K-4th grade New Mexico Content of Science Standards (very edited!)

K-4 Content Standard 1: Students will understand the structure and properties of **matter**, the characteristics of **energy** and the **interactions** between matter and energy. Students will:

1. recognize that matter has different forms and properties:
   - i. observe that objects are made of different types of materials and have different properties (e.g., color, odor)
   - ii. observe that the three states of matter (i.e., solids, liquids and gases) have different properties (e.g., water can be liquid, ice or steam) and describe simple properties of matter (e.g., hardness, flexibility, transparency);
   - iii. observe that properties of substances can change when they are mixed, cooled or heated (e.g., salt dissolves in water, ice melts);
   - iv. identify and compare properties of pure substances and mixtures
   - v. know that changes to matter may be chemical or physical, and when two or more substances are combined, a new substance may be formed with properties that are different from those of the original substances (e.g., white glue and borax, cornstarch and water, vinegar and baking soda);
   - vi. know that materials are made up of small particles (atoms and molecules) that are too small to see with the naked eye;

2. know that energy is needed to get things done and that energy has different forms
   - i. observe how energy does things (e.g., batteries, the sun, wind, electricity) and produces changes (e.g., heat melts ice, gas makes car go)
   - ii. know that heat moves more rapidly in thermal conductors (e.g., metal pan) than in insulators (e.g., plastic handle);
   - iii. describe how energy (e.g., heat, light) can affect common objects (e.g., sunlight warms dark objects, heat melts candles);
   - iv. understand that light is a form of energy and can travel through a vacuum;
   - v. know that light travels in a straight line until it strikes an object and then it is reflected, refracted or absorbed;
   - vi. measure energy and energy changes (e.g., temperature changes);
   - vii. identify the characteristics of several different forms of energy and describe how energy can be converted from one form to another(e.g., light to heat, motion to heat, electricity to heat, light or motion);
   - viii. describe how some waves move through materials (e.g., water, sound) and how others can move through a vacuum (e.g., x-ray, television, radio);

Comment [EB1]: Basic intro to materials of artists, different properties and thus ways of working – additive vs reductive sculpture, for example, clay is malleable, stone is hard.

Comment [EB2]: Metal melts, plastics formed from liquids, modeling wax, paint drying, other film formation – adhesives?...

Comment [s3]: SB: Expansion of metals when heated, can cause structural problems. Adhesives, as you note—solutions and solubility. Dissolution and efflorescence of salt in ceramic pores and related conservation concerns.

Comment [s4]: Different types of marble deterioration—acid rain versus mechanical damage

Comment [s5]: Fluorescence and ultra-violet illumination as conservation tool

Comment [s6]: IRR and paintings conservation

Comment [BME7]: How colors are perceived; pigments; preferential heating of dark surfaces vs light ones, outdoor sculpture perhaps

K-4 Content Standard 3: Students will understand the structure of earth, the solar system and the universe, the interconnections among them and the processes and interactions of earth's systems. Students will:

2. Know the structure and formation of earth and its atmosphere and the processes that shape them

i. observe that the sun warms the land and water and they warm the air;

ii. know that rocks have different shapes and sizes (e.g., boulders, pebbles, sand) and that smaller rocks result from the breaking and weathering of larger rocks;

iii. understand that rocks are made of materials with distinct properties;

iv. know that earth's features are constantly changed by a combination of slow and rapid processes that include the action of volcanoes, earthquakes, mountain building, biological changes, erosion and weathering;

v. identify how water exists in the air in different forms (e.g., in clouds and fog as tiny droplets, in rain, snow and hail) and changes from one form to another through various processes (e.g., freezing, condensation, precipitation, evaporation);

vi. know that the properties of rocks and minerals reflect the processes that shaped them (e.g., igneous, metamorphic and sedimentary rocks);

Comment [s8]: Hardness and artists' ability to work stone; solubility of alabaster v marble

Comment [BME9]: Conservation of outdoor stone, monuments/buildings/gravestones

Comment [BME10]: Freeze/thaw cycles; relative humidity demonstrations

5-8th grade New Mexico Content of Science Standards (very edited!)

