

Utah State Office of Education
Elementary STEM Endorsement Course Framework
Matter in STEM for Elementary Teachers

Course Description

This course provides teachers with a deep and useful understanding of **matter** and the nature of how students use concepts of **matter** to make sense of phenomena across life, earth, and physical science. This understanding enhances teacher insights into: 1) how **matter** and energy interact, 2) the relationships of **matter** to forces and interactions within fields, and 3) pedagogical content knowledge around teaching and learning about **matter**. The course provides course participants with knowledge of how **matter** concepts may be used by students with the Crosscutting Concepts, and Engineering and Science practices.

Course Objectives

This course will provide course participants with a deep and useful understanding of the nature and use of matter. This understanding will enhance participant insights into the:

- Conservation of matter in different states
- Matter is made of particles
- The relationships of matter to forces and energy

During this course students will:

- *Objective 1 - Content Knowledge*
Matter can be understood in terms of the types of atoms present and the interactions both between and within them. The states (i.e., solid, liquid, gas, or plasma), properties (e.g., hardness, conductivity), and reactions (both physical and chemical) of matter can be described and predicted based on the types, interactions, and motions of the atoms within it. Chemical reactions, which underlie so many observed phenomena in living and nonliving systems alike, conserve the number of atoms of each type but change their arrangement into molecules.
- *Objective 2 - Cross-Cutting Concepts*
Flows, cycles, and conservation are the foundational concepts of energy and matter. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations. The course focuses matter, whose conservation has important implications for the disciplines of science.
- *Objective 3 - Shared Objectives from STEM Outcomes*
Connect theory and practice through reflection, teaching, scholarship, and STEM educational action research.
 - Capacity and confidence to run a student inquiry-based classroom.
 - Course Participants have an understanding of how to integrate cross curricular concepts in the classroom.

- Use formative assessment to to design authentic, innovative, problem-based learning experiences.
- Explore uses of appropriate assessment and technological tools to enhance STEM teaching, learning, student achievement, and college and career readiness.
- Possess the ability to help learners learn “with” technology as opposed to “from” technology. STEM endorsed teachers will be confident users and implementers of technology education tools in the classroom.

Course Construction Recommendations

- Engage participants in discussion about matter using science and engineering practices, disciplinary core ideas and crosscutting concepts to enhance their understanding of pedagogical content knowledge.
- Know, use, and interpret scientific explanations of the natural world.
- Generate and evaluate scientific evidence and explanations for real world phenomena.
- Participate productively in scientific practices using problem based learning strategies.

Course Topics

Please see Addendum A for a more detailed outline of topics for science content that would support the main ideas highlighted below.

- *Main Idea 1 - Matter and Earth/ Space Science*
Materials in and on Earth’s crust change over time and impact living organisms. The movement of tectonic plates impacts the surface of Earth. Water is the most powerful force on earth; it influences weather, circulates in the oceans, and shapes Earth’s surface.
- *Main Idea 2 - Matter and Life Science*
Cells contribute to the function of living organisms. Important ideas are structure and function, growth and development of organisms, matter and energy flow in organisms, information processing, interdependent relationships in ecosystems, cycles of matter and energy transfer in ecosystems, and ecosystem dynamics, functioning, and resilience.
- *Main Idea 3 - Matter in Physical Science*
Atomic and molecular interactions explain the properties of matter. Objects keep moving, and fall to the ground. Some materials are attached to each other while others are not. Physical interactions occur between objects and within systems of objects as energy is transferred from one object or system to another. Waves have properties and operate in predictable patterns.

Pedagogy Focus of the Course

The purpose of this course is to ensure that course participants apply the pedagogical content knowledge consistent with the current research in teaching and learning. Course participants must know how to create environments to ensure content knowledge and conceptual understandings inherent in the content. Course participants should integrate the content with a variety of pedagogical concepts and strategies into the course. This integration should be modeled throughout the course to create a student-centered learning environment in which elementary students plan and carry out investigations, engineer solutions to problems, and construct evidence-based explanations of real-world phenomena. The course should model quality instructional strategies including multiple opportunities to engage students in science investigations, field experiences, and lab activities.

Knowledge of STEM for Course Participants

Course participants learn the skills and dispositions to employ content knowledge, skills, beliefs and concepts to engage students in cross curricular instruction that clarifies misconceptions about particular topics. Course participants utilize knowledge of cognition, child development, and learning theory to enhance instruction.

Effective STEM Teaching Practices

- Ability to Ask Scientific Questions and Define Problems
- Ability to Plan and Carry Out Investigations
- Ability to Analyze, Interpret Data, and Make Predictions
- Ability to Develop and Use Models
- Ability to Construct Explanations and Design Solutions
- Ability to Engage in Argument from Evidence
- Ability to Use Mathematical and Computational Thinking
- Ability to Obtain, Evaluate and Communicate Information

Knowledge of STEM Curriculum and Assessment

- Know common developmental paths (learning trajectories) related to foundational STEM topics understand and use them to sequence activities to build learning environments that are developmentally appropriate and effective.
- Select, use, adapt and determine the suitability of science curricula and teaching materials (e.g., textbooks, technology, manipulatives) for particular learning goals.
- Be cognizant of a formative assessment cycle (administering a formative assessment task, analyzing student work from the task, using that analysis to enhance teacher knowledge, and designing and teaching re engagement lessons) and resources.
- Provide appropriate interpretations of assessment results, and communicate results to specific individuals and groups (e.g., students, parents, caregivers, colleagues, administrators, policy makers, community members).

