Foundational Services
Science

Next Generation Science Standards Overview

Participant Workbook

The following statements relate to the Science Foundational Service training:

Next Generation Science Standards Overview

Please indicate your comfort level with the following:

4 = Fully Agree
3 = Agree
2 = Somewhat Agree
1 = Disagree
NA = Not Applicable to this training session

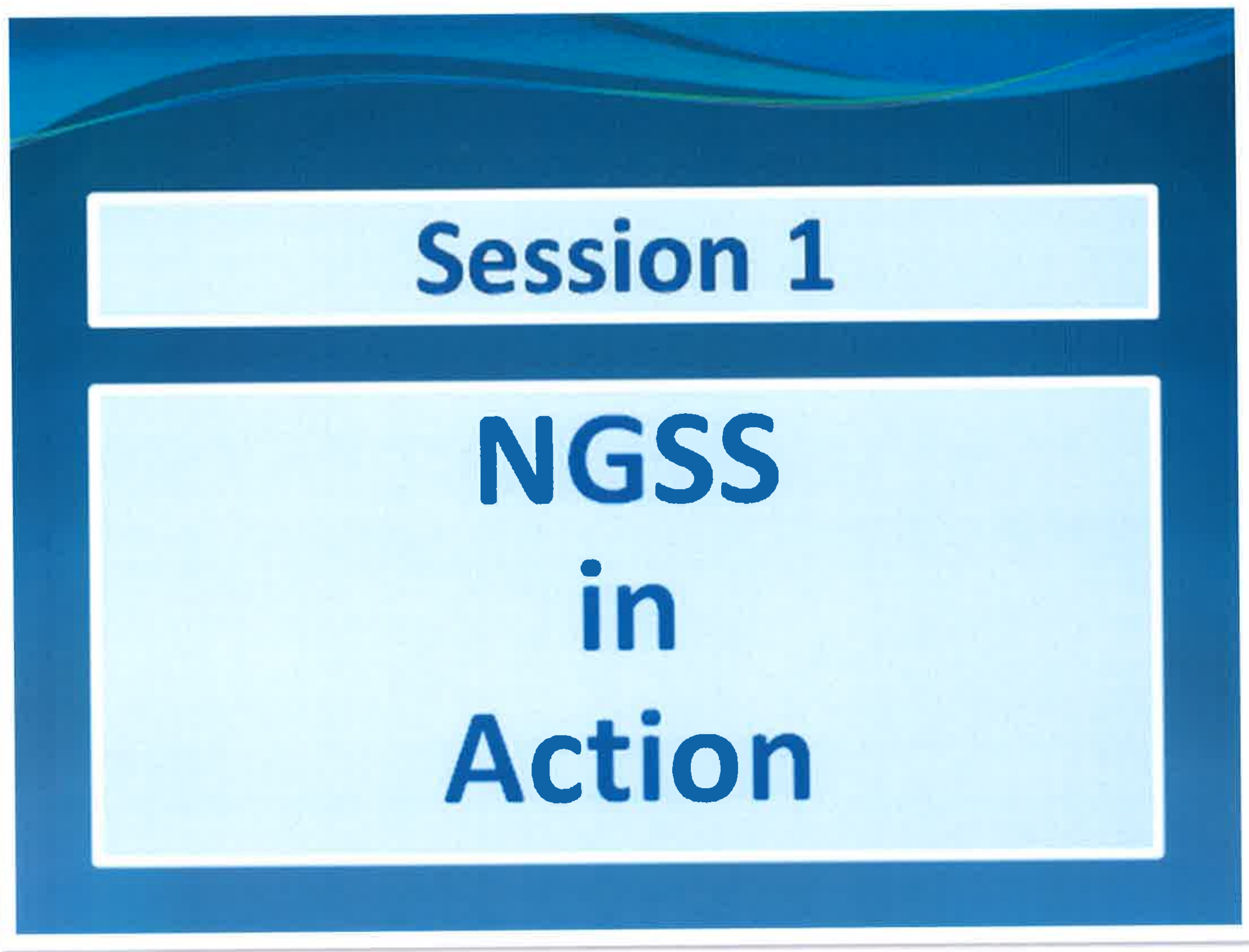
Science	Pre	Post
I can articulate the most significant shifts in the Next Generation Science Standards (NGSS) from the previous Illinois Learning Standards in Science.		
I can describe three-dimensional learning.		
I can identify how students will engage in the science and engineering practices.		
I can utilize the crosscutting concepts when observing and investigating phenomenon.		
I can summarize the disciplinary core ideas in the four areas of science.		
I can read the performance expectations and identify where to go for more information from those performance expectations.		
I can explain how different a Next Generation Science Standards (NGSS) classroom should look compared to a traditional science classroom.		

Reflection Questions following post survey:

1. What areas did you grow the most?

2. What areas do you need further development?

3. What next steps do you plan to take to further develop your knowledge and skills related to NGSS?


Session 1
NGSS
in
Action

Modeling

Through investigation, the students determine the conditions needed to see an object. The students then work to model their understanding. In the space below, take a moment to draw representation of how we see an object.

Investigating Transmission of Light

Question:

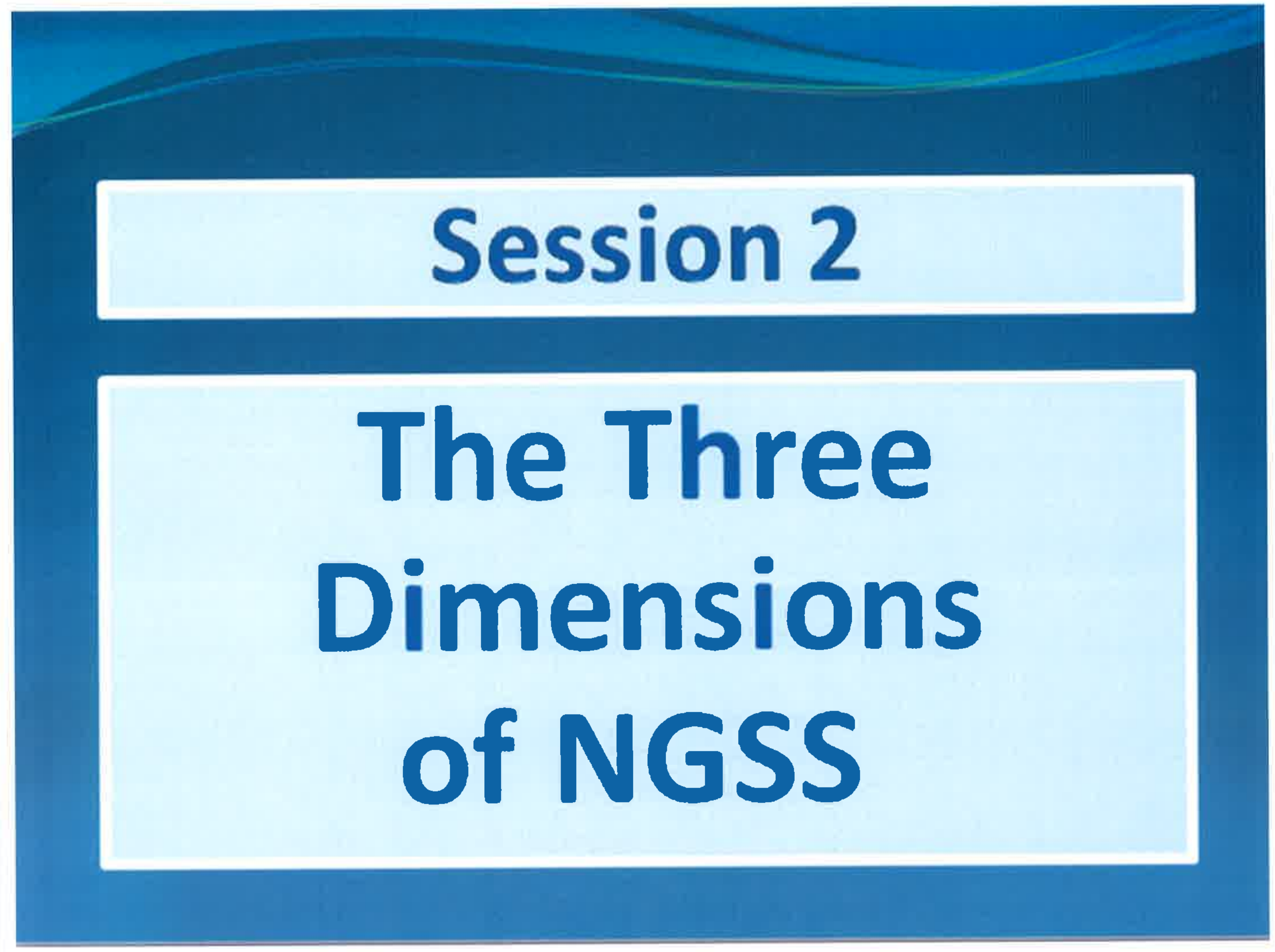
Procedure:

Data:

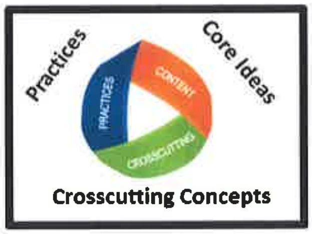
Making Sense:

Brainstorming

Consider the most significant shifts as we move from old to new science standards. In the space below, write down some of your own thoughts on which shifts will need to occur to implement the Next Generation Science Standards.


Session 2
The Three Dimensions of NGSS

Initial Thoughts: Three-Dimensional Learning



One of the most significant shifts is three-dimensional science learning. Consider the term "Three-Dimensional Science Learning." What does this mean? How would you explain this term to students, parents, administrations, and scientists? In the space below, write your current working definition for the term "Three-Dimensional Science Learning."

Three Dimensions of the *Framework for K-12 Science Education* being used to Develop the *Next Generation Science Standards* (NGSS)

Scientific and Engineering 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 the ideas of others.

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.

Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis.

Engineering investigations include analysis of data collected in the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria—that is, which design best solves the problem within given constraints. Like scientists, engineers require a range of tools to identify patterns within data and interpret the results. Advances in science make analysis of proposed solutions more efficient and effective.

Developing and Using Models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations.

Modeling tools are used to develop questions, predictions and explanations; analyze and identify flaws in systems; and communicate ideas. Models are used to build and revise scientific explanations and proposed engineered systems. Measurements and observations are used to revise models and designs.

Constructing Explanations and Designing Solutions

The products of science are explanations and the products of engineering are solutions.

The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories.

The goal of engineering design is to find a systematic solution to problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.

Engaging in Argument from Evidence

Argumentation is the process by which explanations and solutions are reached.

In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem. Scientists and engineers use argumentation to listen to, compare, and evaluate competing ideas and methods based on merits.

Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to identify strengths and weaknesses of claims.

Using Mathematics and 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; statistically analyzing data; and recognizing, expressing, and applying quantitative relationships.

Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions. Statistical methods are frequently used to identify significant patterns and establish correlational relationships.

Obtaining, Evaluating, and Communicating Information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity.

