MEMORANDUM

TO: Members, Utah State Board of Education

FROM: David Smith
STEM Coordinator

DATE: October 8-9, 2015

ACTION: Approval of Grade 6-8 Science with Engineering Education (SEEd) Standards for Additional 30-day Public Review

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Background:
Following a 90-day public review SEEd writing teams met, reviewed, and responded to all feedback and prepared suggestions for how they would like to improve the standards in preparation of draft progression. The Utah State Board of Education approved the suggestions made and gave permission to move forward in revising the draft 6-8 SEEd Standards in the August 2015 Board meeting. Writing teams made the adjustments that were approved by the board in August to improve clarity, age appropriateness, and learning progressions.

Key Points:
1. Updated draft SEEd Standards (Grades 6-8) will be presented.
2. Supplemental information about standards will be provided to answer Board member questions.

Anticipated Action:
The Board will consider approving the release of the Utah Science with Engineering Education (SEEd) Standards (Grades 6-8) for an additional 30-day public review.

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Utah Science with Engineering Education (UT SEEd) Standards Release for 30-day Review

Prepared by the

Utah State Office of Education

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Utah Science with Engineering Education Standards - Grades 6-8

UT SEEd Standards -Draft for 30-day Public Review – October 2015

Overview

This document is available as a draft for public feedback. Please utilize the survey tool available online to provide feedback on this document found at:

https://www.surveymonkey.com/r/SEEdReview.

Once the 30-Day Public Review has concluded, the teacher writing teams for science grades 6-8 will reconvene to respond to comments and revise the draft accordingly. Thank you for taking time to provide your feedback and supporting the process of developing science standards that prepare Utah students to be college and career ready.

Crosswalk comparing current standards, SEEd standards, and NGSS

A crosswalk comparing the current 6-8 grade science standards, the draft 6-8 Grade SEEd Standards, and the Next Generation Science Standards (NGSS) is available online at:

http://tinyurl.com/SEEdCrosswalk.

The online spreadsheet has a tab for each grade, six through eight, and is sortable by clicking on the down arrow to the right of each column header/title. A simplified crosswalk comparing content and a comparison of standards formatting between current and SEEd standards are attached on the following pages.

Crosswalk comparing science content of current standards with the SEEd standards

This table provides a crosswalk of the science content found in each grade 6-8 for the current Utah Science standards and the draft Utah SEEd standards. It is meant to help give an overview of how content has shifted. Italicized content in the SEEd Standards show content that is new to that grade level.

	Current Utah Science Standards	Draft Utah SEEd Standards
6th Grade	**Earth & Space Science** · Moon phases · Solar system (objects, observation technology, forces, scale and size) · Seasons **Physical Science** · Heat, light, and sound energy **Life Science** · Microorganisms	**Earth & Space Science** · Moon phases · Solar system (objects, observation technology, forces, scale and size) · Seasons · *Weather and climate* **Physical Science** · *Atoms and molecules* · Heat energy and states of matter **Life Science** · *Matter and energy flow in ecosystems* · *Change and effects on ecosystems* ***Engineering*** · *Identify problems, test solution models* · *Analyze data from tests to make an optimal design*
7th Grade	**Earth & Space Science** · Structure of Earth · Classification (also Life Science) **Physical Science** · Structure of Matter · Density of Matter **Life Science** · Cells to systems – life organization · Heredity · Organisms and adaptations · Classification (also E&S Science)	**Earth & Space Science** · Earth's history, structure, and plates · *Rock cycle and fossil formation* **Physical Science** · *Forces interact with matter* **Life Science** · Cells to systems – life organization · Heredity and mutations · Organisms and adaptations · *Evidence of change in species* ***Engineering*** · *Identify problems, test solution models* · *Analyze data from tests to make an optimal design*
8th Grade	**Earth & Space Science** · Rock cycle and fossil formation · Earth's History **Physical Science** · Properties/changes in matter · Chemical reactions · Energy, force, motion, and waves **Life Science** · Flow of matter and energy in ecosystems · Organisms respond to energy	**Earth & Space Science** · Earth's resources and their uses · *Change in climate* · *Natural hazards* **Physical Science** · *Atoms and molecules* · Properties/changes in matter · Chemical reactions · Energy, force, motion, and waves **Life Science** · *Factors and maintenance of life* · Flow of matter and energy in ecosystems ***Engineering*** · *Identify problems, test solution models* · *Analyze data from tests to make an optimal design*

Comparison of Current Science Standards with the draft SEEd Standards

This table provides a comparison of the current science standards for grades 6-8 with the draft Utah SEEd standards for grades 6-8. It is meant to compare the expectations expressed in the current standards with the comprehensive integration of science practices, crosscutting concepts, and science core ideas into each standards.

Current Utah Science Standards	Draft Utah SEEd Standards
6.2.2 Explain how the relationship between the tilt of Earth's axis and its yearly orbit around the sun produces the seasons.	6.1.1 **Develop and use a model** of the sun-Earth-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. Examples of models could be physical, graphical, or conceptual.
8.2.2 Generalize the dependent relationships between organisms.	6.4.2 **Construct an explanation** that predicts patterns of interactions among organisms across multiple ecosystems. Emphasize consistent interactions in different environments such as competition, predation, and mutualism.
7.3.1 Observe and describe cellular structures and functions.	7.3.1 **Plan and carry out an investigation** that provides evidence that the basic structures of living things are cells. Emphasize that cells can form single-celled or multicellular organisms and that multicellular organisms are made of different types of cells.
7.4.2 Relate the adaptability of organisms in an environment to their inherited traits and structures.	7.4.2 **Obtain, evaluate, and communicate information** about specific animal and plant adaptations and structures that affect the probability of successful reproduction. Examples of adaptations could include nest building to protect young from cold, herding of animals to protect young from predators, vocalization of animals and colorful plumage to attract mates for breeding, bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.
8.2.3 Analyze human influence on the capacity of an environment to sustain living things	8.4.2 **Engage in argument** supported by evidence about the effect of per-capita consumption of natural resources on Earth's systems. Emphasize that these resources are limited and may be non-renewable. Examples of evidence include rates of consumption of food and natural resources such as freshwater, minerals, and energy sources.
8.4.4 Analyze various forms of energy and how living organisms sense and respond to energy.	8.2.2 **Ask questions** about how the amount of potential energy varies as distance within the system changes. **Plan and conduct an investigation** to answer a question about potential energy. Emphasize comparing relative amounts of energy. Examples could include a roller coaster cart at varying positions on a hill or objects being dropped from different heights. Calculations of kinetic and potential energy will be learned at the high school level.

Cost and Budget Analysis for New 6-8 SEEd Standards

A cost and budget analysis for the new 6-8 SEEd Standards was prepared to show the funding spent on standard preparation and the estimated costs of assessment adjustments and state-wide professional development by USOE. There is also an estimate cost and budget analysis for LEAs based on the data collected from Utah districts.

Cost and Budget Analysis for New 6-8 SEEd Standards (USOE)

Standards Development	Cost	#mtngs	Total Cost	Total 6-8 Cost	Budgeted
Original Standard Writing Team Meetings (per grade per meeting) (substitutes, meals, travel, lodging, and materials)	$1,300	3	$3,900	$11,700	
State Standards Review Committee Meeting (per meeting) (meals, travel, lodging, and materials)	$685	2	$1,370	$4,110	
Standards Writing Team Revision Meetings (per grade per meeting) (substitutes, meals, travel, lodging, and materials)	$1,200	5	$6,000	$18,000	
Public Hearing Meetings on the Standards (per meeting) (meals, travel, lodging, and materials)	$50	5	$250	$750	
Total Development Costs			$11,520	$34,560	
Science Development Budget Standards development makes up 20% of the FY16 Science budget*.					$40,000

Assessment	Cost	#items	Total Cost	Total 6-8 Cost	Budgeted
Avg. Cost of a new item on the SAGE Test (per grade per item) (item development, graphics, review, storage, etc.)	$1,150	144	$165,600	$496,800	
Yearly Assessment New Item Development Budget SAGE tests requires a bank of at least 400 questions (items). It is estimated that more than 65% of the current science items can be realigned or slightly adjusted and reused with new tests for the SEEd standards. The yearly budgeted funding to improve all nine science SAGE tests was about $500,000. Science will focus on writing items for the new 6-8 SEEd tests with the FY16 funding which will account for more than the 35% that may be lost to realignment. FY17 funding will help to cover additional item needs.					$500,000

State Professional Development	Total Cost	Total 6-8 Cost	Budgeted
LEA Leader Professional Development (substitutes, meals, travel, lodging, and materials)	$25,000	$75,000	
Science Professional Development Budget Professional Development makes up about 42% of the FY16 Science budget*. USOE intends to work with writing teams and professional learning experts in Utah higher education to train LEA teacher leaders that will increase the capacity of LEAs to train their teachers. USOE is also working with online programs funded through the STEM Action Center and Professional Learning Series budget to further increase capacity without additional costs.			$83,000

Total USOE Costs and Allotted Budget	Cost/Grade	Total 6-8 Cost	Budgeted
	$202,120	**$606,360**	**$623,000**

*The FY16 budget for Science includes funding for standards, materials, professional development, online courses, etc. and totals $200,000. This is an increase from previous years to help prepare for new science standards, however extra funding was reallocated from other areas of the USOE Teaching and Learning Department budget.

Cost and Budget Analysis for New 6-8 SEEd Standards (LEAs)

Avg. LEA Professional Development and Materials Cost	Cost/teacher	Total 6-8 Cost	Budgeted
Avg. LEA Teacher Professional Development (substitutes and meals)	$270	$28,400	
Avg. LEA Teacher Materials/Equipment (Text, materials, curriculum, equipment)	$112	$8,750	
Total	$382	$37,150	
The average cost of per-teacher and total spending was determined by surveying ten districts on how much they estimated they will spend on professional development and materials for their 6-8 grade science teachers for the SEEd standards. Eight districts responded and gave varying answers of estimated spending per-teacher (from $0 - $1200 for P.D. and from $0 - $333 for materials) and estimated total spending (from $0 to $70,000 for PD and from $0 to $20,000 for materials).			
Avg. LEA Professional Development and Materials Budget The average estimated district budgets were also determined through surveys. All districts agreed that more spending needed to happen to prepare 6-8 grade science teachers for eventual implementation of the SEEd standards, however most districts noted that they were not going to adjust their PD and materials funding and would simply focus most of the funding that they have towards 6-8 grade science. Many mentioned that, to prepare for the change and make up the difference, they have applied for outside grant funding to help train and prepare their teachers.			$38,500

Additional funding/training options for LEAs:

- Utah Science Technology and Research (USTAR) Programs - Legislative funding for LEAs, 20% can be used for teacher professional development
- Informal Science Education Enhancement (iSEE) - Legislative funding where part of their focus is in teacher professional development
- Utah Science Open Educational Resource (OER) Textbooks - A USOE program that helps Utah teachers write textbooks for Utah standards (accounts for 13% of the science budget. New books will be made for grades 6-8 before the pilot year begins)
- Online Endorsement Courses - A USOE program that trains teachers and improves content and pedagogy knowledge (24% of the science budget)

Draft Science with Engineering Education (SEEd) Standards-Grades 6-8

DESCRIPTION OF REVISION: The draft Utah SEEd standards have been revised and improved based on the 90-day public review feedback. Four main areas were addressed by the writing teams as was approved by the State Board of Education in the August Board Meeting:

- Clarity –
  - A robust introduction was added that describes the nature of science, importance of students doing science, explanation of the three dimensions of science, description of how to read and understand the document, and a specific description of the grade's learning progression
  - Clarity was improved with the addition of emphasis and example statements being added to most standards that give clear expectations for what students should be able to do
  - Science content was added specifically to engineering standards to give better direction and understanding
- Shifts in Content and Sequence of Standards –
  - Content was shifted in the current draft to more closely align with current 6-8 science standards allowing teachers to continue using some of their current materials and resources. There is still a shift in some content to allow for better horizontal progressions between grades 6 through 8 and vertical progressions within a single grade. Examples of shifted content include space returning to 6th grade and cells returning to 7th grade.
- Political Motivations –
  - Most SEEd standards remain based on the Next Generation Science Standards. Some changes were made to provide a clearer identification of the science & engineering practices and the crosscutting concepts. Furthermore, some adjustments and additional standards were added based on the expertise of the writing teams to improve learning progressions and clarity using other resources such as other state science standards and the Fordham Report on NGSS.
- Age Appropriateness -
  - Standards suggesting that students debate with evidence about climate change and human effects on the environment were removed from 6th grade
  - Content in the 6th grade standards cover more concrete science topics (e.g. solar system, moon, seasons, atoms, heat energy, and ecosystems)

Utah Science with Engineering Education Standards begin on the following page.

Utah Science with Engineering Education (SEEd) Standards - Grade Six

Science Literacy for All Students

Science is a way of knowing, a process for gaining knowledge and understanding of the natural world. By the very nature of scientific inquiry, it has little to do with popular consensus and requires evidence, there are infinite possibilities for further refinement, and it is the constant questioning and refinement that advances scientific knowledge and understanding. Since progress in the modern world is tied so closely to this way of knowing, scientific literacy is essential for a society to be competitively engaged in a global economy. Students should be active learners who demonstrate their scientific understanding by using it. It is not enough for students to read about science; they must participate in the three dimensions of science. They should observe, inquire, question, formulate and test hypotheses, analyze data, report, and evaluate findings. The students, as scientists, should have hands–on, active experiences throughout the instruction of the science curriculum. The standards help students find value in developing scientific literacy as they grapple with complex problems and create solutions to real world puzzles.

Three Dimensions of Science[1]

Science education includes three dimensions of science understanding: science and engineering practices, crosscutting concepts, and disciplinary core ideas. Every standard includes each of the three dimensions, **Science and Engineering Practices are bolded**, Crosscutting Concepts are underlined, and Disciplinary core ideas are in normal font. Standards with *specific engineering expectations are italicized*.

Scientific and Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
· Asking questions or defining problems · Developing and using models · Planning and carrying out investigations · Analyzing and interpreting data · Using mathematics and computational thinking · Constructing explanations and designing solutions · Engaging in argument from evidence · Obtaining, evaluating, and communicating information	· Patterns · Cause and effect: Mechanism and explanation · Scale, proportion and quantity · Systems and system models · Energy and matter: flows, cycles and conservation · Structure and function · Stability and change	· Earth and Space Science · Life Science · Physical Science · Engineering

Organization of Standards

The Utah SEEd standards[2] are organized into **strands**, which represent significant areas of learning within content areas. Within each strand are **standards**. A standard is an articulation of the demonstrated proficiency to be obtained. A standard represents an essential element of the learning that is expected. While some standards within a strand may be more comprehensive than others, all standards are essential for mastery.

[1] NRC Framework K-12 Science Education: http://www.nap.edu/catalog.php?record_id=13165

[2] Most SEEd Standards are based on the Next Generation Science Standards: http://www.nextgenscience.org

Sixth Grade SEEd Overview

The 6th Grade SEEd standards provide a framework for student understanding of the cycling of matter and the flow of energy through the study of observable phenomena on Earth. Students will explore the role of energy and gravity in the solar system as they compare the scale and properties of celestial objects and model the sun-Earth-moon system. These strands also emphasize heat energy as it affects some properties of matter - including states of matter and density. The relationship between heat energy and matter is observable in many phenomena on Earth such as seasons, the water cycle, weather, and climates. Types of ecosystems on Earth are dependent upon the interaction of organisms with each other and with the physical environment. By researching interactions between the living and nonliving components of ecosystems, students will understand how the flow of energy and cycling of matter affects stability and change within their environment.

Strand 6.1: Structure and Motion within the Solar System

The solar system consists of the sun and other celestial objects within its gravitational influence. Gravity is the force of attraction between masses. The sun-Earth-moon system provides an opportunity to study interactions between objects in the solar system that influence phenomena observed from Earth. Scientists use data from many sources to determine the scale and properties of objects in our solar system.

6.1.1 **Develop and use a model** of the sun-Earth-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons. Examples of models could be physical, graphical, or conceptual.

6.1.2 **Develop and use a model** to describe the role of gravity and inertia in orbital motions of objects in our solar system.

6.1.3 Use **computational thinking** to **analyze data** and determine the scale and properties of objects in the solar system. Examples of scale could include size and distance. Examples of properties could include layers, temperature, surface features, and orbital radius. Data sources could include Earth and space-based instruments such as telescopes and satellites. Types of data could include graphs, data tables, drawings, photographs, and models.

Strand 6.2: Energy Affects Matter

Matter and energy are fundamental components of the universe. Matter is anything that has mass and takes up space. Transfer of energy creates change in matter. Changes between general states of matter can occur through the transfer of energy. Density describes how closely matter is packed together. Substances with a higher density have more molecules in a given space than substances with a lower density. Changes in heat energy can alter the density of a material. Insulators resist the transfer of heat energy, while conductors easily transfer heat energy. These differences in energy flow can be used to design products to meet the needs of society.

6.2.1 **Develop models** to show that molecules are made of different kinds, proportions, and quantities of atoms. Emphasize understanding that there are differences between atoms and molecules, and that certain combinations of atoms form specific molecules. Examples of simple molecules could include water (H_2O), atmospheric oxygen (O_2), and carbon dioxide (CO_2).

6.2.2 **Develop a model** to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid or gas) and during phase changes (melting, freezing, condensing, and evaporating).

6.2.3 **Plan and carry out an investigation** to determine the relationship between temperature changes and varying types or amounts of matter. Emphasize recording and evaluating data, and communicating the results of the investigation.

6.2.4 ***Design*** *an object, tool, or process* that minimizes or maximizes heat energy transfer. *Identify criteria and constraints, develop a prototype for iterative testing, analyze data from testing, and propose modifications for optimizing the* ***design solution****.* Emphasize demonstrating how the structure of differing materials allows them to function as either conductors or insulators.

Strand 6.3: Earth's Weather Patterns and Climate

All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. Heat energy from the sun, transmitted by radiation, is the primary source of energy that affects Earth's weather and drives the water cycle. Uneven heating across Earth's surface causes changes in density, which result in convection currents in water and air, creating patterns of atmospheric and oceanic circulation that determine regional and global climates.

6.3.1 **Develop a model** to describe how the cycling of water through Earth's systems is driven by energy from the sun, gravitational forces, and density.

6.3.2 **Investigate** the interactions between air masses that cause changes in weather conditions. Collect and analyze weather data to provide evidence for how air masses flow from regions of high pressure to low pressure causing a change in weather. Examples of data collection could include field observations, laboratory experiments, weather maps, or diagrams.

6.3.3 **Develop and use a model** to show how unequal heating of Earth's systems cause patterns of atmospheric and oceanic circulation that determine regional climates. Emphasize how warm water and air move from the equator toward the poles. Examples of models could include Utah regional patterns such as lake-effect and inversion.

6.3.4 **Construct an explanation supported by evidence** for how the natural greenhouse effect maintains Earth's energy balance and a relatively constant temperature. Emphasize how the natural greenhouse effect is necessary for maintaining life on Earth. Examples could include comparisons between Earth and the moon or other planets.

Strand 6.4: Stability and Change in Ecosystems

The study of ecosystems includes the interaction of organisms with each other and with the physical environment. Consistent interactions occur within and between species in various ecosystems as organisms obtain resources, change the environment, and are affected by the environment. This influences the flow of energy through an ecosystem resulting in system variations. Additionally, ecosystems benefit humans through processes and resources such as the production of food, water and air purification, and recreation opportunities. Scientists and engineers investigate interactions among organisms and evaluate design solutions to preserve biodiversity and ecosystem resources.