Possible Assignments

- Content exams, performance tasks, and homework for determining participants' knowledge for teaching matter using STEM principles.
- A data-based investigation into a classroom experiment measuring mass.
- Clinical interview: Design an interview to determine student understanding of matter, including interview questions with extensions to press for student understanding. Videotape and conduct the interview. Analyze the video using a rubric that assesses both student understanding and the interview process.
- Differentiated lesson: Select one of the course objectives. Develop a lesson to meet the objective for the whole group implementing STEM principles and using technology to facilitate differentiation activities for at least three populations (e.g., gifted students, English Language Learners, Students with Disabilities).
- Case study: Write a case presenting the STEM thinking of a student or group of students on the subject of Matter. Be sure to include details such as student dialogue and questions. Analyze the student thinking and discuss the questions that are raised in the students' STEM thinking.
- Lesson study cycle: Work with a group to develop a task-based lesson including anticipated student responses, questions for classroom discourse, and formative assessment. One person in the group will teach the lesson while other members of the group observe student thinking. Group members refine the lesson in response to the observation data and then teach and analyze the lesson.
- Reflections of STEM understanding: Keep a reflection log that discusses: a concept relating to matter, a question the course participant has, and an application of the STEM idea for your classroom.
 - Reading research – choose from possible articles and complete an assignment based on the article; discussions, agreement/disagreement, impact in classrooms.
 - Use an online tool, such as a learning management system (e.g. Google Classroom, Canvas Free for Teacher, or Edmodo) to create a lesson on matter with STEM principles, the cross-cutting concept, and the core concept.

Suggested Resources

A framework for k-12 science education; practices, crosscutting concepts, and core ideas. [PDF version]. (2012). Retrieved from www.nap.edu, Washington, D.C.

Addendum A

ESS2.A Earth materials and systems

- K-2 Wind and water change the shape of the land.
- 3-5 Four major Earth systems interact. Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, organisms, and gravity break rocks, soils, and sediments into smaller.
- 6 - 8 Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources. Plate tectonics is one result of these processes.

ESS2.E Biogeology

- K-2 Plants and animals can change their local environment.
- 3-5 Living things can affect the physical characteristics of their environment.

ESS3.A - Natural Resources

- K - 2 - Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.
- 3 - 5 Energy and fuels humans use are derived from natural sources and their use affects the environment. Some resources are renewable over time, others are not.
- 6 - 8 Humans depend on Earth's land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.

LS1.A - Structure and Function

- K-2 All organisms have external parts that they use to perform daily functions.
- 3-5 Organisms have both internal and external macroscopic structures that allow for growth, survival, behavior, and reproduction.
- 6 - 8 All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.

LS1.B - Growth and Development of Organisms

- K-2 Parents and offspring often engage in behaviors that help the offspring survive.
- 3-5 Reproduction is essential to every kind of organism. Organisms have unique and diverse life cycles.
- 6-8 Animals engage in behaviors that increase the odds of reproduction. A organism's growth is affected by both genetic and environmental factors.

LS1.C - Organization for Matter and Energy Flow in Organisms

- K-2 Animals obtain food they need from plants or other animals. Plants need water and light.

- 3-5 Food provides animals with the materials and energy they need for body repair, growth, warmth, and motion. Plants acquire material for growth chiefly from air, water, and process matter and obtain energy from sunlight, which is used to maintain conditions necessary for survival.
- 6-8 Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy.

LS2.A - Interdependent Relationships in Ecosystems

- K-2 Plants depend on water and light to grow, and also depend on animals for pollination or to move their seeds around.
- 3-5 The food of almost any animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants, while decomposers restore some materials back to the soil.
- 6-8 Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth. Competitive, predatory, and mutually beneficial interactions vary across ecosystems but the patterns are shared.

LS2.B - Cycles of Matter and Energy Transfer in Ecosystems

- K-2 [Content found in LS1.C and ESS3.A]
- 3-5 Matter cycles between the air and soil and among organisms as they live and die.
- 6-8 The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Food webs model how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem.

PS1.A Structure of Matter

- K - 2 Matter exists as different substances that have observable different properties. Different properties are suited to different purposes. Objects can be built up from smaller parts.
- 3 - 5 Because matter exists as particles that are too small to see, matter is always conserved even if it seems to disappear. Measurements of a variety of observable properties can be used to identify particular materials.
- 6 8 The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter.

PS1.B Chemical Reactions

- K-2 Heating and cooling substances cause changes that are sometimes reversible and sometimes not.

- 3-5 Chemical reactions that occur when substances are mixed can be identified by the emergence of substances with different properties; the total mass remains the same.
- 6-8 Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy.