OKLAHOMA ACADEMIC STANDARDS

SCIENCE

FRAMEWORK

Crosscutting Concepts Progressions

OKLAHOMA STATE DEPARTMENT OF EDUCATION

CHAMPION EXCELLENCE

Introduction:

The Oklahoma Academic Standards for Science were adopted by the State Board of Education and signed into law by Governor Fallin in 2014.

The vision of the Oklahoma Academic Standards for Science is based on accumulated research on effective science teaching and learning and informed by the vision of the National Research Council's publication, *A Framework for K-12 Science Education* (National Research Council, 2012), for "three dimensional science learning". In this vision, **all students engage** in **science and engineering practices (SEPs)** and apply crosscutting concepts (CCCs) as a path to develop and apply knowledge of disciplinary core ideas (DCIs) to explain natural phenomenon. The Framework for K-12 Science Education builds on the strong foundation of previous studies that sought to identify and describe the major ideas for K-12 science education including: *Science for All Americans* and the *Benchmarks for Science Literacy developed by the* American Association for the Advancement of Science (1993) the *National Science Education Standards* (NRC, 1996) and the work of the National Science Teacher's Association, particularly the 2009 Anchors project. Previous Oklahoma science standards were informed by these documents.

Through experiences explaining natural phenomena, students not only learn science but they gain skills in scientific ways of thinking and problem solving.

By engaging in repeated learning experiences whereby students engage in three dimensional science learning to explain natural phenomena, students will have numerous opportunities to develop and apply deep conceptual understanding of science ideas, while gaining skills in scientific ways of thinking and problem solving. This expectation of students is explicitly indicated through each standard or performance expectation in the Oklahoma Academic Standards for Science. Each performance expectation leads with the statement "students who demonstrate understanding can". Demonstration of understanding occurs when students are able to support their explanations through science and engineering practices or apply their knowledge through those practices to a new situation.

Introduction: Crosscutting Concepts

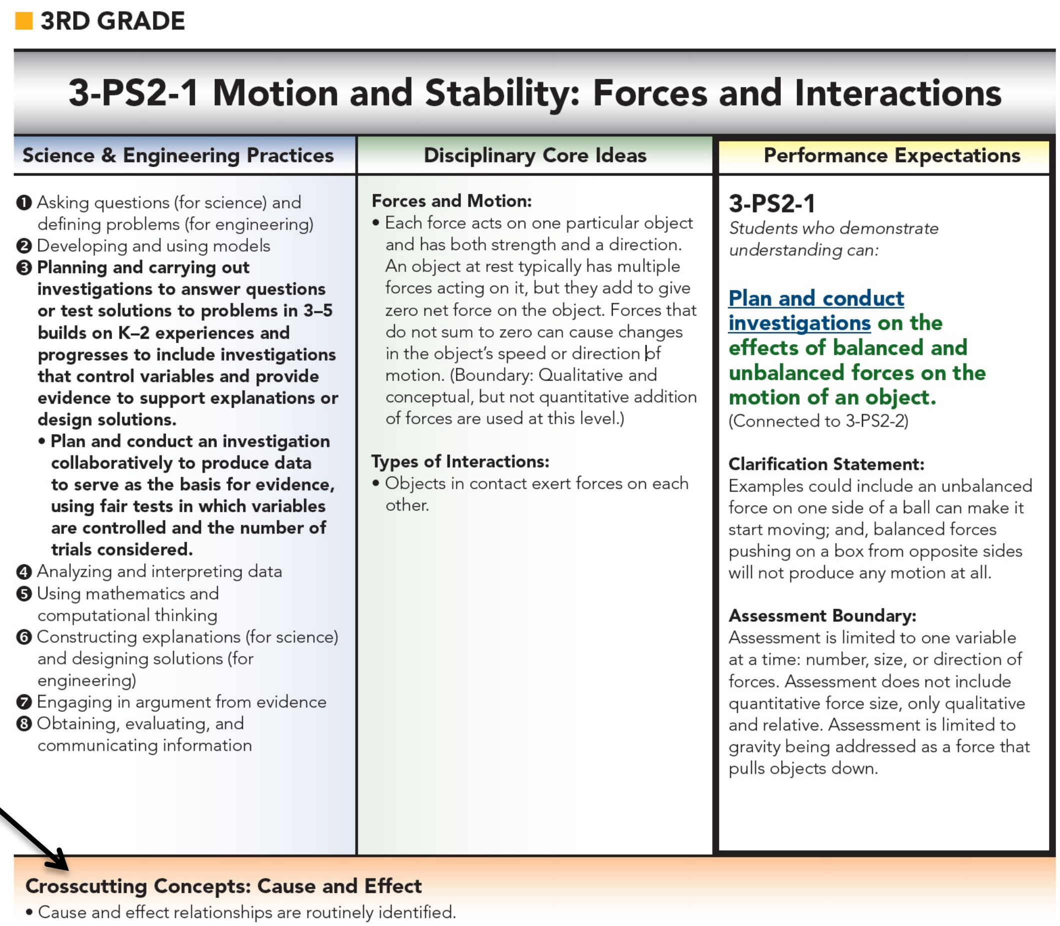
The Crosscutting Concepts represent the second dimension of three-dimensional teaching and learning. Crosscutting Concepts are