5-8 Content Standard 1: Students will understand the structure and properties of matter, the characteristics of energy and the interactions between matter and energy. Students will:

1. know the forms and properties of matter and how matter interacts;
   - i. describe properties (e.g., relative volume, flow) of the three states of matter;
   - ii. describe how matter changes from one phase to another (condensation, evaporation);
   - iii. know that the periodic table is a chart of the elements that make up all matter; explain that elements are organized in the periodic table according to their properties
   - iv. describe the relative location and motion of the particles (atoms and molecules) in each state of matter, and explain the relationship between temperature and the motion of particles in each state of matter;
   - v. understand that substances have characteristic properties and identify the properties of various substances (e.g., density, boiling point, solubility, chemical reactivity);
   - vi. know how to use properties to identify substances (e.g., for minerals: hardness, streak, color, reactivity to acid, cleavage, fracture); or density, boiling point, solubility
   - vii. explain how matter is transferred from one organism to another and between organisms and their environment (e.g., consumption, the water cycle, the carbon cycle, the nitrogen cycle);
   - viii. identify characteristics of radioactivity, including: decay in time of some elements to others, release of energy, damage to cells;
   - ix. describe how substances react chemically in characteristic ways to form new substances (compounds) with different properties (e.g., carbon and oxygen combine to form carbon dioxide in respiration);
   - x. distinguish between metals and non-metals;
   - xi. know that phase changes are physical changes that can be reversed (e.g., evaporation, condensation, melting);
   - xii. describe various familiar physical and chemical changes that occur naturally (e.g., snow melting, photosynthesis, rusting, burning);
   - xiii. identify factors that influence the rate at which chemical reactions occur (e.g., temperature, concentration);
2. explain the physical processes involved in the transfer, change and conservation of energy:
   - i. know that heat is transferred from hotter to cooler materials or regions until both reach the same temperature;

Comment [s11]: Metals and alloys—metallic elements v alloyed mixes

Comment [s12]: Metallic bond/lattice and ability to work metal to form it

Comment [s13]: Introduction to x-radiography and conservation

Comment [s14]: Acid rain reaction with marble, a good one here

ii. identify various types of energy (e.g., heat, light, mechanical, electrical, chemical, nuclear);

iii. understand that heat energy can be transferred through conduction, radiation and convection;

iv. understand that some energy travels as waves (e.g., seismic, light, sound) including: the sun as source of energy for many processes on earth, different wavelengths of sunlight (e.g., visible, ultraviolet, infrared), vibrations of matter (e.g., sound, earthquakes), different speeds through different materials;

v. sunlight and photosynthesis, energy transformation in living systems

vi. understand how light and radio waves carry energy through vacuum or matter by: straight-line travel unless an object is encountered, reflection by a mirror, refraction by a lens, absorption by a dark object, separation of white light into different wave lengths by prisms, visibility of objects due to light emission or scattering;

Comment [s15]: Review of light spectrum and its application to conservation study (From IRR to X-ray and UV)

Comment [EB16]: Biodeterioration

5-8 Content Standard 3: Students will understand the structure of earth, the solar system and the universe, the interconnections among them and the processes and interactions of earth's systems. Students will:

2. describe the structure of earth and its atmosphere, and explain how energy, matter and forces shape earth's systems;

i. know that earth is composed of layers that include crust, mantle and core;

ii. know that sedimentary, igneous and metamorphic rocks contain evidence of the materials, temperatures and forces that created them;

iii. understand factors that create and influence weather and climate, including: heat, air movement, pressure, humidity

iv. know that land forms are created and change through a combination of constructive and destructive forces, including: weathering of rock and soil, transportation, deposition of sediment and tectonic activity

v. understand how the remains of living things give us information about the history of earth, including: layers of sedimentary rock, the fossil record and radioactive dating, showing that life has been present on earth for more than 3.5 billion years;

9-12th grade New Mexico Content of Science Standards (very edited!)

9-12 Content Standard 1
Students will understand the structure and properties of matter, the characteristics of energy and the interactions between matter and energy. Students will:

1. understand the properties underlying structure and reactions of matter;
   i. classify matter in a variety of ways (e.g., element, compound, mixture; solid, liquid, gas; acidic, basic, neutral);
   ii. identify, measure and use a variety of physical and chemical properties (e.g., electrical conductivity, density, viscosity, chemical reactivity, pH, melting point);
   iii. explain how electrons determine the properties of substances: valence electrons, ionic and covalent bonds, carbon bonding
   iv. make predictions about elements using the periodic table (valence electrons, metallic character, reactivity, conductivity, type of bond);
   v. understand how the type and arrangement of atoms and their bonds determine macroscopic properties (e.g., boiling point, electrical conductivity, hardness of minerals);
   vi. know that states of matter (i.e., solid, liquid, gas) depend on the arrangement of atoms and molecules and on their freedom of motion;
   vii. know that chemical reactions involve the rearrangement of atoms and that they occur on many time scales (e.g., picoseconds to millennia);
   viii. understand types of chemical reactions (e.g., synthesis, decomposition, combustion, redox, neutralization)
   ix. know how to express chemical reactions with balanced equations that show conservation of mass and products of common reactions;
   x. describe how the rate of chemical reactions depends on many factors that include temperature, concentration and the presence of catalysts;
   xi. know that some atomic nuclei can change, including: spontaneous decay, half-life of isotopes, fission, fusion (e.g., the sun), alpha, beta and gamma radiation;
2. understand the transformation and transmission of energy and how energy and matter interact;
   i. identify different forms of energy, including kinetic, gravitational (potential), chemical, thermal, nuclear and electromagnetic;
   ii. explain how thermal energy (heat) consists of the random motion and vibrations of atoms and molecules, and is measured by temperature;
   iii. understand that energy can change from one form to another (e.g., changes in kinetic and potential energy in a gravitational field, heats of reaction, hydroelectric dams) and know that energy is conserved in these changes;

