Teaching Science: The Next Generation

Let's Do Science!

Questions → Explanation → Model

Key Points:

This module will provide an overview of the Next Generation Science Standards and the latest information regarding the new release of these standards. The focus of this module will be on the key components of the document and the format related to the Scientific and Engineering Practices, Crosscutting Concepts and Disciplinary Core Ideas. Along with the instructional shifts in the NGSS, emphasis will be placed on a deep understanding of the Scientific and Engineering Practices and the implication that these have on the K-12 classroom. An introduction to the connection boxes that correlate to the Common Core ELA and Math and correlation to STEM will be included.

An Essential Question

What are the new science standards and how do they impact teaching and learning?

Learning Outcomes:

- Gain a deeper understanding of the design and organization of the new science standards
- Explore and practice problem solving in science
- Understand how students learn science and how to implement science review boxes
- Learn how to design science assessments
- Collaborate with colleagues and develop an action plan for next steps

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The Five Easy Steps to a Balanced Science Program

Establishing an Effective Science Classroom → Problem Solving → Conceptual Understanding → Mastery of Science Information → Common Formative Assessments

Activity: Balancing Your Science Program

The introduction to *Five Easy Steps Science* focuses on the analysis of the district's or school's current science program. The steps provide a 'balance' to science instruction and assessment in today's schools.

Science Practice	4	3	2	1
My district/school has a balanced science program in place.				
My classroom is a model for effective science instruction.				
I feel comfortable teaching science.				
My teaching includes the integration of literacy and math.				
I read science journals and belong to at least one professional science organization.				
My teaching incorporates the best instructional practices for science labs and experiments.				
My classroom instruction integrates problem solving on a weekly basis.				
My team designs conceptual science units around the Priority Standards and objectives.				
My team uses data to drive instruction.				
My team designs and administers pre- and post-assessments (e.g., common formative assessments).				

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A Framework for K-12 Science Education, developed by the National Research Council (NRC) focuses on the integration of Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas that together define rigorous science literacy for all students.

Students who meet these expectations will:

- have the **ability to discuss and think critically** about science issues
- have the **knowledge and skills to pursue careers** in science or engineering
- be **prepared for college-level** science level courses

The Next Generation Science Standards are intended to reflect a new vision for American science education. There are seven conceptual shifts demonstrated in the Next Generation Science Standards.

K-12 Science Education Should Reflect the Interconnected Nature of Science as it is **Practiced and Experienced in the Real World**.

The Next Generation Science Standards are **student performance expectations** – NOT curriculum

The Science Concepts in the NGSS **Build Coherently from K–12**.

The NGSS Focus on Deeper **Understanding of Content** as well as **Application of Content**.

Science and Engineering are Integrated in the NGSS, from K–12.

The NGSS are designed to prepare students **for college, career, and citizenship.**

The NGSS and Common Core State Standards (English Language Arts and Mathematics) **are Aligned** .

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The Framework for K-12 Science Education contains three dimensions:

Dimension 1 - Science and Engineering Practices
Dimension 2 – Crosscutting Concepts
Dimension 3 – Disciplinary Core Ideas

K.Weather and Climate

K.Weather and Climate

Students who demonstrate understanding can:

K-PS3-1. Make observations to determine the effect of sunlight on Earth's surface. [Clarification Statement: Examples of Earth's surface could include sand, soil, rocks, and water] [Assessment Boundary: Assessment of temperature is limited to relative measures such as warmer/cooler.]

K-PS3-2. Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.* [Clarification Statement: Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.]

K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time. [Clarification Statement: Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months.] [Assessment Boundary: Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.]

