

Science Framework,
And
Next Generation Science Standards

Context

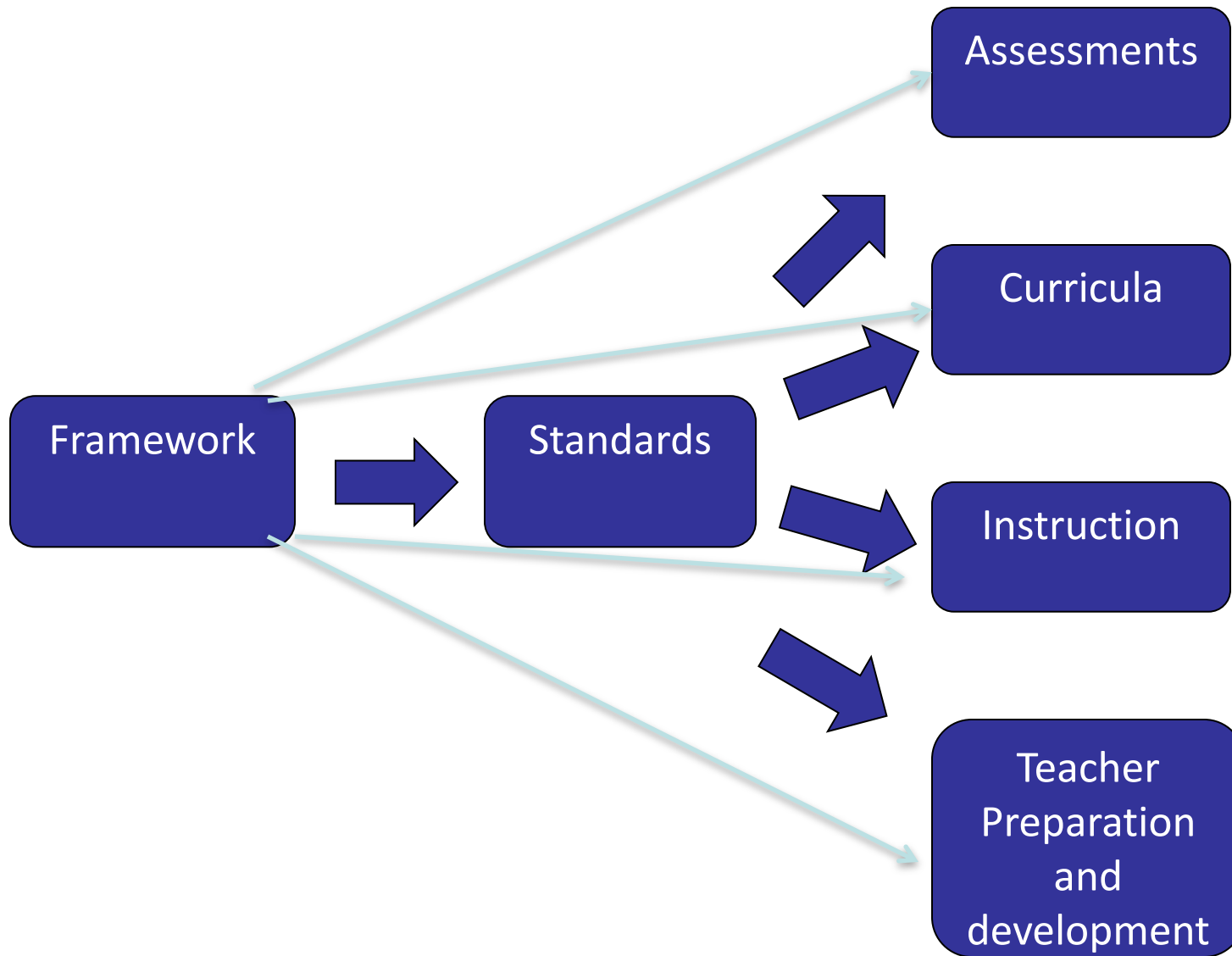
- Education in US is controlled at the state and local level.
- Common Core Math and Language Arts -- **47+ states** choosing common standards

