might students understanding of the core ideas be impacted?

Grouping the Practices



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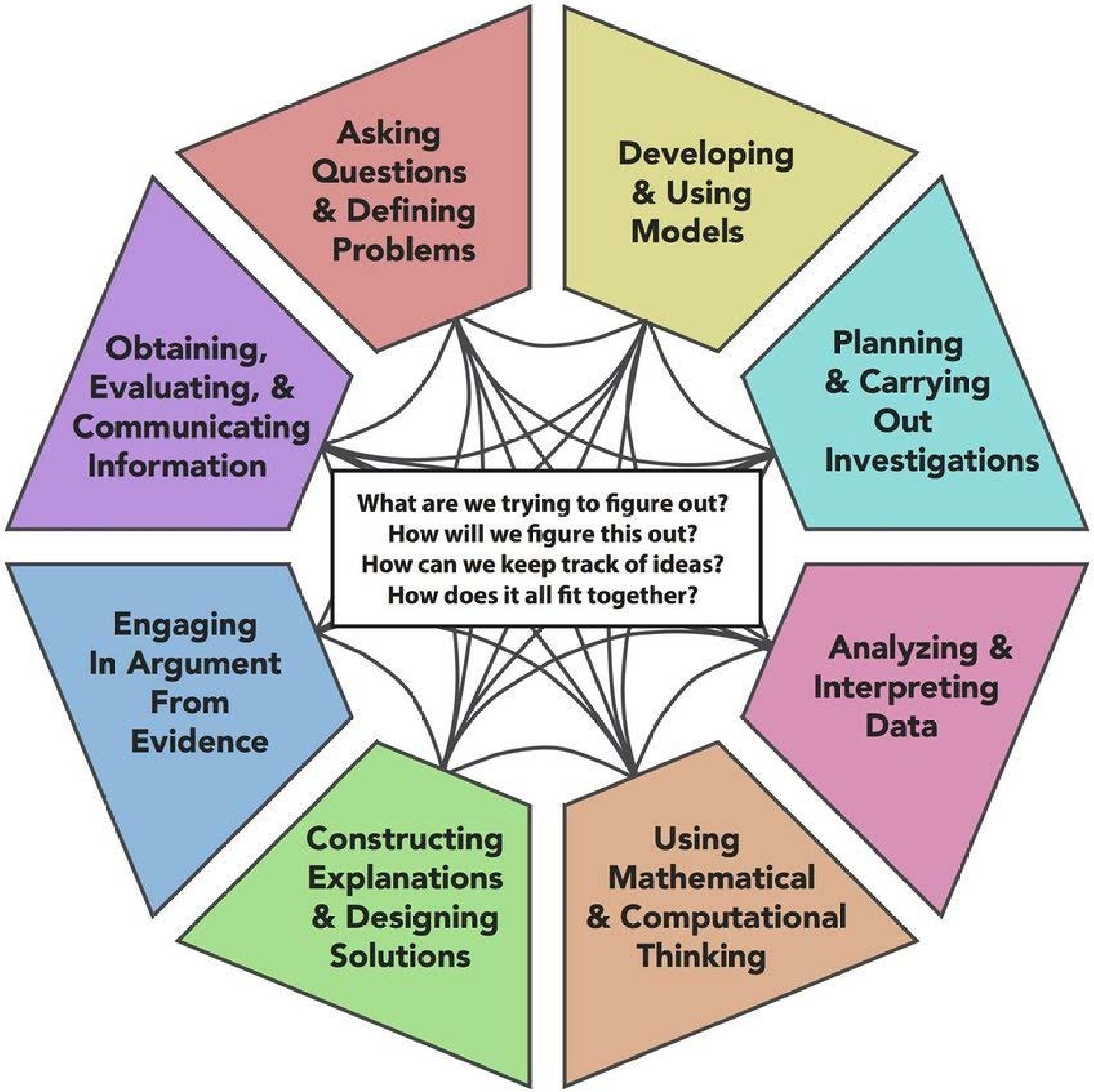

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What questions do you have?

AZ Science Standards

Arizona Science Standards
2018

Arizona Department of Education
High Academic Standards for Students

https://www.azed.gov/standards-practices/k-12standards/standards-science/

Where are the science and engineering practices in the standards?

1.L3U1.9	Crosscutting Concepts & Background Information for Educators
Obtain, evaluate, and communicate information to **support an evidence-based explanation** that plants and animals produce offspring of the same kind, but offspring are generally not identical to each other or their parents.	**Crosscutting Concepts:** Patterns; **Cause and Effect**; Scale, Proportion and Quantity; Systems and System Models; Energy and Matter; Structure and Function; **Stability and Change**[4] **Background Information:** **Living** things produce **offspring** of the same kind, but offspring are not **identical** with each other or with their **parents**. Plants and animals, including humans, resemble their parents in many features because information is passed from one **generation** to the next.[2 (p. 22)] Organisms have **characteristics** that can be similar or different. Young animals are very much, but not exactly, like their parents and also resemble other animals of the same kind. Plants also are very much, but not exactly, like their parents and resemble other plants of the same kind.[4 (p. 158)]

1.L4U1.10	Crosscutting Concepts & Background Information for Educators
Develop a model to describe how animals and plants are classified into groups and subgroups according to their similarities. **1.L4U3.11** **Ask questions** and explain how factors can cause species to go extinct.	**Crosscutting Concepts:** Patterns; **Cause and Effect**; Scale, Proportion and Quantity; Systems and System Models; Energy and Matter; Structure and Function; **Stability and Change**[4] **Background Information:** There are many different kinds of **plants** and **animals** in the world today and many kinds that once lived but are now **extinct**. We know about these from **fossils**. Animals and plants are **classified** into groups and subgroups according to their **similarities**.[2 (p.29)] Some kinds of plants and animals that once lived on Earth (e.g., dinosaurs) are no longer found anywhere, although others now living (e.g., lizards) resemble them in some ways.[4 (p. 162)]

Where are the science and engineering practices in the standards?

1.L3U1.9
Obtain, evaluate, and communicate information to support an evidence-based explanation that plants and animals produce offspring of the same kind, but offspring are generally not identical to each other or their parents.

Where are the science and engineering practices in the standards?

Chemistry – P1: All matter in the Universe is made of very small particles.

Structures and Properties of Matter

Essential standards are standards that will be assessed on the state exam and are intended for ALL students to have learned by the end of 3 credits of high school science courses.

Essential HS.P1U1.1

Develop and use models to explain the relationship of the structure of atoms to patterns and properties observed within the Periodic Table and describe how these models are revised with new evidence.

Physical Science Plus (+) Standards HS+C are supporting standards designed to be used with the essential standards for students taking a high school chemistry (C) course.

Plus HS+C.P1U1.1

Develop and use models to demonstrate how changes in the number of subatomic particles (protons,

Crosscutting Concepts & Background Information for Educators

Crosscutting Concepts:

Patterns; Cause and Effect; Scale, Proportion and Quantity; Systems and System Models; Energy and Matter; Structure and Function; Stability and Change[4]

Background Information:

Each **atom** has a charged substructure consisting of a **nucleus**, which is made of **protons** and **neutrons**, surrounded by **electrons**. The **periodic table** orders elements horizontally by the number of protons in the atom's nucleus and places those with similar **chemical properties** in columns. The repeating patterns of this table reflect patterns of **outer electron states**. The structure and interactions of matter at the bulk

Science and Engineering Practices Progression

K-2

3-5

6-8

9-12

K-12 Standards Section

Arizona Science Standards

Tweet Share

COVID-19 HELPFUL GUIDANCE AND INFORMATION

The Arizona Department of Education's Virtual Learning Hub is a resource for teachers and families to assist them as they plan for non-traditional instruction and should be used with discretion and in the way that best fits with their school/district curricula. This is a living document that will be updated frequently.