The authors of *A Framework for K-12 Science Education* recommended seven crosscutting concepts:

1. Patterns
2. Cause and effect: Mechanisms and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change

Each of the performance expectations/standards in the Oklahoma Academic Standards for Science incorporates a Science and Engineering Practice, Disciplinary Core Ideas and a **Crosscutting Concept.**

To the right, you will find a standards page from the Oklahoma Academic Standards for Science at 3rd grade. The Performance Expectation, 3-PS2-1 is located in the far right column and reads, "Plan and conduct investigations on the effect of balanced and unbalanced forces on the motion of an object." The crosscutting concept, Cause and Effect, is embedded in the performance expectation. In this example the crosscutting concept is **explicit** and mentioned in the performance expectation. In some performance expectations the crosscutting concept is **implicit**.



3RD GRADE

3-PS2-1 Motion and Stability: Forces and Interactions

Science & Engineering Practices	Disciplinary Core Ideas	Performance Expectations
❶ Asking questions (for science) and defining problems (for engineering) ❷ Developing and using models ❸ **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.** • **Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.** ❹ Analyzing and interpreting data ❺ Using mathematics and computational thinking ❻ Constructing explanations (for science) and designing solutions (for engineering) ❼ Engaging in argument from evidence ❽ Obtaining, evaluating, and communicating information	**Forces and Motion:** • Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) **Types of Interactions:** • Objects in contact exert forces on each other.	**3-PS2-1** *Students who demonstrate understanding can:* **Plan and conduct investigations on the effects of balanced and unbalanced forces on the motion of an object.** (Connected to 3-PS2-2) **Clarification Statement:** Examples could include an unbalanced force on one side of a ball can make it start moving; and, balanced forces pushing on a box from opposite sides will not produce any motion at all. **Assessment Boundary:** Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.

Crosscutting Concepts: Cause and Effect
• Cause and effect relationships are routinely identified.

The standards page also provides a little more information about the crosscutting concept integrated into the performance expectation. This information can be found towards the bottom of a standards page in an orange row.

Crosscutting Concept 1: Patterns

Observed patterns in nature guide organization and classification and prompted questions about relationships and causes underlying them.

K-2	3-5	6-8	9-12
Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.	Similarities and difference in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. *Patterns of change can be used to make predications. *Patterns can be used as evidence to support an explanation.	Macroscopic patterns are related to the nature of microscopic and atomic-level structure. Patterns in rate of change and other numerical relationships can provide information about natural and human designed systems. Patterns can be used to identify cause and effect relationships. Graphs, charts, and images can be used to identify patterns in data.	Different patterns may be observed at each of the scales at which a system is studied and can provide for causality in explanations of phenomena. Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. Patterns of performance of designed systems can be analyzed and interpreted to re-engineer and improve the system. Mathematical representations are needed to identify some patterns. Empirical evidence is needed to identify patterns.