Communicating information and ideas can be done in multiple ways: using tables, diagrams, graphs, models, and equations as well as orally, in writing, and through extended discussions. Scientists and engineers employ multiple sources to acquire information that is used to evaluate the merit and validity of claims, methods, and designs.

Disciplinary Core Ideas in Physical Science	Disciplinary Core Ideas in Life Science	Disciplinary Core Ideas in Earth and Space Science	Disciplinary Core Ideas in Engineering, Technology, and the Application of Science
PS1: Matter and Its Interactions PS1.A: Structure and Properties of Matter PS1.B: Chemical Reactions PS1.C: Nuclear Processes **PS2: Motion and Stability: Forces and Interactions** PS2.A: Forces and Motion PS2.B: Types of Interactions PS2.C: Stability and Instability in Physical Systems **PS3: Energy** PS3.A: Definitions of Energy PS3.B: Conservation of Energy and Energy Transfer PS3.C: Relationship Between Energy and Forces PS3.D: Energy in Chemical Processes and Everyday Life **PS4: Waves and Their Applications in Technologies for Information Transfer** PS4.A: Wave Properties PS4.B: Electromagnetic Radiation PS4.C: Information Technologies and Instrumentation	**LS1: From Molecules to Organisms: Structures and Processes** LS1.A: Structure and Function LS1.B: Growth and Development of Organisms LS1.C: Organization for Matter and Energy Flow in Organisms LS1.D: Information Processing **LS2: Ecosystems: Interactions, Energy, and Dynamics** LS2.A: Interdependent Relationships in Ecosystems LS2.B: Cycles of Matter and Energy Transfer in Ecosystems LS2.C: Ecosystem Dynamics, Functioning, and Resilience LS2.D: Social Interactions and Group Behavior **LS3: Heredity: Inheritance and Variation of Traits** LS3.A: Inheritance of Traits LS3.B: Variation of Traits **LS4: Biological Evolution: Unity and Diversity** LS4.A: Evidence of Common Ancestry and Diversity LS4.B: Natural Selection LS4.C: Adaptation LS4.D: Biodiversity and Humans	**ESS1: Earth's Place in the Universe** ESS1.A: The Universe and Its Stars ESS1.B: Earth and the Solar System ESS1.C: The History of Planet Earth **ESS2: Earth's Systems** ESS2.A: Earth Materials and Systems ESS2.B: Plate Tectonics and Large-Scale System Interactions ESS2.C: The Roles of Water in Earth's Surface Processes ESS2.D: Weather and Climate ESS2.E: Biogeology **ESS3: Earth and Human Activity** ESS3.A: Natural Resources ESS3.B: Natural Hazards ESS3.C: Human Impacts on Earth Systems ESS3.D: Global Climate Change	**ETS1: Engineering Design** ETS1.A: Defining and Delimiting an Engineering Problem ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution **ETS2: Links Among Engineering, Technology, Science, and Society** ETS2.A: Interdependence of Science, Engineering, and Technology ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World

Crosscutting Concepts

Patterns
Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.

Cause and Effect: Mechanism and Explanation
Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

Scale, Proportion, and Quantity
In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Systems and System Models
Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

Energy and Matter: Flows, Cycles, and Conservation
Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.

Structure and Function
The way in which an object or living thing is shaped and its substructure determine many of its properties and functions.

Stability and Change
For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Analyzing Science & Engineering Practices

Within a lesson or unit of study, students may engage in multiple Practices. Consider the lesson from the previous session. The Science and Engineering Practice of "Planning and Carrying Out an Investigation" occurs. Before we simply label this lesson as "Planning and Carrying Out an Investigation," we look for guidance from the Framework on how to ensure the lesson is enabling the students to engage in the Scientific Practice of Planning and Carrying Out an Investigation. Read over the section of the Framework below and focus on the marked sections. Consider the following question: Was this present in the lesson? How?

Practice 3

Planning and Carrying Out Investigations

Scientists and engineers investigate and observe the world with essentially two goals: (1) to systematically describe the world and (2) to develop and test theories and explanations of how the world works. In the first, careful observation and description often lead to identification of features that need to be explained or questions that need to be explored.

The second goal requires investigations to test explanatory models of the world and their predictions and whether the inferences suggested by these models are supported by data. Planning and designing such investigations require the ability to design experimental or observational inquiries that are appropriate to answering the question being asked or testing a hypothesis that has been formed. This process begins by identifying the relevant variables and considering how they might be observed, measured, and controlled (constrained by the experimental design to take particular values).

Planning for controls is an important part of the design of an investigation. In laboratory experiments, it is critical to decide which variables are to be treated as results or outputs and thus left to vary at will and which are to be treated as input conditions and hence controlled. In many cases, particularly in the case of field observations, such planning involves deciding what can be controlled and how to collect different samples of data under different conditions, even though not all conditions are under the direct control of the investigator.

Decisions must also be made about what measurements should be taken, the level of accuracy required, and the kinds of instrumentation best suited to making such measurements. As in other forms of inquiry, the key issue is one of precision—the goal is to measure the variable as accurately as possible and reduce sources of error. The investigator must therefore decide what constitutes

Analyzing Crosscutting Concepts

Within a lesson or unit of study, students may utilize multiple Crosscutting Concepts. Consider the lesson from the previous session. The Crosscutting Concept of "Patterns" was utilized. Before we simply label this lesson as "Patterns," we look for guidance from the Framework on how to ensure the lesson is enabling the students to utilize the Crosscutting Concept of Patterns. Read over the section of the Framework below and focus on the marked sections. Consider the following question: Was this present in the lesson? How?

Patterns

Patterns exist everywhere—in regularly occurring shapes or structures and in repeating events and relationships. For example, patterns are discernible in the symmetry of flowers and snowflakes, the cycling of the seasons, and the repeated base pairs of DNA. Noticing patterns is often a first step to organizing and asking scientific questions about why and how the patterns occur.

One major use of pattern recognition is in classification, which depends on careful observation of similarities and differences; objects can be classified into groups on the basis of similarities of visible or microscopic features or on the basis of similarities of function. Such classification is useful in codifying relationships and organizing a multitude of objects or processes into a limited number of groups. Patterns of similarity and difference and the resulting classifications may change, depending on the scale at which a phenomenon is being observed. For example, isotopes of a given element are different—they contain different numbers of neutrons—but from the perspective of chemistry they can be classified as equivalent because they have identical patterns of chemical interaction. Once patterns and variations have been noted, they lead to questions;

Analyzing Disciplinary Core Ideas

Within a lesson or unit of study, students may engage in multiple practices. Consider the lesson from the previous session. The Science and Engineering Practice of "Planning and Carrying Out an Investigation" occurs. Before we simply label this lesson as "Planning and Carrying Out an Investigation," we look for guidance from the Framework on how to ensure the lesson is enabling the students to engage in the scientific practice of Planning and Carrying Out an Investigation. Read over the section of the Framework below and focus on the marked sections. Consider the following question: Was this present in the lesson? How?

By the end of grade 8. When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. Lenses and prisms are applications of this effect.

A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media (prisms). However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

By the end of grade 12. Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. Quantum theory relates the two models. (Boundary: Quantum theory is not explained further at this grade level.)

Because a wave is not much disturbed by objects that are small compared with its wavelength, visible light cannot be used to see such objects as individual

Dimension 3: Disciplinary Core Ideas—Physical Sciences 135

Reflection & Take-Away: Three-Dimensional Learning

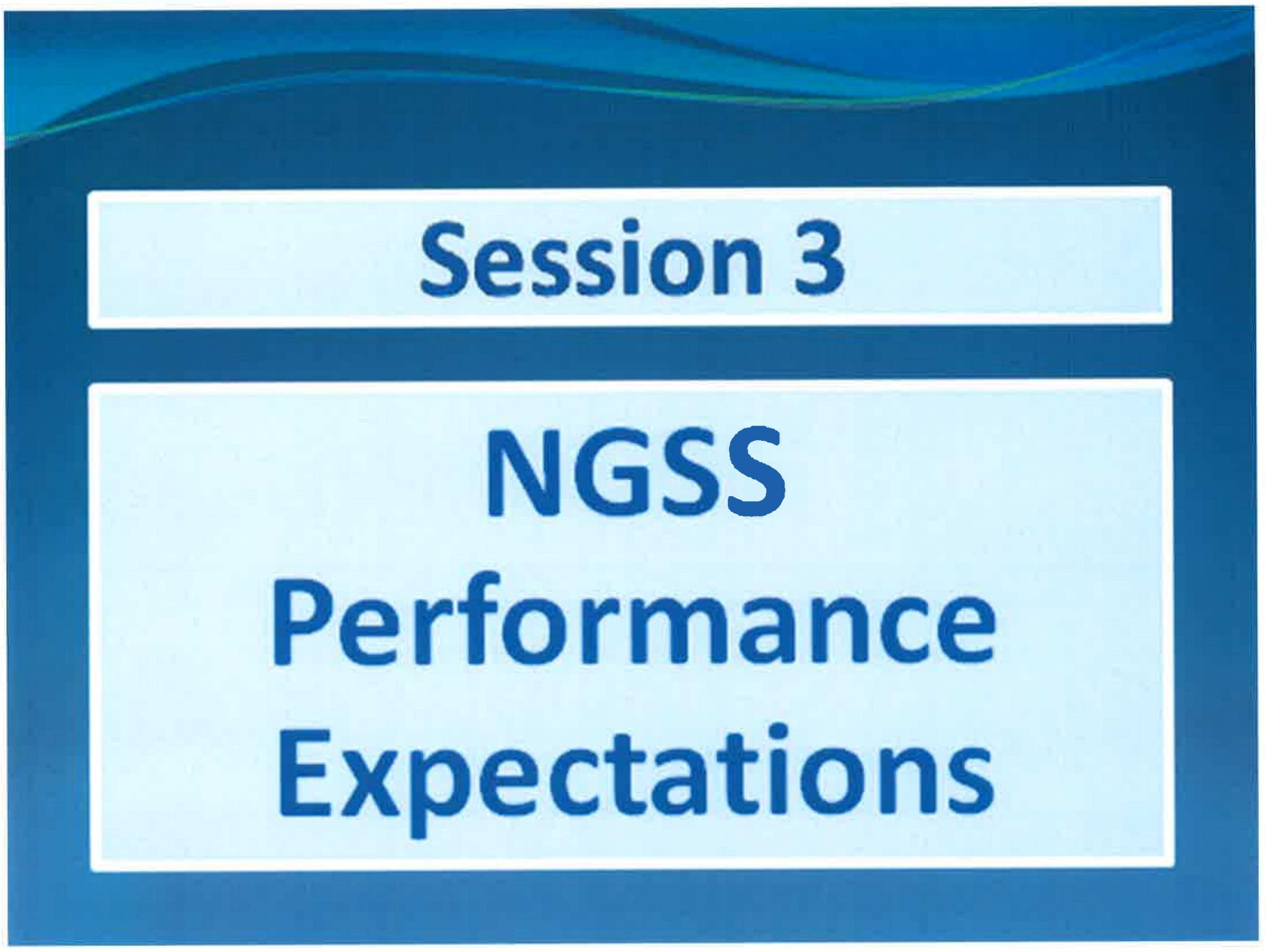
In order to implement NGSS and use the EQuIP Rubric to examine and evaluate NGSS lessons and units, it's imperative that we have a common understanding of the concepts of practices, disciplinary core ideas, and crosscutting concepts as they relate to the Framework. Where are you now in terms of being able to respond to these four questions with confidence?