6.4.1 **Analyze data** to provide evidence for the effects of resource availability on organisms and populations in an ecosystem. **Ask questions** to predict how changes in resource availability affects organisms in those ecosystems. Examples could include water, food, and living space in Utah environments.

6.4.2 **Construct an explanation** that predicts patterns of interactions among organisms across multiple ecosystems. Emphasize consistent interactions in different environments such as competition, predation, and mutualism.

6.4.3 **Develop a model** to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. Emphasize food webs and the role of producers, consumers, and decomposers in various ecosystems. Examples could include Utah ecosystems.

6.4.4 **Construct an argument supported by evidence** that changes to an ecosystem affect the stability of populations. Emphasize how changes to living and nonliving components in an ecosystem affect populations in that ecosystem. Examples could include Utah ecosystems such as mountains, Great Salt Lake, wetlands, and deserts.

6.4.5 *Evaluate competing design solutions* for preserving ecosystem resources and biodiversity based on how well the solutions maintain stability within the ecosystem. Emphasize **obtaining, evaluating and communicating** information of differing design solutions. Examples could include policies affecting ecosystems or solutions for the preservation of ecosystem resources specific to Utah such as air and water quality, prevention of soil erosion, and invasive species.

Utah Science with Engineering Education (SEEd) Standards - Grade Seven

Science Literacy for All Students

Science is a way of knowing, a process for gaining knowledge and understanding of the natural world. By the very nature of scientific inquiry, it has little to do with popular consensus and requires evidence, there are infinite possibilities for further refinement, and it is the constant questioning and refinement that advances scientific knowledge and understanding. Since progress in the modern world is tied so closely to this way of knowing, scientific literacy is essential for a society to be competitively engaged in a global economy. Students should be active learners who demonstrate their scientific understanding by using it. It is not enough for students to read about science; they must participate in the three dimensions of science. They should observe, inquire, question, formulate and test hypotheses, analyze data, report, and evaluate findings. The students, as scientists, should have hands–on, active experiences throughout the instruction of the science curriculum. The standards help students find value in developing scientific literacy as they grapple with complex problems and create solutions to real world puzzles.

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[2] Most SEEd Standards are based on the Next Generation Science Standards: http://www.nextgenscience.org

Seventh Grade SEEd Overview

The 7th Grade SEEd Overview: standards look for relationships of cause and effect which enable students to pinpoint mechanisms of nature and allow them to make predictions. Students will explore how forces can cause changes in motion and are responsible for the transfer of energy and the cycling of matter. This takes place within and between a wide variety of systems, from simple, short term forces on individual objects to the deep, long term forces that shape our planet. In turn, Earth's environments provide the conditions for life as we know it. Organisms survive and reproduce only to the extent that their own mechanisms and adaptations allow. Evidence for the evolutionary histories of life on Earth is provided in Earth itself through the fossil record and organism development. Additionally, mechanisms shaping Earth are understood as forces affecting the cycling of Earth's materials. Questions about cause and effect and the ongoing search for evidence in science drive this storyline.

Strand 7.1: Forces interact with matter

Forces are push or pull interactions between two objects. Changes in motion, balance and stability, and transfers of energy are all facilitated by forces on matter. Forces, including electric, magnetic, and gravitational forces, can act on objects that are not in contact with each other. Scientists use data from many sources to examine the cause and effect relationships determined by different forces.

7.1.1 **Carry out an investigation** which provides evidence that a change in an object's motion is dependent on the mass of the object and the sum of the forces acting on it. *Various experimental designs should be evaluated to determine how well the investigation measures an object's motion.* Emphasize conceptual understanding of Newton's First and Second Laws. Calculations will only focus along one dimensional movement; the use of vectors will be introduced in high school.

7.1.2 Apply Newton's Third Law **to *design a solution*** *to a problem involving the motion of two colliding objects in a system.* Examples could include collisions between two moving objects or between a moving object and a stationary object.

7.1.3 **Construct a model** using observational evidence to describe the nature of fields that exist between objects that exert forces on each other even though the objects are not in contact. Emphasize the cause and effect relationship between properties of objects (such as magnets or electrically-charged objects) and the forces they exert.

7.1.4 **Collect and analyze data** to determine the factors that affect the strength of electric and magnetic forces. Examples could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or of increasing the number or strength of magnets on the speed of an electric motor.

7.1.5 **Engage in argument from evidence** to support the claim that gravitational interactions within a system are attractive and dependent upon the masses of interacting objects. Examples of evidence for arguments could include **mathematical** data generated from simulations or digital tools.

Strand 7.2: Changes to Earth over time

Earth's processes are dynamic and interactive and are the result of energy flowing and matter cycling within and among Earth's systems. Energy from the sun and Earth's internal heat are the main sources driving these processes. Plate tectonics is a unifying theory that explains crustal movements of Earth's surface, how and where different rocks form, the occurrence of earthquakes and volcanoes, and the distribution of fossil plants and animals.

7.2.1 **Develop a model** of the rock cycle to describe the relationship between energy flow and matter cycling that create igneous, sedimentary, and metamorphic rocks. Emphasize the processes of melting, crystallization, weathering, deposition, sedimentation, and deformation, which act together to form minerals and rocks.