Virtual Learning Resources

Important message to read for information regarding the implementation of the 2018 Arizona Science Standards and the new science assessment, please click here

NEW STANDARDS (2018)

(Adopted October 2018)
Complete Standards document | PDF

- Grades K-2
- Grades 3-5
- Grades 6-8
- High School

NEW STANDARDS SUPPORT MATERIALS

- Planning Tools *NEW
- Administrator Tool Kit *NEW
- Vertical Progressions
- Distribution of Core Ideas

PROFESSIONAL DEVELOPMENT VIDEOS

- Recorded Webinars
- Science Standards Videos
- Timeline and Resources

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- Formative Assessment Resources
- Early Literacy Grant
- Excellence in Civic Engagement
- Move On When Reading
- CSPD Program Fund
- Newsletters

HASS DIVISION (Click below)

HASS | CTE | ELL | ECE

- Grades K-2
- Grades 3-5
- Grades 6-8
- High School

- Planning Tools *NEW
- Administrator Tool Kit *NEW
- Vertical Progressions

Arizona State Science Standards

Vertical Progression of Knowing Science

Accessibility Versions

Vertical Progression of Knowing Science

Vertical Progression of Crosscutting Concepts

Vertical Progression of Science and Engineering Practices

- Distribution of Core Ideas

Excellence in Civic Engagement

Move On When Reading

CSPD Program Fund

Newsletters

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PROFESSIONAL DEVELOPMENT VIDEOS

K-12 Science and Engineering Practices* Progression Matrix of Elements

For use with *Arizona Science Standards*

Science and Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Asking Questions and Defining Problems A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested. Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve problems about the designed world. Both scientists and engineers also ask questions to clarify ideas.	Asking questions and defining problems in grades K–2 builds on prior experiences and progresses to simple descriptive questions that can be tested. ▪ Ask questions based on observations of the natural and/or designed world. ▪ Define a simple problem that can be solved through the development of a new or improved object or tool.	Asking questions and defining problems in grades 3–5 builds from grades K–2 experiences and progresses to specifying qualitative relationships. ▪ Identify scientific (testable) and non-scientific (non-testable) questions. ▪ Ask questions based on careful observations of phenomena and information. ▪ Ask questions to clarify ideas or request evidence. ▪ Ask questions that relate one variable to another variable. ▪ Ask questions to clarify the constraints of solutions to a problem. ▪ Use prior knowledge to describe problems that can be solved. ▪ Define a simple design problem that can be solved through the development of an object, tool or process and includes several criteria for success and constraints on materials, time, or cost. ▪ Formulate questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.	Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to formulating and refining empirically testable models that support explanations of phenomena or solutions to problems. ▪ Ask questions that arise from careful observation of phenomena, models, or unexpected results. ▪ Ask questions to clarify or identify evidence and the premise(s) of an argument. ▪ Ask questions to determine relationships between independent and dependent variables. ▪ Ask questions that challenge the interpretation of a data set. ▪ Ask questions to clarify and refine a model, an explanation, or an engineering problem. ▪ Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. ▪ Formulate a question that can be investigated within the scope of the classroom, school laboratory, or field with available resources and, when appropriate, frame a hypothesis (a possible explanation that predicts a particular and stable outcome) based on a model or theory.	Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design solutions using models and simulations. ▪ Ask questions that arise from careful observation of phenomena, models, theory, or unexpected results. ▪ Ask questions that require relevant empirical evidence to answer. ▪ Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables. ▪ Ask and evaluate questions that challenge the premise of an argument, the interpretation of a data set, or the suitability of a design. ▪ Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations

K-12 Science and Engineering Practices* Progression Matrix of Elements

For use with *Arizona Science Standards*

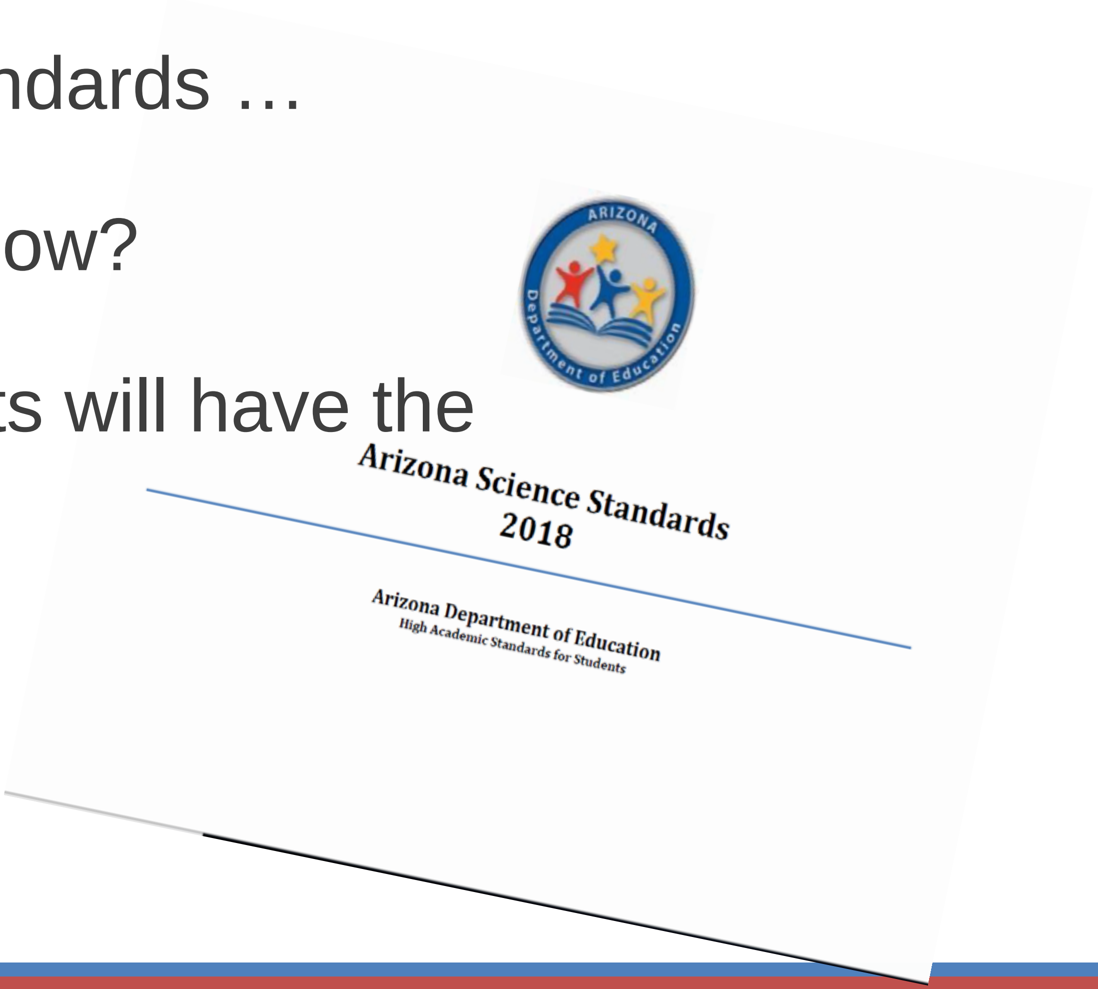
Science and Engineering Practices	K–2 Condensed Practices	3–5 Condensed Practices	6–8 Condensed Practices	9–12 Condensed Practices
Planning and Carrying Out Investigations Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters. Engineering investigations identify the effectiveness, efficiency, and durability of designs under different conditions.	Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • With guidance, design and conduct investigations in collaboration with peers. • Design and conduct investigations collaboratively. • Evaluate different ways of observing and/or measuring an attribute of interest. • Make direct or indirect observations and/or measurements to collect data, which can be used to make comparisons. • Identify questions and make predictions based on prior experiences. • Make direct or indirect observations and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal.	Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Design and conduct investigations collaboratively, using fair tests in which variables are controlled and the number of trials considered. • Evaluate appropriate methods and tools for collecting data. • Make observations and/or measurements, collect appropriate data, and identify patterns that provide evidence for an explanation of a phenomenon or test a design solution. • Make measurements of two different models of the same proposed object, tool or process to determine which better meets criteria for success.	Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. • Conduct an investigation and evaluate and revise the experimental design to ensure that the data generated can meet the goals of the experiment. • Design an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data are needed to support their claim. • Evaluate the accuracy of various methods for collecting data. • Collect data and generate evidence to answer scientific questions or test design solutions under a range of conditions. • Collect data about the performance of a proposed object, tool, process or system under a range of conditions.	Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that build, test, and revise conceptual, mathematical, physical, and empirical models. • Design an investigation individually and collaboratively and test designs as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Design and conduct an investigation individually and collaboratively, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Select appropriate tools to collect, record, analyze, and evaluate data. • Design and conduct investigations and test design solutions in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Manipulate variables and collect data

AZ 2018 Science Standards

Thinking about your own grade level standards …

Which practices do you explicitly teach now?