iv. understand how heat can be transferred by conduction, convection and radiation, and how heat conduction differs in conductors and insulators;

v. understand that the ability of energy to do something useful (work) tends to decrease (and never increases) as energy is converted from one form to another;

vi. understand that electromagnetic waves carry energy that can be transferred when they interact with matter;

vii. describe the characteristics of electromagnetic waves (e.g., visible light, radio, microwave, X-ray, ultraviolet, gamma) and other waves (e.g., sound, seismic waves, water waves), including origin and potential hazards of various forms of electromagnetic radiation, and energy of electromagnetic waves carried in discrete energy packets (photons) whose energy is inversely proportional to wavelength;

viii. explain how wavelengths of electromagnetic radiation can be used to identify atoms, molecules and the composition of stars;

ix. understand the concept of equilibrium (i.e., thermal, mechanical and chemical);

3. students will understand the motion of objects and waves and the forces that cause them (physics)

9-12 Content Standard 3
Students will understand the structure of earth, the solar system and the universe, the interconnections among them and the processes and interactions of earth's systems.

i. understand the scale and contents of the universe, including: range of structures from atoms through astronomical objects to the universe, and objects in the universe, such as: planets, stars, galaxies and nebulae;

ii. predict changes in the positions and appearances of objects in the sky (e.g., moon, sun) based on knowledge of current positions and patterns of movements (e.g., lunar cycles, seasons);

iii. understand how knowledge about the universe comes from evidence collected from advanced technology (e.g., telescopes, satellites, images, computer models);

iv. describe the key observations that led to the acceptance of the big bang theory and that the age of the universe is over 10 billion years;

v. explain how objects in the universe emit different electromagnetic radiation and how this information is used;

vi. describe how stars are powered by nuclear fusion, how luminosity and temperature indicate their age, and how stellar processes create heavier and stable elements that are found throughout the universe;

vii. examine the role that New Mexico research facilities play in current space exploration (e.g., very large array, Goddard space center);

viii. understand the changes in earth's past and the investigative methods used to determine geologic time, including: rock sequences, relative dating, fossil correlation and radiometric dating, geologic time scales, historic changes in life

forms and the evidence for absolute ages (e.g., radiometric methods, tree rings, paleomagnetism);

ix. describe the composition and structure of earth's materials, including: the major rock types (i.e., sedimentary, igneous, metamorphic) and their formation

K-4th grade New Mexico Scientific Thinking and Practice Standards – Selected

Students will understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting and validating in order to think critically. Students will:

1. use scientific methods to observe, collect, record, analyze, predict, interpret and determine reasonableness of data
    1. **Kindergarten**
        i. use observation and questioning skills in science inquiry (e.g., "What happens when something is pushed or pulled?");
        ii. record observations and data with pictures, numbers and symbols;
    2. **1st Grade**
        i. make observations, develop simple questions and make comparisons of familiar situations (e.g., "What does the seed look like when it starts to grow?");
        ii. describe relationships between objects (e.g., above, next to, below) and predict the results of changing the relationships (e.g., "When that block moves, what will happen to the one next to it?");
    3. **2nd Grade**
        i. conduct simple investigations (e.g., measure the sizes of plants of the same kind that are grown in sunlight and in shade);
        ii. use tools to provide information not directly available through only the senses (e.g., magnifiers, rulers, thermometers);
        iii. make predictions based on observed patterns as opposed to random guessing;
        iv. follow simple instructions for a scientific investigation;
    4. **3rd Grade**
        i. make new observations when discrepancies exist between two descriptions of the same object or phenomenon to improve accuracy;
        ii. recognize the difference between data and opinion;
        iii. use numerical data in describing and comparing objects, events and measurements;
        iv. collect data in an investigation and analyze those data;
        v. know that the same scientific laws govern investigations in different times and places (e.g., gravity, growing plants);
    5. **4th Grade**
        i. use instruments to perform investigations (e.g., timers, balances) and communicate findings;

ii. differentiate observation from interpretation and understand that a scientific explanation comes in part from what is observed and in part from how the observation is interpreted;

iii. conduct multiple trials to test a prediction, draw logical conclusions and construct and interpret graphs from measurements;

iv. collect data in an investigation using multiple techniques, including control groups, and analyze those data to determine what other investigations could be conducted to validate findings