K-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.* [Clarification Statement: Emphasis is on local forms of severe weather.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education:*

Science and Engineering Practices

Asking Questions and Defining Problems
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 to find more information about the designed world. (K-ESS3-2)

Planning and Carrying Out Investigations
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.
- Make observations (firsthand or from media) to collect data that can be used to make comparisons. (K-PS3-1)

Analyzing and Interpreting Data
Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.
- Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions. (K-ESS2-1)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.
- Use tools and materials provided to design and build a device that solves a specific problem or a solution to a specific problem. (K-PS3-2)

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in K–2 builds on prior experiences and uses observations and texts to communicate new information.
- Read grade-appropriate texts and/or use media to obtain scientific information to describe patterns in the natural world. (K-ESS3-2)

Connections to Nature of Science

Scientific Investigations Use a Variety of Methods
- Scientists use different ways to study the world. (K-PS3-1)

Science Knowledge is Based on Empirical Evidence
- Scientists look for patterns and order when making observations about the world. (K-ESS2-1)

Disciplinary Core Ideas

PS3.B: Conservation of Energy and Energy Transfer
- Sunlight warms Earth's surface. (K-PS3-1),(K-PS3-2)

ESS2.D: Weather and Climate
- Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (K-ESS2-1)

ESS3.B: Natural Hazards
- Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. (K-ESS3-2)

ETS1.A: Defining and Delimiting an Engineering Problem
- Asking questions, making observations, and gathering information are helpful in thinking about problems. *(secondary to K-ESS3-2)*

Crosscutting Concepts

Patterns
- Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (K-ESS2-1)

Cause and Effect
- Events have causes that generate observable patterns. (K-PS3-1),(K-PS3-2),(K-ESS3-2)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology
- People encounter questions about the natural world every day. (K-ESS3-2)

Influence of Engineering, Technology, and Science on Society and the Natural World
- People depend on various technologies in their lives; human life would be very different without technology. (K-ESS3-2)

Connections to other DCIs in kindergarten: K.ETS1.A (K-PS3-2),(K-ESS3-2); K.ETS1.B (K-PS3-2)

Articulation of DCIs across grade-levels: 1.PS4.B (K-PS3-1),(K-PS3-2); 2.ESS1.C (K-ESS3-2); 2.ESS2.A (K-ESS2-1); 2.ETS1.B (K-PS3-2); 3.ESS2.D (K-PS3-1),(K-ESS2-1); 3.ESS3.B (K-ESS3-2); 4.ESS2.A (K-ESS2-1); 4.ESS3.B (K-ESS3-2); 4.ETS1.A (K-PS3-2)

Common Core State Standards Connections:

ELA/Literacy –

RI.K.1	With prompting and support, ask and answer questions about key details in a text. (K-ESS3-2)
W.K.7	Participate in shared research and writing projects (e.g., explore a number of books by a favorite author and express opinions about them). (K-PS3-1),*(K-PS3-2)*,(K-ESS2-1)
SL.K.3	Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-ESS3-2)

Mathematics –

MP.2	Reason abstractly and quantitatively. (K-ESS2-1)
MP.4	Model with mathematics. (K-ESS2-1),*(K-ESS3-2)*
K.CC	Counting and Cardinality *(K-ESS3-2)*
K.CC.A	Know number names and the count sequence. (K-ESS2-1)
K.MD.A.1	Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. (K-ESS2-1)
K.MD.A.2	Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. (K-PS3-1),(K-PS3-2)
K.MD.B.3	Classify objects into given categories; count the number of objects in each category and sort the categories by count. (K-ESS2-1)