- What does "THREE-DIMENSIONAL LEARNING" look like?
- What are some ways the eight "PRACTICES" help teachers and students make sense of phenomena and/or to design solutions to problems?
- What are some ways the seven "CROSSCUTTING CONCEPTS" provide ways of looking at phenomena across different science disciplines?
- What criteria characterize "CORE IDEAS" and help focus K-12 science curriculum, instruction, and assessments on the most important aspects of science?

- Has your thinking changed as a result of this segment?

- What did you hear that was new?

- What's still rolling around in your head that you need to know more about?


Session 3
NGSS
Performance
Expectations

A Look at the Next Generation Science Standards

The *Next Generation Science Standards* (*NGSS*) differ from prior science standards in that they integrate three dimensions (science and engineering practices, disciplinary core ideas, and crosscutting concepts) into a single performance expectation and have intentional connections between performance expectations. The system architecture of *NGSS* highlights the performance expectations as well as each of the three integral dimensions and connections to other grade bands and subjects. The architecture involves a table with three main sections.

What Is Assessed (Performance Expectations)

A performance expectation describes what students should be able to do at the end of instruction and incorporates a science and engineering practice, a disciplinary core idea, and a crosscutting concept from the foundation box. Performance expectations are not instructional strategies or objectives for a lesson. Instead, they are intended to guide the development of assessments. Groupings of performance expectations do not imply a preferred ordering for instruction—nor should all performance expectations under one topic necessarily be taught in one course. This section also contains *Clarification Statements* and *Assessment Boundary Statements* that are meant to render additional support and clarity to the performance expectations.

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Foundation Box

The foundation box contains the learning goals that students should achieve. It is critical that science educators consider the foundation box an essential component when reading the *NGSS* and developing curricula. There are three main parts of the foundation box: science and engineering practices, disciplinary core ideas, and crosscutting concepts, all of which are derived from *A Framework for K–12 Science Education*. During instruction, teachers will need to have students use multiple practices to help students understand the core ideas. Most topical groupings of performance expectations emphasize only a few practices or crosscutting concepts; however, all are emphasized within a grade band. The foundation box also contains learning goals for *Connections to Engineering, Technology, and Applications of Science* and *Connections to the Nature of Science*.

Connection Box

The connection box identifies other topics in *NGSS* and in the *Common Core State Standards* (*CCSS*) that are relevant to the performance expectations in this topic. The *Connections to other DCIs in this grade level* contain the codes for topics in other science disciplines that have corresponding disciplinary core ideas at the same grade level. The *Articulation of Disciplinary Core Ideas (DCIs) across grade levels* contains the names of other science topics that either provide a foundation for student understanding of the core ideas in this standard (usually standards at prior grade levels) or build on the foundation provided by the core ideas in this standard (usually standards at subsequent grade levels). The *Connections to the Common Core State Standards* contains the coding and names of *CCSS* in Mathematics and in English Language Arts & Literacy that align to the performance expectations.

Inside the NGSS Box

What Is Assessed

A collection of several performance expectations describing what students should be able to do at the end of instruction

Foundation Box

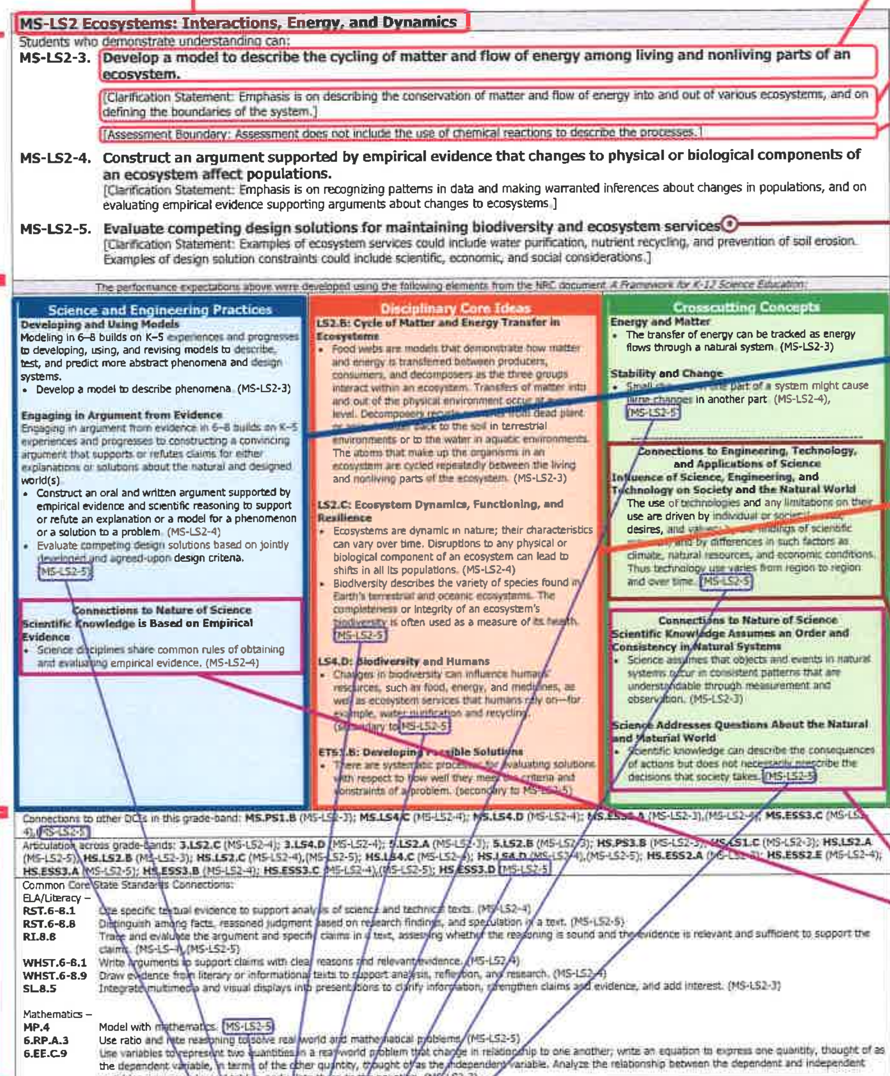
The practices, disciplinary core ideas, and crosscutting concepts from the *Framework for K-12 Science Education* that were used to form the performance expectations

Connection Box

Places elsewhere in *NGSS* or in the *Common Core State Standards* that have connections to the performance expectations on this page

Title

The title for a set of performance expectations is not necessarily unique and may be reused at several different grade levels.


MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
[Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.]
[Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
[Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*
[Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

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

Developing and Using Models
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
- Develop a model to describe phenomena. (MS-LS2-3)

Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).
- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4)
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-LS2-5)

Connections to Nature of Science
Scientific Knowledge is Based on Empirical Evidence
- Science disciplines share common rules of obtaining and evaluating empirical evidence. (MS-LS2-4)

Disciplinary Core Ideas

LS2.B: Cycle of Matter and Energy Transfer in Ecosystems
- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)

LS2.C: Ecosystem Dynamics, Functioning, and Resilience
- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)
- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)

LS4.D: Biodiversity and Humans
- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5)

ETS1.B: Developing Possible Solutions
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (secondary to MS-LS2-5)

Crosscutting Concepts

Energy and Matter
- The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)

Stability and Change
- Small changes in one part of a system might cause large changes in another part. (MS-LS2-4), (MS-LS2-5)

Connections to Engineering, Technology, and Applications of Science
Influence of Science, Engineering, and Technology on Society and the Natural World
- The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-LS2-5)

Connections to Nature of Science
Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. (MS-LS2-3)

Science Addresses Questions About the Natural and Material World
- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS2-5)

Connections to other DCIs in this grade-band: MS.PS1.B (MS-LS2-3); MS.LS4.C (MS-LS2-4); MS.LS4.D (MS-LS2-4); MS.ESS2.A (MS-LS2-3),(MS-LS2-4); MS.ESS3.C (MS-LS2-4),(MS-LS2-5)

Articulation across grade-bands: 3.LS2.C (MS-LS2-4); 3.LS4.D (MS-LS2-4); 5.LS2.A (MS-LS2-3); 5.LS2.B (MS-LS2-3); HS.PS3.B (MS-LS2-3); HS.LS1.C (MS-LS2-3); HS.LS2.A (MS-LS2-5); HS.LS2.B (MS-LS2-3); HS.LS2.C (MS-LS2-4),(MS-LS2-5); HS.LS4.C (MS-LS2-5); HS.LS4.D (MS-LS2-4),(MS-LS2-5); HS.ESS2.A (MS-LS2-3); HS.ESS2.E (MS-LS2-4); HS.ESS3.A (MS-LS2-5); HS.ESS3.B (MS-LS2-4); HS.ESS3.C (MS-LS2-4),(MS-LS2-5); HS.ESS3.D (MS-LS2-5)

Common Core State Standards Connections:

ELA/Literacy –
RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-4)
RST.6-8.8 Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5)
RI.8.8 Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS-4),(MS-LS2-5)
WHST.6-8.1 Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)
WHST.6-8.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-4)
SL.8.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS2-3)

Mathematics –
MP.4 Model with mathematics. (MS-LS2-5)
6.RP.A.3 Use ratio and rate reasoning to solve real world and mathematical problems. (MS-LS2-5)
6.EE.C.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. (MS-LS2-3)

Performance Expectations

A statement that combines practices, core ideas, and crosscutting concepts together to describe how students can show what they have learned.

Clarification Statement

A statement that supplies examples or additional clarification to the performance expectation.

Assessment Boundary

A statement that provides guidance about the scope of the performance expectation at a particular grade level.

Engineering Connection (*)

An asterisk indicates a performance expectation integrates traditional science content with engineering through a practice or core idea.

Scientific & Engineering Practices

Activities that scientists and engineers engage in to either understand the world or solve a problem

Disciplinary Core Ideas

Concepts in science and engineering that have broad importance within and across disciplines as well as relevance in people's lives.

Crosscutting Concepts

Ideas, such as *Patterns* and *Cause and Effect*, which are not specific to any one discipline but cut across them all.

Connections to Engineering, Technology and Applications of Science

These connections are drawn from the disciplinary core ideas for engineering, technology, and applications of science in the *Framework*.

Connections to Nature of Science

Connections are listed in either the practices or the crosscutting connections section of the foundation box.

Codes for Performance Expectations

Every performance expectation has a unique code and items in the foundation box and connection box reference this code. In the connections to common core, italics indicate a potential connection rather than a required prerequisite connection.

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MS-PS4 Waves and Their Applications in Technologies for Information Transfer

MS-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]

MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]

MS-PS4-3. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. [Clarification Statement: Emphasis is on a basic understanding that waves can be used for communication purposes. Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.] [Assessment Boundary: Assessment does not include binary counting. Assessment does not include the specific mechanism of any given device.]

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

Developing and Using Models

Modeling in 6–8 builds on K–5 and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop and use a model to describe phenomena. (MS-PS4-2)

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 6–8 level builds on K–5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.

- Use mathematical representations to describe and/or support scientific conclusions and design solutions. (MS-PS4-1)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 6-8 builds on K-5 and progresses to evaluating the merit and validity of ideas and methods.

- Integrate qualitative scientific and technical information in written text with that contained in media and visual displays to clarify claims and findings. (MS-PS4-3)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

- Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS4-1)

Disciplinary Core Ideas

PS4.A: Wave Properties

- A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude. (MS-PS4-1)
- A sound wave needs a medium through which it is transmitted. (MS-PS4-2)

PS4.B: Electromagnetic Radiation

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2)
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2)
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media. (MS-PS4-2)
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves. (MS-PS4-2)

PS4.C: Information Technologies and Instrumentation

- Digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information. (MS-PS4-3)

Crosscutting Concepts

Patterns

- Graphs and charts can be used to identify patterns in data. (MS-PS4-1)

Structure and 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. (MS-PS4-2)
- Structures can be designed to serve particular functions. (MS-PS4-3)

Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World

- Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. (MS-PS4-3)

Connections to Nature of Science

Science is a Human Endeavor

- Advances in technology influence the progress of science and science has influenced advances in technology. (MS-PS4-3)

Connections to other DCIs in this grade-band: **MS.LS1.D** (MS-PS4-2)

Articulation across grade-bands: **4.PS3.A** (MS-PS4-1); **4.PS3.B** (MS-PS4-1); **4.PS4.A** (MS-PS4-1); **4.PS4.B** (MS-PS4-2); **4.PS4.C** (MS-PS4-3); **HS.PS4.A** (MS-PS4-1),(MS-PS4-2),(MS-PS4-3); **HS.PS4.B** (MS-PS4-1),(MS-PS4-2); **HS.PS4.C** (MS-PS4-3); **HS.ESS1.A** (MS-PS4-2); **HS.ESS2.A** (MS-PS4-2); **HS.ESS2.C** (MS-PS4-2); **HS.ESS2.D** (MS-PS4-2)

Common Core State Standards Connections:

ELA/Literacy –

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts. (MS-PS4-3)
RST.6-8.2	Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. *(MS-PS4-3)*
RST.6-8.9	Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-PS4-3)
WHST.6-8.9	Draw evidence from informational texts to support analysis, reflection, and research. (MS-PS4-3)
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS4-1),(MS-PS4-2)*

Mathematics –

MP.2	Reason abstractly and quantitatively. (MS-PS4-1)
MP.4	Model with mathematics. (MS-PS4-1)
6.RP.A.1	Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS4-1)
6.RP.A.3	Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-PS4-1)
7.RP.A.2	Recognize and represent proportional relationships between quantities. (MS-PS4-1)
8.F.A.3	Interpret the equation $y = mx + b$ as defining a linear function, whose graph is a straight line; give examples of functions that are not linear. *(MS-PS4-1)*

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

The section entitled "Disciplinary Core Ideas" is reproduced verbatim from A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas. Integrated and reprinted with permission from the National Academy of Sciences.

Comparing Standards

Understanding the differences between the standards that guided pedagogy for the last twenty years and those that we are called to currently implement informs our understanding of how instruction, curriculum, and assessment will change in the classroom as well. Examine the two standard comparisons below. Working in a small group, respond to the questions on the right of the page.

Current Standards versus NGSS

Current IL Learning Standard - Science	New IL Learning Standard – Science NGSS Performance Expectation
Identify and classify *biotic and abiotic factors in an environment that affect population density, habitat and placement of organisms in an energy pyramid.* (IL Middle School 12B.3a)	***Construct an explanation that predicts*** *patterns of interactions among organisms across multiple ecosystems.* (NGSS MS-LS-2)

Current Standards versus NGSS

Current IL Learning Standard - Science	New IL Learning Standard – Science NGSS Performance Expectation
Compare *physical, ecological and behavioral factors that influence interactions and interdependence of organisms.* (IL Early HS 12B.4a)	***Evaluate the claims, evidence, and reasoning*** *that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.* (NGSS HS-LS2-6)

What differences do you observe between the old and new standards?

What aspects of scientific inquiry and processes (e.g., skills and habits of mind) are expressed in the standards, and how are they related to or integrated with the content?

What type of questions (e.g., what, why, and how) are the students answering as they work to meet this standard?

In what ways do the standards encourage students to apply content knowledge or to use content knowledge in novel situations to build and demonstrate depth of understanding?