Next Generation Science Standards

- Stage 1 NRC Framework –July 2011
- Stage 2 Achieve and 26 State teams

Next Gen Standards – released April 2013

so far **5 states** have adopted, CA likely will



A Framework for K-12 Science Education

Product of National Research Council
(Board on Science Education) study

9 scientists (all NAS members, 2 Nobel)

9 education experts (research and practice)

www.nap.edu free to download

Framework task

- What does research on learning tell us about how to teach science most effectively? (scientific science education)
- What are the most important ideas in science for k-12 students?
- Things **every** student needs to know something about or be able to do

Science for life and citizenship, not just for those who will become scientists and engineers.

Three Dimensions

- Scientific and engineering practices
- Crosscutting concepts
- Disciplinary core ideas

Demands instruction that is 3 dimensional

- **NGSS –standards as performance tasks that involve all 3**

Goals of the Framework

- Coherent investigation and development of core ideas across multiple years of school
- Blending of science and engineering practices with core ideas and crosscutting concepts

NGSSS closely based on Framework

Scientific and Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Developing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

*Crosscutting Concepts

1. Patterns
2. Cause and effect: mechanism 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

***All require models!**

Disciplinary Core Ideas

Physical Sciences

PS 1: Matter and its interactions

PS 2: Motion and stability: Forces and interactions

PS 3: Energy

PS 4: Waves and their applications in technologies
for information transfer

Life Sciences

LS 1: From molecules to organisms: Structures and processes

LS 2: Ecosystems: Interactions, energy, and dynamics

LS 3: Heredity: Inheritance and variation of traits

LS 4: Biological Evolution: Unity and diversity

Earth and Space Sciences

ESS 1: Earth's place in the universe

ESS 2: Earth's systems

ESS 3: Earth and human activity

Engineering, Technology, and the Applications of Science

ETS 1: Engineering design

ETS 2: Links among engineering, technology, science, and society

NGSS task

- Create a multi-state network
- Develop standards based on framework
- Standards as **performance expectations**
- Blending practices, cross-cutting concepts and disciplinary core ideas (dci)

Multiple rounds of review

- 7 times for state teams
- AAPT, NSTA etc invited to review parts
- 2 times for public
- Real changes made based on input

Example

Middle School – Matter and its Interactions

1. Performance expectations
2. Framework basis
3. Connections

MS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

- MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.** [Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.] [Assessment Boundary: Assessment does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete depiction of all individual atoms in a complex molecule or extended structure.]
- MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.** [Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with HCl.] [Assessment Boundary: Assessment is limited to analysis of the following properties: density, melting point, boiling point, solubility, flammability, and odor.]
- MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.** [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [Assessment Boundary: Assessment is limited to qualitative information.]
- MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.** [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]
- MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.** [Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms, that represent atoms.] [Assessment Boundary: Assessment does not include the use of atomic masses, balancing symbolic equations, or intermolecular forces.]
- MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.*** [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.]

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 a model to predict and/or describe phenomena. (MS-PS1-1),(MS-PS1-4)
- Develop a model to describe unobservable mechanisms. (MS-PS1-5)

Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and differences in findings. (MS-PS1-2)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints. (MS-PS1-6)

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.

- Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-PS1-3)

Connections to Nature of Science

Scientific Knowledge is Based on Empirical Evidence

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-2),(MS-PS1-3)
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4)
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4)
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals). (MS-PS1-1)
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)

PS1.B: Chemical Reactions

- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2),(MS-PS1-3),(MS-PS1-5)
- The total number of each type of atom is conserved, and thus the mass does not change. (MS-PS1-5)
- Some chemical reactions release energy, others store energy. (MS-PS1-6)

PS3.A: Definitions of Energy

- The term "heat" as used in everyday language refers both to thermal motion (the motion of atoms or molecules within a substance) and radiation (particularly infrared and light). In science, heat is used only for this second meaning; it refers to energy transferred when two objects or systems are at different temperatures. (*secondary to MS-PS1-4*)
- Temperature is not a measure of energy; the relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (*secondary to MS-PS1-4*)

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (*secondary to MS-PS1-6*)

Crosscutting Concepts

Patterns

- Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1)

Energy and Matter

- Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5)
- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6)

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-PS1-3)

Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology

- Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-PS1-3)

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

- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the

Less

- Detailed vocabulary
- Disconnected lessons
- Rote problems
- Teacher lecture

More

- Student discourse and argumentation
- Student developed MODELS
- Open ended problem solving

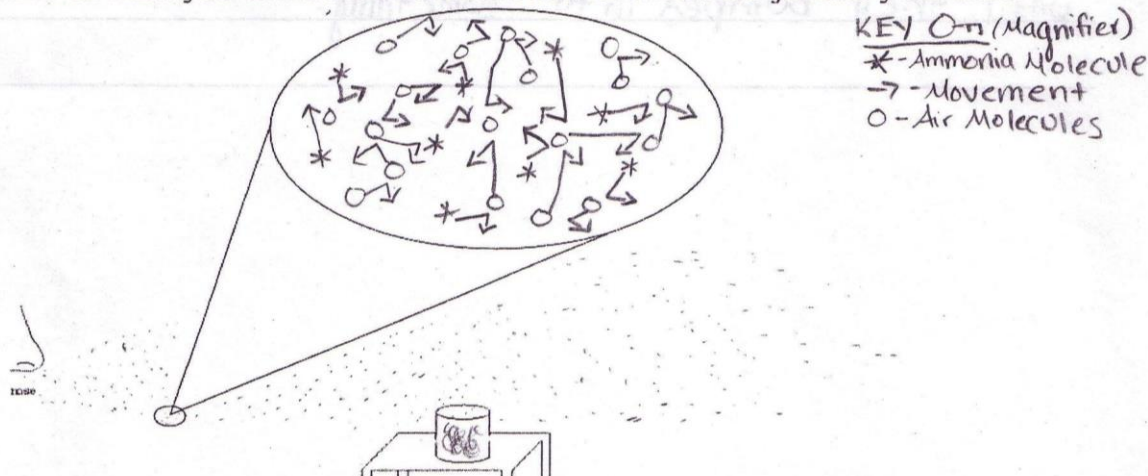
IQST Assessment: Modeling Smell

Your teacher opened a jar that contained a substance that had an odor. Imagine you had a very powerful microscope that allowed to see the odor up really, really close. What would you see?

•Lesson 15: student models

- 75% of students create a particle model, 25% a mixed model
- 68% of students include odor particles that are moving in straight lines until they collide into each other; 32% include both odor and air

etc, draw a picture of what you think the odor looks like between the jar and your nose.



2. Label what the parts in your drawing (in the magnifier) represent.

* - Ammonia Molecules - Tissue soaked in Ammonia in a Jar - Movement

3. Now, imagine that a friend of yours from a different science class was looking at

Models make thinking visible and explicit

- What system is being studied?
- What (artificial) boundary delimits the system under study?
- What are its components or subsystems?
- How do the components interact?
- What (matter or energy) flows into or out of system?
- What forces act across boundary?

Model building and observation

As in art, so in science, the attempt to represent drives to more careful observation of what is being represented

Decisions must be made:

what to foreground,

what to leave out

how to revise...

What comes next

- State decisions on adoption
- New Assessments??
- New or revised curriculum materials??
- Professional development??

Standards are not curriculum

- Knowledge in pieces, even when given as performance expectations
- Curriculum must be **designed** to be coherent, sequenced and connected

Implementation

- Requires multiple years of work
- Colleges and Universities have a role to play

If teachers never meet science practices
in their own science courses how can
they teach students to engage in them?