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.
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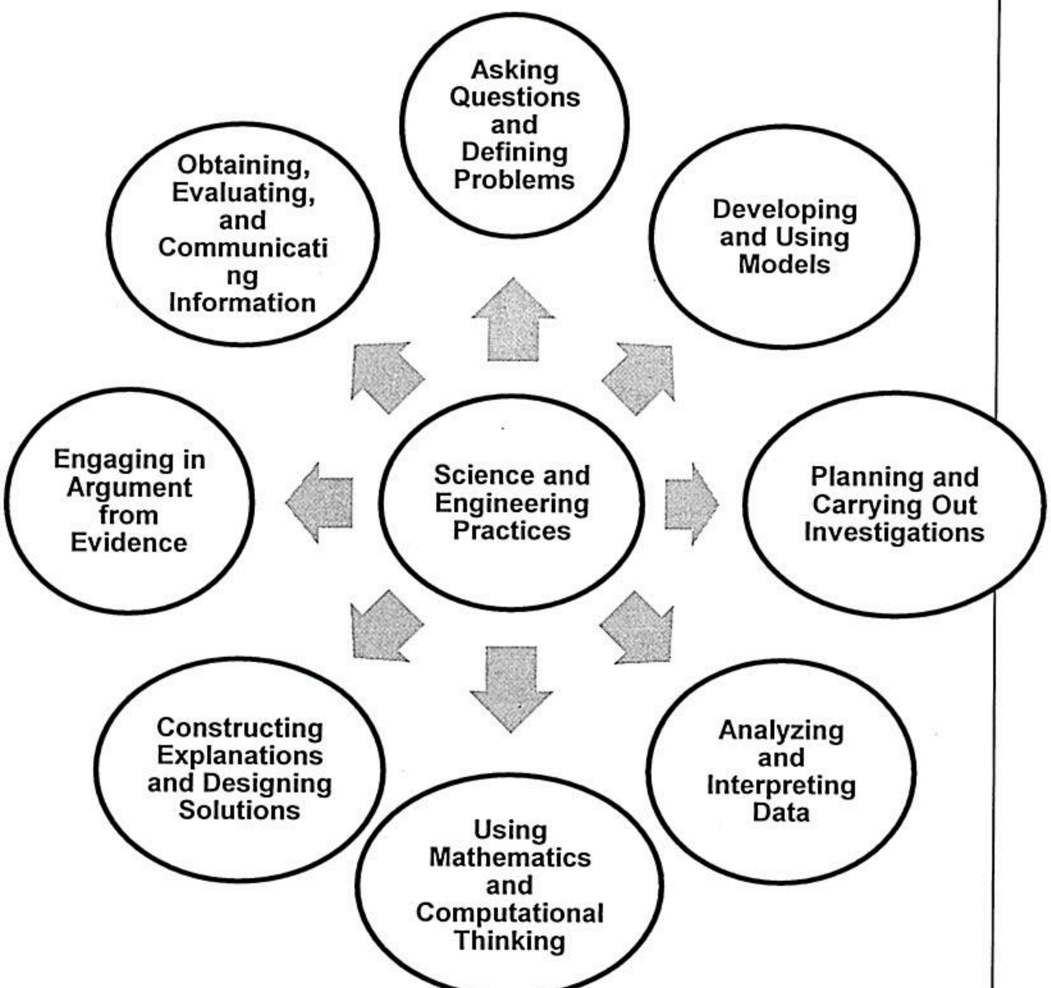
Components of the NGSS	Description
Performance Expectations	
Assessment Boundaries	
Science and Engineering Practices	
Crosscutting Concepts	
Disciplinary Core Ideas	
Connection Boxes (ELA and Math)	
Abbreviations used in the NGSS	

Dimension 1 – Science and Engineering Practices

Science and Engineering Practice Statements: These statements are derived from and grouped by the eight categories detailed in the *Framework* to further explain the science and engineering practices important to emphasize in each grade band. Most topical groupings of performance expectations emphasize only a few of the practice categories; however, all practices are emphasized within a grade band. Teachers should be encouraged to utilize several practices in any instruction. The purpose is to demonstrate the specific practice for which students will be held accountable—not to limit instruction.



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Science and Engineering Practice	Key Points	Classroom Implications
Asking and Defining Questions		
Developing and Using Models		
Planning and Carrying Out Investigations		
Analyzing and Interpreting Data		

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Science and Engineering Practice	Key Points	Classroom Implications
Using Mathematics and Computational Thinking		
Constructing Explanations and Designing Solutions		
Engaging in Argument from Evidence		
Obtaining, Evaluating, and Communicating Information		

The Six Types of Questions

1. Interest Focusing Questions

These questions focus children's attention on using their senses and the science process skills. Teachers that are beginning a demonstration or experiment should pose this type of question for students as they explore a new topic or concept.

2. Measurement Questions

These questions encourage better observation, classification and communication. They typically will include the integration of mathematics skills and application of real-world problem solving.

3. Compare and Contrast Questions

These questions ask children to use similarities and differences in their analysis. Compare and contrast is a process of identifying like and different characteristics. This is one of the most difficult skills for students to understand because it requires higher-level thinking such as synthesizing and evaluating. Students are asked to determine relationships, quantify ways things are similar and different, and create a scheme to describe the comparisons.

4. Prediction Questions

These questions allow for predicting, experimenting and investigating. This is the "What if..." question that all science teachers include in the problem-solving step because it deals with manipulating variables. This type of question requires that students use prior knowledge in order to predict the outcome of an investigation or experiment.

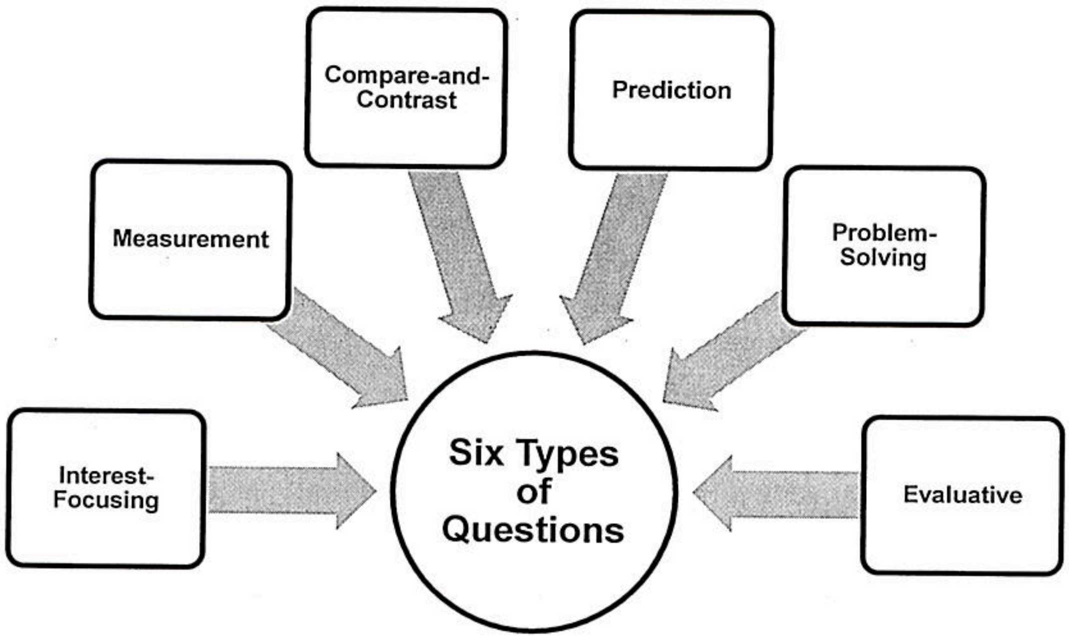
5. Problem-Solving Questions

These questions encourage the testing of hypotheses and the formulation of conclusions. Teachers that use problem-solving questions are asking students to think at a very high level of complexity.

6. Evaluative Questions

These questions focus on how and why things work and on evaluating the results. They are designed around the highest levels of thinking and require verbal and written explanations to justify, defend or prove the reasoning behind the answer.

The Six Types of Questions



PERFORMANCE EXPECTATION	
Interest	
Measurement	
Compare and Contrast	
Prediction	
Problem Solving	
Evaluative	

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Common Formative Assessments

This step provides an overview of selected-response, constructed-response and performance assessments. These assessments are collaboratively designed, administered, scored, and analyzed by grade levels throughout the school year. Common formative assessments provide teachers with valid feedback about the students' current understanding and knowledge of the Standards. Emphasis is on increasing understanding of Bloom's Taxonomy and Webb's Depth of Knowledge, along with creating an action plan of what teachers can start doing now in the classroom to prepare for new science assessments. Teachers learn how scoring guides/rubrics are used for constructed-response items and performance tasks and address the initial question of: "what is proficient?"

Regular and timely feedback from common formative assessments allows teachers to modify and adjust instruction to meet the diverse learning needs of all students.

2) Students are allowed to demonstrate scientific understanding through multiple measures of assessments.

Essential Question: How are you assessing the effectiveness of science instruction?

Types of Science Assessment Items

Selected-Response	Constructed Response	Performance Tasks
• Multiple choice, true-false, open or closed question stem • Promotes recall or memorization	• Short-answer or open-ended • Promotes organization and understanding of concepts	• Multi-leveled tasks (kinesthetic, oral, written) • Promotes a demonstration of learning

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Mastery of Science Information

Understanding in science incorporates thinking, reasoning, and making connections between specific content and real-world applications. Questioning is a large part of science investigation and an integral part of the Science and Engineering Practices. This step will focus on getting students to master science information and retain it over time. Science Review Boxes are the framework for this module as standards are re-visited on a continual basis. The Data Team process is introduced so that teams learn to analyze assessment data and determine best instructional practices. Tools, such as non-linguistic representation are presented to help teachers improve student understanding.

