COMPETENCIES FOR MIDDLE CHILDHOOD TEACHERS OF SCIENCE, GRADES 4-8

In addition to the Arkansas Teaching Standards (ATS) and the competencies for the Teacher Excellence and Support System (TESS), including competencies regarding the knowledge and use of educational technology that reflect the International Society for Technology in Education standards, the teacher of Middle Childhood Science grades 4-8, shall also demonstrate knowledge and competencies in the following areas:

1. CONTENT KNOWLEDGE

NSTA/ASTE: Standard 1

NSTA/ASTE Standard 1: *Effective teachers of science understand and articulate the knowledge and practices of contemporary science and engineering. They connect important disciplinary core ideas, crosscutting concepts, and science and engineering practices for their fields of licensure.*

1.1 Uses and applies major concepts, principles, theories, laws, and interrelationships of their fields of licensure and supporting fields. Explains the nature of science and the cultural norms and values inherent to the current and historical development of scientific knowledge

1.2 Demonstrates knowledge of crosscutting concepts, disciplinary core ideas, practices of science and engineering, the supporting role science-specific technologies, and contributions of diverse populations to science

1.3 Demonstrates knowledge of how to implement science standards, learning progressions, and sequencing of science content for teaching their licensure level 4-8 students

2. CONTENT PEDAGOGY

NSTA/ASTE: Standard 2

NSTA/ASTE Standard 2: *Effective teachers of science plan learning units of study and equitable, culturally responsive opportunities for all students based upon their understanding of how students learn and develop science knowledge, skills, and habits of mind. Effective teachers also include appropriate connections to science and engineering practices and crosscutting concepts in their instructional planning.*

2.1 Uses science standards and a variety of appropriate, student-centered, and culturally relevant science disciplinary-based instructional approaches that follow safety procedures and incorporate science and engineering practices, disciplinary core ideas, and crosscutting concepts

2.2 Incorporates appropriate differentiation strategies, wherein all students develop conceptual knowledge and an understanding of the nature of science. Lessons should engage students in applying science practices, clarifying relationships, identifying natural patterns and empirical experiences

2.3 Uses engineering practices in support of science learning wherein all students design, construct, test and optimize possible solutions to a problem

2.4 Aligns instruction and assessment strategies to support instructional decision making that identifies and addresses student misunderstandings, prior knowledge, and naïve conceptions

2.5 Integrates science-specific technologies to support all students' conceptual understanding of science and engineering

COMPETENCIES FOR MIDDLE CHILDHOOD TEACHERS OF SCIENCE, GRADES 4-8

3. FUNDAMENTAL UNDERSTANDING OF THE VISION OF 4-8 SCIENCE EDUCATION:SCIENTIFIC AND ENGINEERING PRACTICES, CROSS CUTTING CONCEPTS, AND CORE IDEAS

AR K-12 State Standards

NGSS

NRC Framework

ISTE

3.1 Demonstrating a command of the vision for K-12 science education- "…students, over multiple years of school, actively engage in scientific and engineering practices and apply crosscutting concepts to deepen their understanding of the core ideas in these fields."

3.2 Demonstrating a command of the eight scientific and engineering practices identified in the NRC Framework listed below:

a. Asking questions (for science) and defining problems (for engineering)
b. Developing and using models
c. Planning and carrying out investigations
d. Analyzing and interpreting data
e. Using mathematics and computational thinking
f. Constructing explanations (for science) and designing solutions (for engineering)
g. Engaging in argument from evidence
h. Obtaining, evaluating, and communicating information

3.3 Demonstrating understanding through the application of the seven crosscutting concepts that should be reinforced by repeated use in instruction across the disciplinary core ideas with:

a. Patterns
b. Cause and effect: Mechanism and explanation
c. Scale, proportion, and quantity
d. Systems and system models
e. Energy and matter: flows, cycles, and conservation
f. Structure and function
g. Stability and change