7.2.2 **Construct an explanation** based on evidence for how processes have changed Earth's surface at varying time and spatial scales. Examples of processes that occur at varying time scales could include slow plate motions or rapid landslides. Examples of processes that occur at varying spatial scales could include uplift of a mountain range or deposition of fine sediments.

7.2.3 **Ask questions** to *identify constraints* of specific geologic hazards and *evaluate competing design solutions* for maintaining the stability of human engineered structures such as homes, roads and bridges. Examples of geologic hazards could include earthquakes, landslides, or floods.

7.2.4 **Develop and use a scale model** of the matter in Earth's interior to demonstrate how differences in density and chemical composition (silicon, oxygen, iron, and magnesium) cause the formation of the crust, mantle, and core.

7.2.5 **Ask questions** and **analyze and interpret data** about patterns between plate tectonics and (1) the occurrence of earthquakes and volcanoes, (2) continental and ocean floor features, and (3) the distribution of rocks and fossils. Examples could include identifying patterns on maps of earthquakes and volcanoes relative to plate boundaries, the shapes of the continents, the locations of ocean structures (including mountains, volcanoes, faults, and trenches), and similarities of rock and fossil types on different continents.

7.2.6 **Make an argument from evidence** for how the geologic time scale shows the age and history of Earth. Emphasize scientific evidence from rock strata, the fossil record, and the principles of relative dating such as superposition, uniformitarianism and recognizing unconformities.

Strand 7.3: Structure and Function of Life

Living things are made of smaller structures which function to meet the needs of survival. The basic structural unit of all living things is the cell. Parts of a cell work together to function as a system. Cells work together and form tissues, organs, and organ systems. Organ systems interact to meet the needs of the organism.

7.3.1 **Plan and carry out an investigation** that provides evidence that the basic structures of living things are cells. Emphasize that cells can form single-celled or multicellular organisms and that multicellular organisms are made of different types of cells.

7.3.2 **Develop and use a model** to describe the function of a cell in living systems and the way parts of cells contribute to cell function. Emphasize the cell as a system, including the interrelating roles of the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.

7.3.3 **Construct an explanation** using evidence to explain how body systems have various levels of organization. Emphasize understanding that cells form tissues, tissues form organs, and organs form systems specialized for particular body functions. Examples could include relationships between the circulatory, excretory, digestive, respiratory, muscular, skeletal, and nervous systems. Specific organ functions will be taught at the high school level.

7.4 Strand: Reproduction and Inheritance

The great diversity of species on Earth is a result of genetic variation. Genetic traits are passed from parent to offspring. These traits affect the structure and behavior of organisms, which affect the organism's ability to survive and reproduce. Mutations can cause changes in traits that may affect an organism. As technology has developed, humans have been able to change the inherited traits in organisms which may impact society.

7.4.1 **Develop and use a model** to explain the effect that different types of reproduction have on genetic variation, including asexual and sexual reproduction.

7.4.2 **Obtain, evaluate, and communicate** information about specific animal and plant adaptations and structures that affect the probability of successful reproduction. Examples of adaptations could include nest building to protect young from cold, herding of animals to protect young from predators, vocalization of animals and colorful plumage to attract mates for breeding, bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.

7.4.3 **Develop and use a model** to describe why genetic mutations may result in harmful, beneficial, or neutral effects to the structure and function of the organism. Emphasize the conceptual idea that changes to traits can happen. Specific changes of genes at the molecular level, mechanisms for protein synthesis or specific types of mutations will be introduced at the high school level.

7.4.4 **Obtain, evaluate, and communicate** information about the technologies that have changed the way humans affect the inheritance of desired traits in organisms. *Analyze data from tests or simulations to determine the best solution to achieve success* in cultivating selected desired traits in organisms. Examples could include artificial selection, genetic modification, animal husbandry, and gene therapy.

7.5 Strand: Changes in Species Over Time

Genetic variation and the proportion of traits within a population can change over time. Additional evidence of change over time can be found in the fossil record, anatomical similarities and differences between modern and ancient organisms and in embryological development.

7.5.1 **Construct an explanation** that describes how the genetic variation of traits in a population can affect some individuals' probability of surviving and reproducing in a specific environment. Over time, specific traits may increase or decrease in populations. Emphasize the use of proportional reasoning to support explanations of trends in changes to populations over time. Examples could include camouflage, variation of body shape, speed and agility, or drought tolerance.

7.5.2 **Analyze** and interpret **data** for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

7.5.3 **Construct explanations** that describe the patterns of body structure similarities and differences between modern organisms and between ancient and modern organisms to infer possible evolutionary relationships.

7.5.4 **Analyze** displays of pictorial **data** to compare patterns in the embryological development across multiple species to identify similarities and differences not evident in the fully formed anatomy.