Key Points:

1) Conceptual understanding in science incorporates thinking, reasoning, and making connections between specific content and real-world applications.
2) Writing in science improves reading in science.
3) A strong understanding of science terminology and vocabulary enables students to comprehend complex scientific information
4) Nonlinguistic representations are tools that students can use to organize their scientific thinking and problem solving.

Essential Question: How do students learn science?

Content-Based Review		
How do desert animals survive?	***Name and describe the rock cycle.***	***Name three conductors and three insulators.***
Animal Behavior and Adaptation	**Rocks and Minerals**	**Electricity**
Explain how a breakfast cereal provides energy to the body.	***How is magnetism related to electricity?***	***What is adaptation?***
Food, Energy and the Body	**Scientific Inquiry**	**Vocabulary**

Activity: Designing Science Review Boxes

1.	SU:
	R:
2.	SU:
	R:
3.	SU:
	R:

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Problem Solving in Science

This step provides the structure for effective problem solving, questioning and implementing higher-order thinking skills within the framework of standards and objectives. The steps to effective problem solving guide the development of an activity for students that allows them to communicate their science understanding using a structured format and specific procedure. The ultimate goal is to have students transfer the process into real-world situations. The focus is on the science process skills, effective questioning and how to design instruction so that students are actively engaged in the science and engineering practices and scientific thinking. Strategies include using Bloom's Taxonomy and Webb's Depth of Knowledge. Discrepant events and Creative Science Challenges are incorporated as tools for engaging and motivating student learning.

Problem Solving Tasks	Creative Challenges
Discrepant Events	

Key Points:

1) Problem solving allows students to understand the process of scientific thinking.
2) Scientific reasoning, problem solving, and the science process skills are the keys to gaining effective scientific knowledge with real-world challenges.

Essential Question: What is problem solving and how do we provide opportunities for students to practice science with the 21st Century Skills?

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.

The basic science process skills are what we do when we conduct scientific exploration and experimentation. The science process skills form the foundation for scientific methods. There are six basic science process skills.

Observing	Communicating	Classifying	Measuring	Inferring	Predicting

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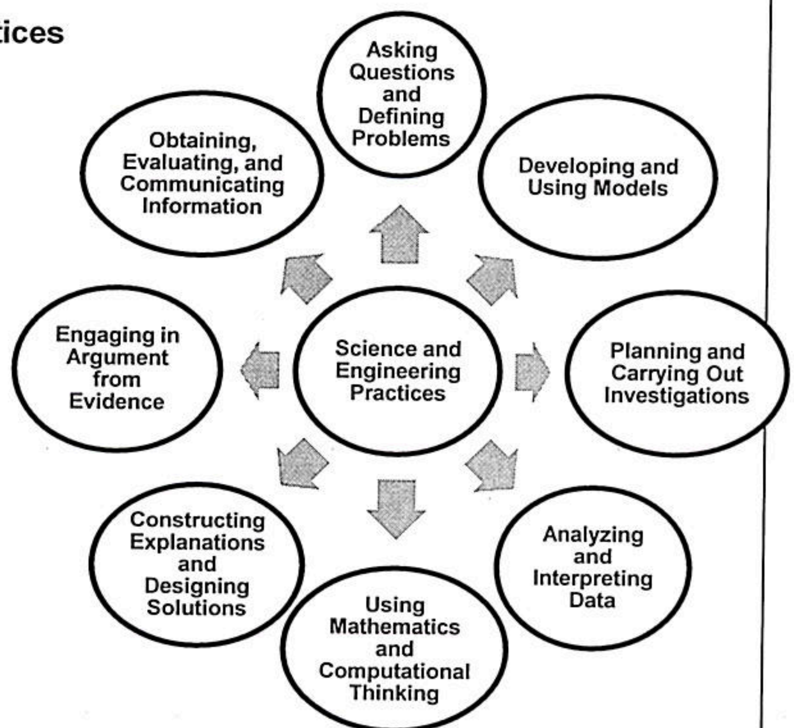
Title of the Lab		
Description		
Performance Expectations		
Essential Question(s)	**Big Idea(s)**	
Science and Engineering Practices	❑ Asking Questions and defining problems ❑ Developing and using models ❑ Planning and carrying out investigations ❑ Analyzing and interpreting data ❑ Using mathematics and computational thinking ❑ Constructing explanations and designing solutions ❑ Engaging in argument from evidence ❑ Obtaining, evaluating, and communicating information	
Science Process Skills	❑ Observing ❑ Inferring ❑ Measuring	❑ Communicating ❑ Classifying ❑ Predicting
Crosscutting Concepts	❑ Patterns ❑ Cause and effect: Mechanism and explanation ❑ Scale, proportion, and quantity ❑ Systems and system models ❑ Energy and Matter: Flows, cycles, and conservation ❑ Structure and Function ❑ Stability and change	
Disciplinary Core Ideas	❑ Life ❑ Earth Space Science ❑ Physical ❑ Engineering and Technology	
Connections to CCSS ELA ❑ Reading ❑ Writing ❑ Language ❑ Speaking and Listening	**Connections to CCSS Math** ❑ Standards for Mathematical Practices	