Which practices do you feel your students will have the most experience with in the fall?

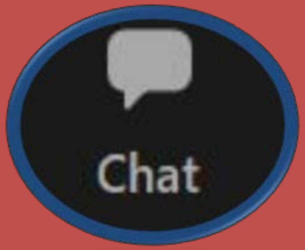

Arizona Science Standards
2018

Arizona Department of Education
High Academic Standards for Students

The Washington Post

Do you agree?

Disagree?



https://www.washingtonpost.com/outlook/2020/04/23/scientific-method-cant-save-us-coronavirus/

The scientific method can't save us from the coronavirus

What we need is problem-solving — creativity, flexibility and teamwork

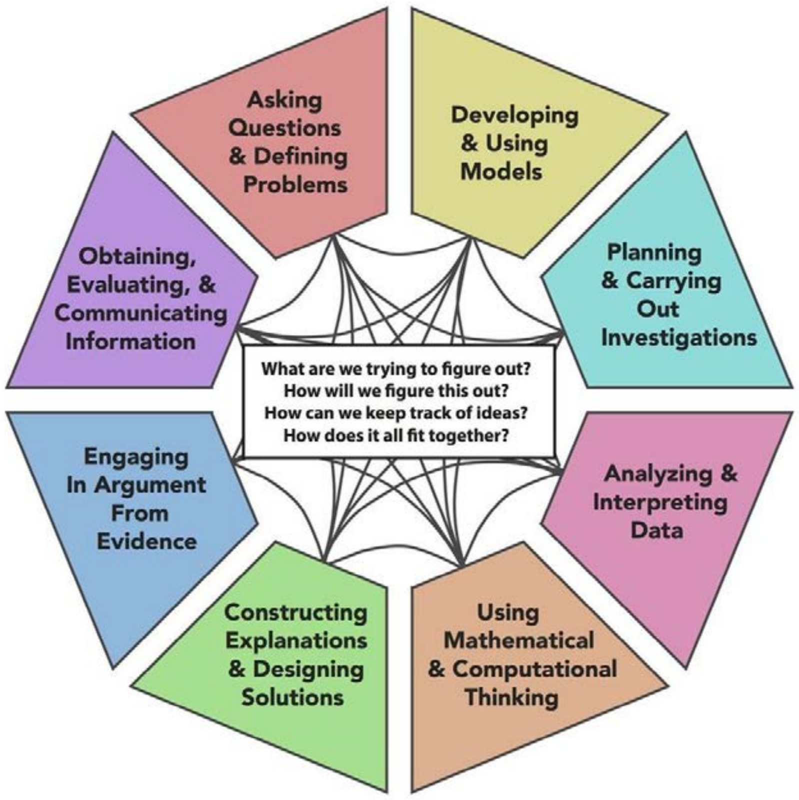
“…there is no such thing as “the scientific method,” no single set of steps or one-size-fits-all solution to the problems we face. Ask any scientist: what they do, individually and collectively, is too diverse, too dynamic, too difficult to follow one recipe.”

The practices engage students in obtaining and using information obtained from investigations and other sources, developing and using models, constructing explanations and communicating arguments that support these explanations.

Key Take-Aways

Our students need to…

- **Inquire** like a scientist.
- **Think** like a scientist.
- **Quantify** like a scientist.
- **Read** like a scientist.
- **Talk** like a scientist.
- **Write** like a scientist
- **Critique** like a scientist.
- **Argue** like a scientist.



ARIZONA Department of Education

How do we do that?

Phenomenon-based instruction:

Figuring out phenomena like a scientist or engineer

What questions do you have?

Thank you

SARA TORRES

SSTORRES71@GMAIL.COM

AZ Science Teachers Association has workshops/webinars on each individual SEP to help teachers deepen their understanding of this dimension