Reflection & Take-Away: NGSS Performance Expectations

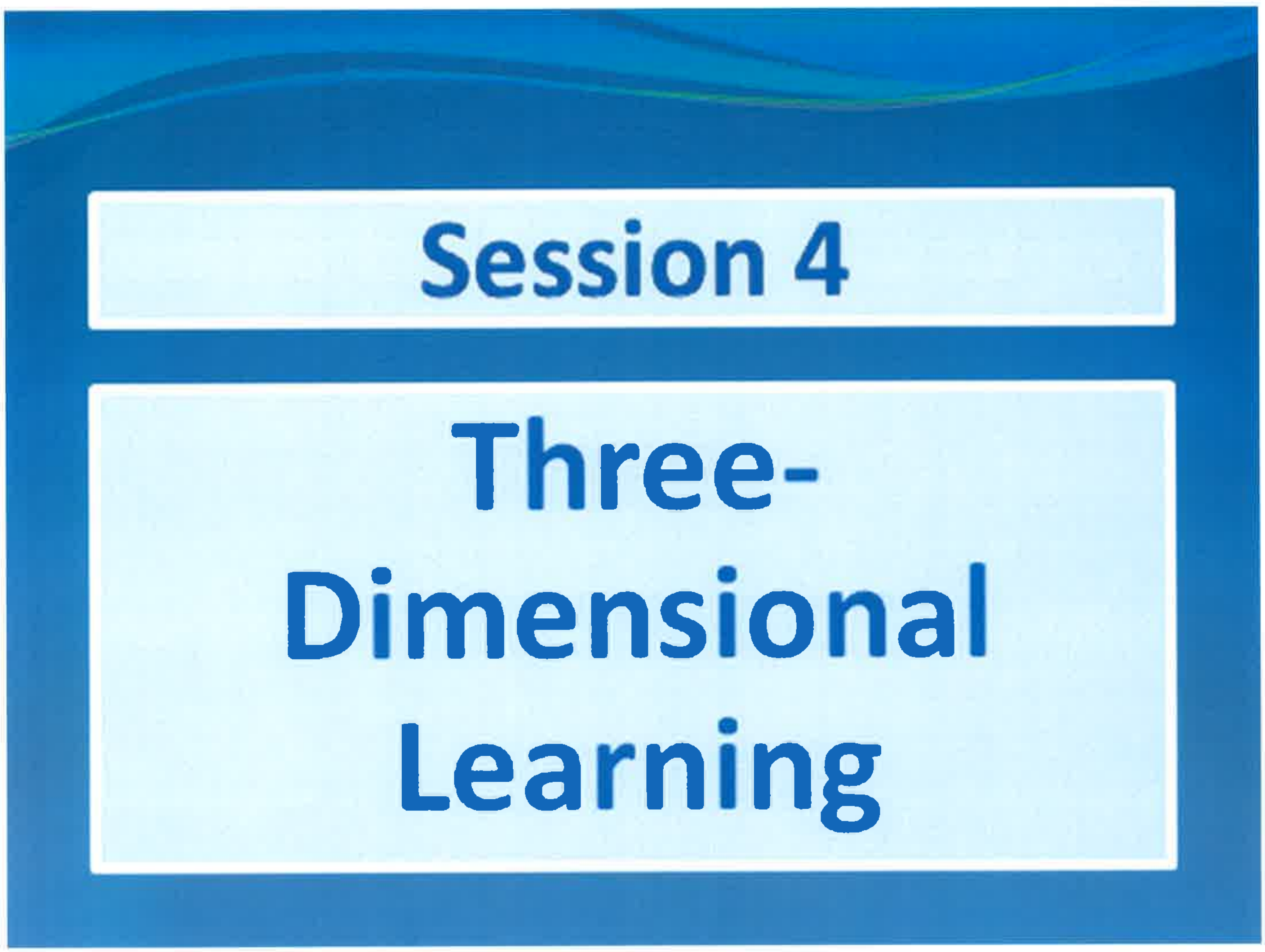
In order to implement NGSS and use the EQuIP Rubric to examine and evaluate NGSS lessons and units, it's imperative that we have a common understanding of the Next Generation Science Standards and the associated performance expectations. Where are you now in terms of being able to respond to these three questions with confidence?

- What are the component parts of a "PERFORMANCE EXPECTATION"?
- How do "PERFORMANCE EXPECTATIONS" exemplify three-dimensional learning in a science classroom?
- How are the new Illinois Learning Standards for Science that are based on the NGSS – "PERFORMANCE EXPECTATIONS" different than the old Illinois Learning Standards for Science?

- Has your thinking changed as a result of this segment?

- What did you hear that was new?

- What's still rolling around in your head that you need to know more about?


Session 4
Three-
Dimensional
Learning

Creating Your Own NGSS Analogy

Using analogies in the classroom is an effective strategy as students tend to find it easier to understand a lesson when teachers form connections between the new topic and what has already been taught. As adult learners, we have been introduced to the concept of Three-Dimensional Learning. Take a moment to consider your own understanding, then create your own analogy to share with colleagues as you describe three-dimensional learning of the NGSS.

Three-Dimensional Learning is like

____:

Where ____

________________________ are the Practices; ____________

____ are

the Core Ideas; and ______________________________

____ are the Crosscutting

Concepts.

Analyzing Lessons for Three-Dimensional Learning

Sample Lesson from Foundational Services	**Lesson from the Classroom**
Consider the lesson you experienced at the onset of our professional development in Foundational Services, note how and where you saw yourself as a student engaged in three-dimensional learning.	Consider lessons from the classroom. How could they be modified to reach three-dimensional learning? Use the space below to jot down ideas or areas of focus for modifications.
✓ What did that look like? ✓ How did the practices, disciplinary core ideas, and crosscutting concepts work together so that students could make sense of phenomena and/or design solutions to problems? ✓ How was this different than other experiences in the classroom?	

Reflection & Take-Away: Three-Dimensional Learning

In order to implement NGSS and use the EQuIP Rubric to examine and evaluate NGSS lessons and units, it's imperative that we have a common understanding Three-Dimensional Learning called for in the Next Generation Science Standards. Where are you now in terms of being able to respond to these two questions with confidence?

- How is "THREE-DIMENTIONAL LEARNING" both the biggest and the most essential shift in the NGSS?
- What does "THREE-DIMENTIONAL LEARNING" look like in lessons and/or units in science classrooms?

- Has your thinking changed as a result of this segment?

- What did you hear that was new?

- What's still rolling around in your head that you need to know more about?