Utah Science with Engineering Education (SEEd) Standards - Grade Eight

Science Literacy for All Students

Science is a way of knowing, a process for gaining knowledge and understanding of the natural world. By the very nature of scientific inquiry, it has little to do with popular consensus and requires evidence, there are infinite possibilities for further refinement, and it is the constant questioning and refinement that advances scientific knowledge and understanding. Since progress in the modern world is tied so closely to this way of knowing, scientific literacy is essential for a society to be competitively engaged in a global economy. Students should be active learners who demonstrate their scientific understanding by using it. It is not enough for students to read about science; they must participate in the three dimensions of science. They should observe, inquire, question, formulate and test hypotheses, analyze data, report, and evaluate findings. The students, as scientists, should have hands–on, active experiences throughout the instruction of the science curriculum. The standards help students find value in developing scientific literacy as they grapple with complex problems and create solutions to real world puzzles.

Three Dimensions of Science[1]

Science education includes three dimensions of science understanding: science and engineering practices, crosscutting concepts, and disciplinary core ideas. Every standard includes each of the three dimensions, **Science and Engineering Practices are bolded**, Crosscutting Concepts are underlined, and Disciplinary core ideas are in normal font. Standards with *specific engineering expectations are italicized*.

Scientific and Engineering Practices	Crosscutting Concepts	Disciplinary Core Ideas
· Asking questions or defining problems · Developing and using models · Planning and carrying out investigations · Analyzing and interpreting data · Using mathematics and computational thinking · Constructing explanations and designing solutions · Engaging in argument from evidence · Obtaining, evaluating, and communicating information	· Patterns · Cause and effect: Mechanism and explanation · Scale, proportion and quantity · Systems and system models · Energy and matter: flows, cycles and conservation · Structure and function · Stability and change	· Earth and Space Science · Life Science · Physical Science · Engineering

Organization of Standards

The Utah SEEd standards[2] are organized into **strands**, which represent significant areas of learning within content areas. Within each strand are **standards**. A standard is an articulation of the demonstrated proficiency to be obtained. A standard represents an essential element of the learning that is expected. While some standards within a strand may be more comprehensive than others, all standards are essential for mastery.

[1] NRC Framework K-12 Science Education: http://www.nap.edu/catalog.php?record_id=13165

[2] Most SEEd Standards are based on the Next Generation Science Standards: http://www.nextgenscience.org

Eighth Grade SEEd Overview

The 8th Grade SEEd standards describe the constant interaction of matter and energy in nature. Students will explore how matter is arranged into either simple or complex substances. The strands emphasize how substances store and transfer energy which can cause them to interact physically and chemically, provide energy to living organisms, or can be harnessed and used by humans. Matter and energy cycle and change form in ecosystems through processes that occur during photosynthesis and cellular respiration. Additionally, substances that provide a benefit to organisms, including humans, are unevenly distributed on Earth due to geologic and atmospheric systems. Some resources form quickly allowing them to be renewable while other resources are nonrenewable. Evidences reveal that Earth systems change and affect ecosystems and organisms in both positive and negative ways.

Strand 8.1: Matter and energy interact in the physical world

The physical world is made of atoms and molecules. Even large objects can be viewed as a combination of small particles. Energy causes particles to move and interact physically or chemically. Those interactions create a variety of substances. As molecules undergo a chemical or physical change, the number of atoms in that system remains constant. Humans use energy to refine natural resources into synthetic materials.

8.1.1 **Develop a model** to describe the scale and proportion of atoms and molecules. Emphasize developing atomic models of elements and their number of protons, neutrons, and electrons as well as models of simple molecules. Topics like valence electrons, bond energy, ionic complexes, ions, and isotopes will be discussed at the high school level.

8.1.2 **Obtain** information about various properties of matter, **evaluate** how different materials' properties allow them to be used for particular functions in society **and communicate** your findings. Emphasize general properties of matter. Examples could include color, density, flammability, hardness, malleability, odor, ability to rust, solubility, state, or the ability to react with water.

8.1.3 **Plan and conduct an investigation** and then **analyze and interpret the data** to identify patterns in changes in a substance's properties to determine if a chemical reaction has occurred. Examples could include changes in properties such as color, density, flammability, odor, solubility, or state.

8.1.4 **Obtain and evaluate information** to describe how synthetic materials come from natural resources, what their functions are, and how society uses these new materials. Examples of new materials could include medicine, foods, building materials, plastics, and alternative fuels.

8.1.5 **Develop a model** that uses **computational thinking** to illustrate the cause and effect relationships in particle motion, temperature, density, and state of a pure substance when heat energy is added or removed. Emphasize molecular-level models of solids, liquids, and gases to show how adding or removing heat energy can result in phase changes and on calculating density of a substance's state.

8.1.6 **Develop a model** to describe how the total number of atoms does not change in a chemical reaction, indicating that matter is conserved. Emphasize demonstrations of an understanding of the law of conservation of matter. Balancing equations and stoichiometry will be learned at the high school level.

8.1.7 **Design, construct,** and **test** a device that can affect the rate of a phase change. *Compare and identify the best characteristics of competing devices, based on **data analysis**, and modify them to improve the device to better meet the criteria for success.*

Strand 8.2: Energy is stored and transferred in physical systems

Objects can store and transfer energy within systems. Energy can be transferred between objects, which involves changes in the object's energy. There is a direct relationship between an object's energy, mass, and velocity. Energy can travel in waves and may be harnessed to transmit information.