2. use scientific thinking and knowledge and communicate findings;

i. communicate observations and answer questions about surroundings;

ii. know that simple investigations do not always turn out as planned;

iii. understand that, in doing science, it is often helpful to work with a team and share findings;

iv. make accurate observations and communicate findings about investigations;

v. use a variety of methods to display data and present findings;

vi. understand that predictions are based on observations, measurements and cause-and-effect relationships;

vii. communicate ideas and present findings about scientific investigations that are open to critique from others;

viii. describe how scientific investigations may differ from one another (e.g., observations of nature, measurements of things changing over time);

ix. understand how data are used to explain how a simple system functions (e.g., a thermometer to measure heat loss as water cools);

5th – 8th grade New Mexico Scientific Thinking and Practice Standards – Selected

Students will understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting and validating in order to think critically. Students will:

1. use scientific methods to develop questions, design and conduct experiments using appropriate technologies, analyze and evaluate results, make predictions and communicate findings;
    i. plan and conduct investigations
    ii. use appropriate technologies (e.g., calculators, computers, balances, spring scales, microscopes, etc.) to perform scientific tests and to collect and display data;
    iii. use graphic representations (e.g., charts, graphs, tables, labeled diagrams) to present data and produce explanations for investigations;
    iv. describe how credible scientific investigations use reproducible elements including single variables, controls and appropriate sample sizes to produce valid scientific results;
    v. communicate the steps and results of a scientific investigation;
    vi. justify predictions and conclusions based on data;
    vii. use a variety of print and web resources to collect information, inform investigations and answer a scientific question or hypothesis;
2. understand the processes of scientific investigation and how scientific inquiry results in scientific knowledge;
    i. understand that different kinds of investigations are used to answer different kinds of questions (e.g., observations, data collection, controlled experiments);
    ii. understand that scientific investigations use common processes that include the collection of relevant data and observations, accurate measurements, the identification and control of variables and logical reasoning to formulate hypotheses and explanations;
    iii. understand that not all investigations result in defensible scientific explanations;
    iv. describe how bias can affect scientific investigation and conclusions;
    v. critique procedures used to investigate an hypothesis;
    vi. analyze and evaluate scientific explanations;
    vii. examine alternative explanations for observations;
    viii. describe ways in which science differs from other ways of knowing and from other bodies of knowledge (e.g., experimentation, logical arguments, skepticism);
    ix. know that scientific knowledge is built on questions posed as testable hypotheses, which are tested until the results are accepted by peers

9th–12th grade New Mexico Scientific Thinking and Practice Standards – Selected

Students will understand the processes of scientific investigations and use inquiry and scientific ways of observing, experimenting, predicting and validating in order to think critically. Students will:

1. use accepted scientific methods to collect, analyze and interpret data and observations, to design and conduct scientific investigations and communicate results;
    i. design and conduct scientific investigations that include: testable hypotheses, controls and variables; methods to collect, analyze and interpret data; results that address hypotheses being investigated; predictions based on results; re-evaluation of hypotheses and additional experimentation as necessary; and error analysis;
    ii. convey results of investigations using scientific concepts, methodologies and expressions, including: scientific language and symbols, diagrams, charts and other data displays, mathematical expressions and processes (e.g., mean, median, slope, proportionality); clear, logical and concise communication and reasoned arguments;
    iii. understand how scientific theories are used to explain and predict natural phenomena (e.g., plate tectonics, ocean currents, structure of atom);
2. understand that scientific processes produce scientific knowledge that is continually evaluated, validated, revised or rejected;
    i. understand how scientific processes produce valid, reliable results, including: consistency of explanations with data and observations, openness to peer review, full disclosure and examination of assumptions, testability of hypotheses, repeatability of experiments and reproducibility of results;
    ii. use scientific reasoning and valid logic to identify: faulty logic, cause and effect, the difference between observation and unsubstantiated inferences, conclusions and potential bias;
    iii. understand how new data and observations can result in new scientific knowledge;
    iv. critically analyze an accepted explanation by reviewing current scientific knowledge;
    v. examine investigations of current interest in science (e.g., superconductivity, molecular machines, age of the universe);
    vi. examine the scientific processes and logic used in: investigations of past events (e.g., using data from crime scenes, fossils), investigations that can be planned in advance but are only done once (e.g., expensive or time-consuming experiments, such as medical clinical trials), and investigations of phenomena that can be repeated easily and frequently;