Crosscutting Concept 2: Cause and Effect

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

K-2	3-5	6-8	9-12
Events have causes that generate observable patterns. Simple tests can be designed to gather evidence to support/refute student ideas about causes.	Cause and effect relationships are routinely identified, tested, and used to explain change. Events that occur together with regularity might or might not be a cause and effect relationship.	Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.	Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. Systems can be designed to cause a desired effect. Changes in system may have various causes that may not have equal effects.

Crosscutting Concept 3: Scale, Proportion and Quantity

In considering phenomena, it is critical to reconginze what is relevant at different size, time, and energy scales, and to recognnize proportional relationships

K-2	3-5	6-8	9-12
Relative scales allow objects and events to be compared and described (e.g., bigger/smaller, hotter/cooler, faster/slower). Standard units are used to measure	Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods. Standard units are used to measure	Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. The observed function of natural and	The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. Some systems can only be studied indirectly as they are too small, too large, too fast, or too

length.	and describe physical quantities such as weight, time, temperature, and volume.	designed systems may change with scale. Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. Scientific relationships can be represented through the use of algebraic expressions and equations. Phenomena that can be observed at one scale may not be observable at another scale.	slow to observe directly. Patterns observable at one scale may not be observable or exist at other scales. Using concepts of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

Crosscutting Concept 4: System and System Models

A system is an organized group of related objects or components; models can be used for understanding and predicting the bahavior of systems.

K-2	3-5	6-8	9-12
Objects and organisms can be described in terms of their parts. Systems in the natural and designed world have parts that work together.	A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. A system can be described in terms of its components and their interactions.	Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. Models can be used to represent systems and their interactions-such as inputs, processes, and outputs-and energy, matter, and information flows within the systems. Models are limited in that they only represent certain aspects of the system under study.	Systems can be designed to do specific tasks. When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. Models (e.g., physical, mathematical, computer) can be used to simulate systems and interactions; including energy, matter, and information flow within and between systems at different scales. Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Crosscutting Concept 5: Energy and Matter

Tracking energy and matter flow, into, out of, and within systems helps one understand their system's behavior.

K-2	3-5	6-8	9-12
Objects may break into smaller pieces, be put together into larger pieces, or change shapes.	Matter is made of particles. Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems. *Energy can be transferred in various ways and between objects.	Matter is conserved because atoms are conserved in physical and chemical processes. Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g., energy in fields, thermal energy, and energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.	The total amount of energy and matter in closed systems is conserved. Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. Energy cannot be created or destroyed-only moves between one place to another, between objects and/or fields, or between systems. Energy drives the cycling of matter within and between systems. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Crosscutting Concept 6: Structure and Function

The way an object is shaped or structured determines many of its properties and functions.

K-2	3-5	6-8	9-12
The shape and stability of structures of natural and designed objects are related to their function(s).	Different materials have different substructures, which can sometimes be observed. Substructures have shapes and parts that serve functions.	Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore complex natural and designed structures/systems can be analyzed to	Investigating or designing net systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and the connections of components to reveal its function and/or solve a problem.

		determine how they function. Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.	The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.

Crosscutting Concept 7: Stability and Change

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

K-2	3-5	6-8	9-12
Some things stay the same while other things change. Things may change slowly or rapidly.	Change is measured in terms of differences over time and may occur at different rates. Some systems appear stable, but over long periods of time will eventually change.	Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. Small changes in one part of a system might cause large changes in another part. Stability might be disturbed either by sudden events or gradual changes that accumulate over time. Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.	Much of science deals with constructing explanations of how things change and how they remain stable. Change and rates of change can be quantified and modeled over very short or very long periods of time. Some systems' changes are irreversible. Feedback can stabilize or destabilize a system. Systems can be designed for greater or lesser stability.

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