Science and Engineering Practices



Problem Solving in Science

To make the teaching of problem solving easier for teachers, a sequence of steps is suggested to help students communicate orally and in writing about the process used in solving the problem.

Title of Problem	
Problem Question	
Plan	
Work	Step 1: Step 2: Step 3: Step 4:
Answer	
Reflection	

Graphic Organizers

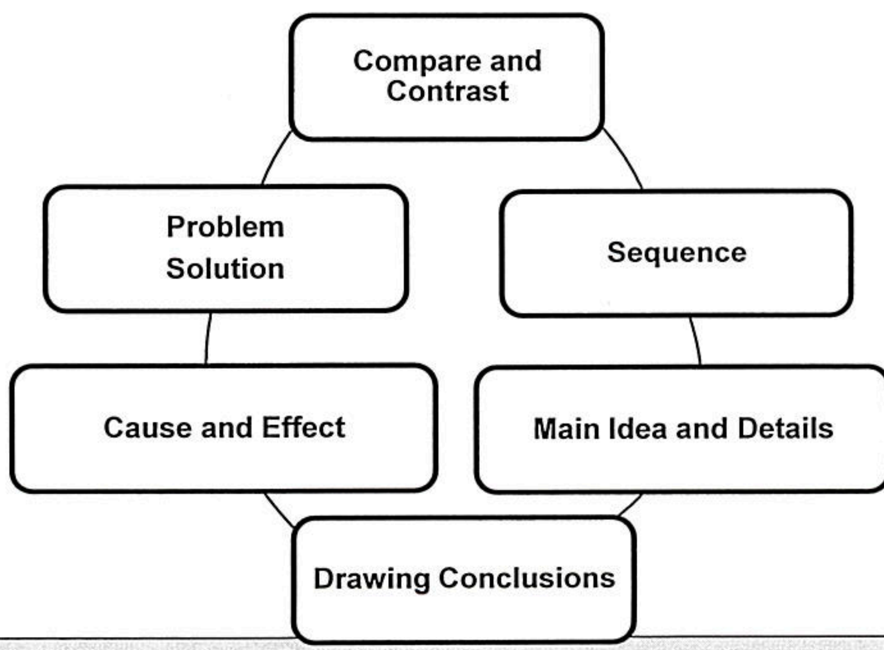
Graphic organizers are visual representations of student's knowledge, including facts, ideas, and concepts. Using graphic organizers in science allows students to personally interact with the content.

(en.wikipedia.org/wiki/Graphic_organizer)

Most include a visual representation such as a chart, timeline, flow chart or diagram to record, organize, synthesize and evaluate information and ideas. Graphic organizers also help to:

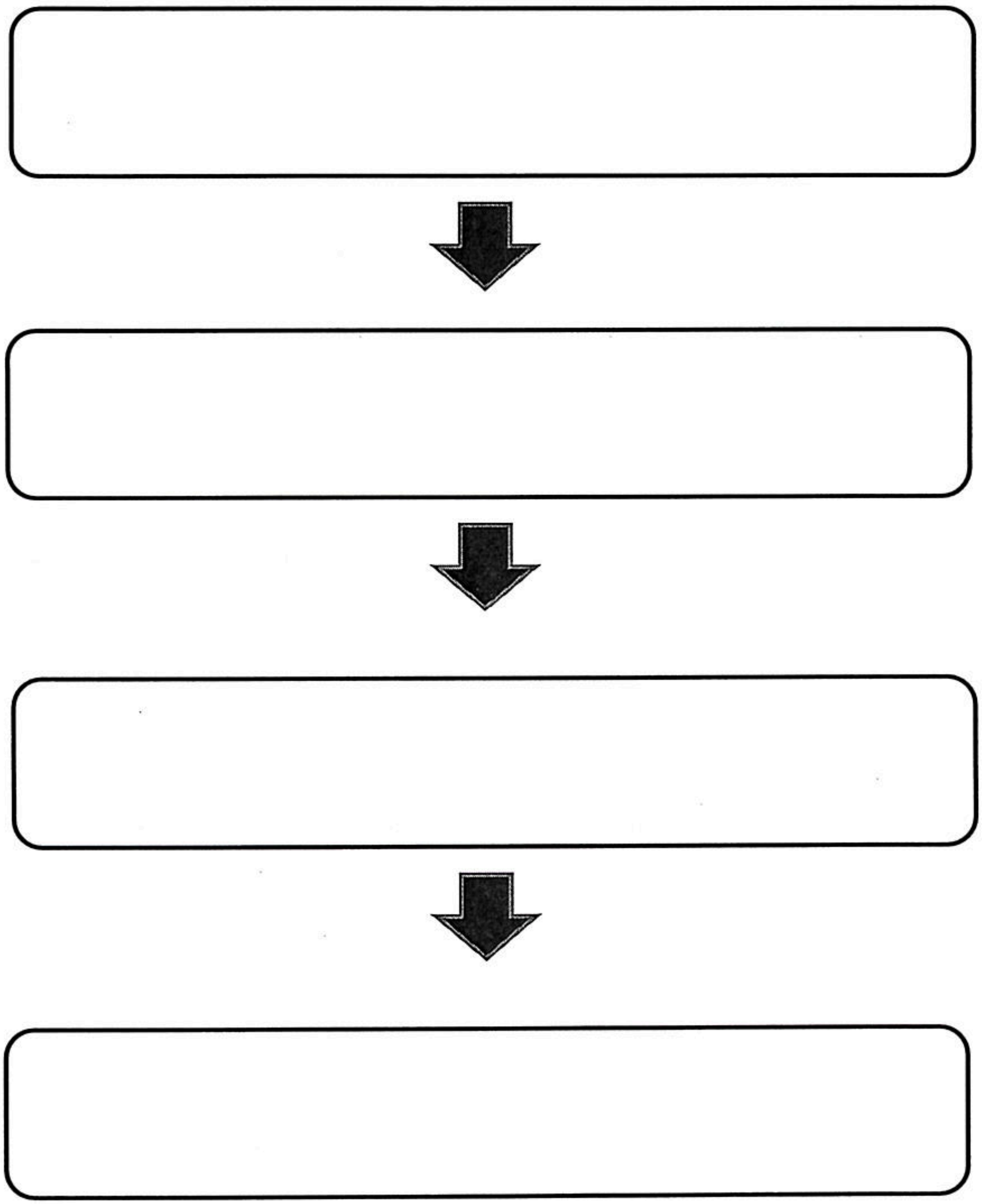
- relieve learner boredom
- enhance recall of content and information
- provide motivation
- create interest in learning a new topic
- clarify information
- assist in organizing thoughts
- promote understanding of complex concepts

They take many forms:

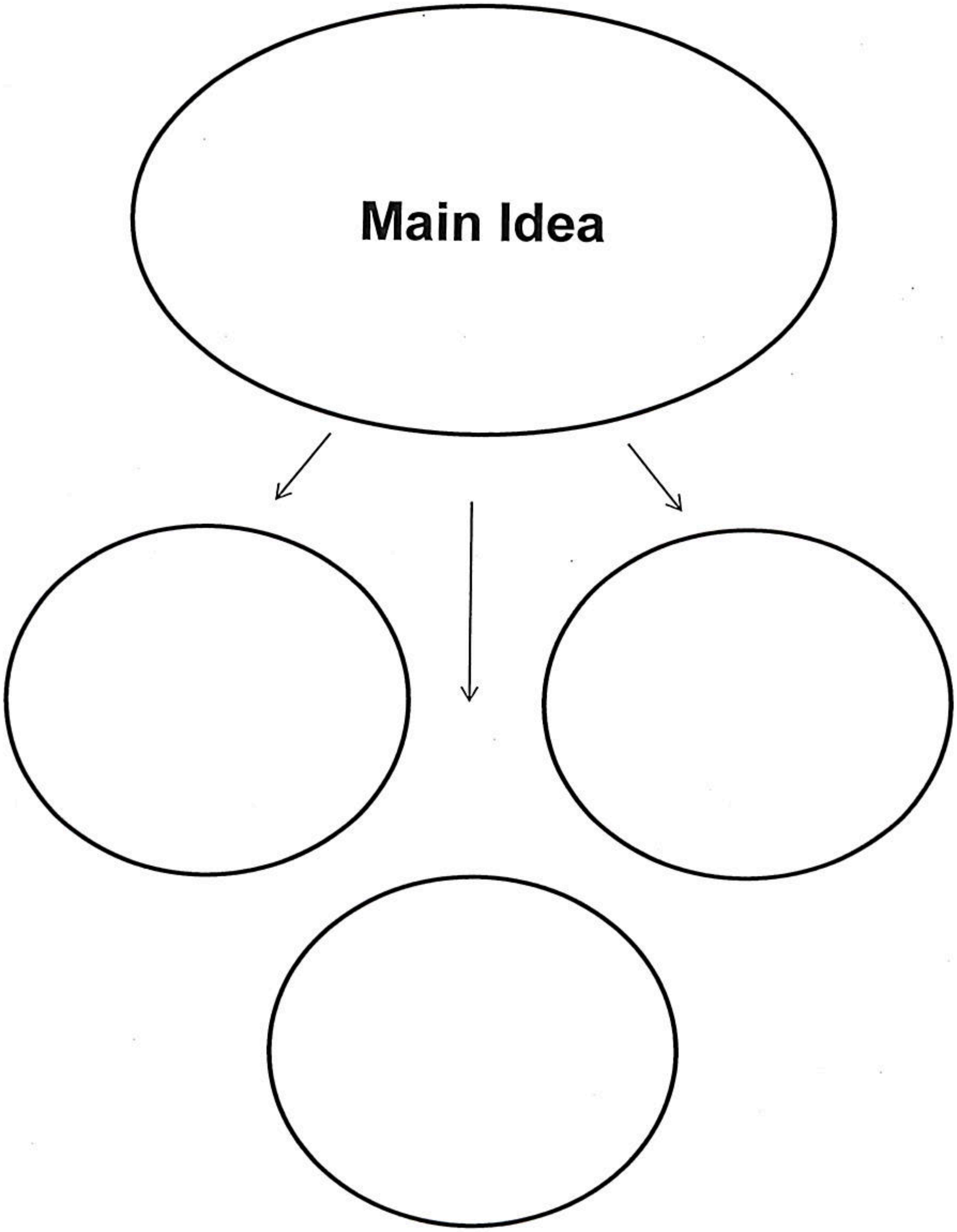


COMPARE AND CONTRAST

SEQUENCE



MAIN IDEA AND DETAILS



DRAWING CONCLUSIONS

FACT

FACT

FACT

FACT

CONCLUSION

CAUSE AND EFFECT

CAUSE → EFFECT

CAUSE → EFFECT

PROBLEM SOLUTION

PROBLEM	SOLUTION
	SOLUTION
	SOLUTION

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Activity: Choose a grade level performance expectation. How would you use graphic organizers to help students understand and remember the information?

Performance Expectation	
Graphic Organizer	**Ideas for Teaching and Learning**
Compare and Contrast	
Sequence	
Main Idea and Details	
Drawing Conclusions	
Text Structure	
Cause and Effect	
Problem Solution	

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