8.2.1 **Use computational thinking** to **analyze data** about the relationship between the mass and speed of objects to the relative amount of kinetic energy of the objects. Emphasis should be on the quantity of mass and relative speed to the observable effects of the kinetic energy. Examples could include a full cart vs. an empty cart or rolling spheres with different masses down a ramp to measure the effects on stationary masses. Calculations of kinetic and potential energy will be learned at the high school level.

8.2.2 **Ask questions** about how the amount of potential energy varies as distance within the system changes. **Plan and conduct an investigation** to answer a question about potential energy. Emphasize comparing relative amounts of energy. Examples could include a roller coaster cart at varying positions on a hill or objects being dropped from different heights. Calculations of kinetic and potential energy will be learned at the high school level.

8.2.3 **Engage in argument** to identify the strongest evidence that supports the claim that the kinetic energy of an object changes as energy is transferred to or from the object. Examples could include observing temperature changes as a result of friction, applying force to an object, or releasing potential energy from an object.

8.2.4 **Use computational thinking** to describe a simple system model for waves that shows the pattern of wave amplitude being related to wave energy. Emphasize describing waves with both quantitative and qualitative thinking. Examples could include using graphs, charts, computer simulations, or physical models to demonstrate amplitude and energy correlation.

8.2.5 **Develop and use a model** to describe the structure of waves and how they are reflected, absorbed, or transmitted through various materials. Emphasize both light and mechanical waves. Examples could include drawings, simulations, and written descriptions of light waves through a prism, mechanical waves through gas vs. liquids vs. solids, or sound waves through different mediums.

8.2.6 **Obtain and evaluate information to communicate** the claim that the structure of digital signals are a more reliable way to store or transmit information than analog signals. Emphasize the basic understanding that waves can be used for communication purposes. Examples could include using vinyl record vs. digital song files, film cameras vs. digital cameras, or alcohol thermometers vs. digital thermometers.

Strand 8.3: Life systems store and transfer matter and energy

Living things use energy from their environment to rearrange matter to sustain life. Photosynthetic organisms are able to transfer light energy to chemical energy. Consumers can break down complex food molecules to utilize the stored energy and use the particles to form new, life-sustaining molecules. Ecosystems are examples of how energy can flow while matter cycles through the living and nonliving components of systems.

8.3.1 **Plan and conduct an investigation** and **use the evidence to construct an explanation** of how photosynthetic organisms use energy to transform matter. Emphasize molecular and energy transformations during photosynthesis.

8.3.2 **Develop a model** to describe how food is changed through chemical reactions to form new molecules that support growth and/or release energy as matter cycles through an organism. Emphasis is on describing that during cellular respiration molecules are broken apart, rearranged into new molecules, and that this process releases energy.

8.3.3 **Ask questions** to **obtain, evaluate, and communicate information** about how changes to an ecosystem affect the stability of cycling matter and the flow of energy among living and nonliving parts of an ecosystem. Emphasize describing the cycling of matter and flow of energy through the carbon cycle.

Strand 8.4: Interactions with natural systems and resources

Interactions of matter and energy through geologic processes have led to the uneven distribution of natural resources. Many of these resources are nonrenewable and per-capita use can cause positive or negative consequences. Global temperatures change due to various factors and can cause a change in regional climates. As energy flows through the physical world, natural disasters can occur which affect human life. Humans can study patterns in natural systems to anticipate and forecast some future disasters and work to mitigate the outcomes.

8.4.1 **Construct a scientific explanation** based on evidence that shows that the uneven distribution of Earth's mineral, energy, and groundwater resources is caused by geological processes. Examples of uneven distribution of resources could include Utah's unique geologic history that led to the formation and irregular distribution of natural resources like copper, gold, natural gas, oil shale, silver, and uranium.

8.4.2 **Engage in argument supported by evidence** about the effect of per-capita consumption of natural resources on Earth's systems. Emphasize that these resources are limited and may be non-renewable. Examples of evidence include rates of consumption of food and natural resources such as freshwater, minerals, and energy sources.

8.4.3 **Design a solution** to monitor or mitigate the potential effects of the use of natural resources. ***Evaluate*** *competing design solutions using a systematic process to determine how well each solution meets the criteria and constraints of the problem.* Examples of uses of the natural environment could include water management, recreation, agricultural, solar energy, and conservation efforts.

8.4.4 **Analyze and interpret data** on the factors that change global temperatures and their effects on regional climates. Examples of factors could include agricultural activity, changes in solar radiation, fossil fuel use, and volcanic activity. Examples of data could include atmospheric levels of gases such as carbon dioxide and methane, graphs and maps of global and regional temperatures, and rates of human activities.

8.4.5 **Analyze and interpret** patterns of the occurrence of natural hazards to forecast future catastrophic events and investigate how data is used to develop technologies to mitigate their effects. Emphasize how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow prediction, but others, such as earthquakes, may occur without warning.