3.4 Demonstrating and understanding of the disciplinary core ideas in physical sciences, life sciences, and earth and space sciences as detailed in the NRC Framework

3.5 Identifying and implementing lessons/units that integrate the scientific and engineering practices and crosscutting concepts with each of the core ideas as specified in the performance expectations of the NRC Framework

3.6 Demonstrating content and science investigation teaching methods for grades 4-8 in the particular core ideas of:

<u>Physical Sciences</u>

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

<u>Life Sciences</u>

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

<u>Earth and Space Sciences</u>

ESS 1: Earth's place in the universe ESS 2: Earth's system
ESS 3: Earth and human activity

COMPETENCIES FOR MIDDLE CHILDHOOD TEACHERS OF SCIENCE, GRADES 4-8

	Engineering, Technology, and the Applications of Science ETS 1: Engineering design ETS 2: Links among engineering, technology, science, and society 3.7 Demonstrating a command of the implementation of the Arkansas English Language Arts Standards, Arkansas Mathematics Standards, and ISTE Standards for Educators as they support the NRC Framework 3.8 Designing and conducting science investigations at least one, if not all, of the disciplinary core ideas with attention to gathering and interpreting scientific data 3.9 Demonstrating diverse teaching strategies for reading and writing informational texts like those read and written by scientists
4. LEARNING ENVIRONMENTS NSTA/ASTE Standards	**NSTA/ASTE Standard 3**: *Effective teachers of science are able to plan for engaging all students in science learning by identifying appropriate learning goals that are consistent with knowledge of how students learn science and are aligned with standards. Plans reflect the selection of phenomena appropriate to the social context of the classroom and community, and safety considerations, to engage students in the nature of science and science and engineering practices. Effective teachers create an anti-bias, multicultural, and social justice-learning environment to achieve these goals.* 4.1 Planning a variety of lesson plans based on science standards that employ strategies that demonstrate their knowledge and understanding of how to select appropriate teaching and motivating learning activities that foster an inclusive, equitable, and anti-bias environment 4.2 Planning learning experiences for all students in a variety of environments (e.g., laboratory, field and community) within their fields of licensure 4.3 Planning lessons in which all students have a variety of opportunities to investigate, collaborate, communicate, evaluate, revise, and defend their own explanations of: scientific phenomena, observations, and data
5. SAFETY NSTA/ASTE Standards	**NSTA/ASTE Standard 4:** *Effective teachers of science demonstrate biological, chemical, and physical safety protocols in their classrooms and workspace. They also implement ethical treatment of living organisms and maintain equipment and chemicals as relevant to their fields of licensure.* 5.1 Implementing activities appropriate for the abilities of all students that demonstrate safe techniques for the procurement, preparation, use, storage, dispensing, supervision, and disposal of all 5.2 Demonstrating an ability to recognize hazardous situations including overcrowding; implement emergency procedures; maintain safety equipment; provide adequate student instruction and supervision; and follow policies and procedures that comply with established state and national guidelines, appropriate legal state (Arkansas Code Annotated § 6-10-113 [2012] for eye protection) and national safety standards (e.g., OSHA, NFPA, EPA), and best professional practices (e.g., NSTA, NSELA) 5.3 Demonstrating ethical decision-making with respect to safe and humane treatment of all living organisms in and out of the classroom, and comply with the legal restrictions and best professional practices on the collection, care, and use of living organisms as relevant to their fields of licensure

COMPETENCIES FOR MIDDLE CHILDHOOD TEACHERS OF SCIENCE, GRADES 4-8

6. IMPACT ON STUDENT LEARNING

NSTA/ASTE Standards

NSTA/ASTE Standard 5: *Effective teachers of science provide evidence that students have learned and can apply disciplinary core ideas, crosscutting concepts and science and engineering practices because of instruction. Effective teachers analyze learning gains for individual students, the class as a whole, and subgroups of students disaggregated by demographic categories, and use these to inform planning and teaching.*

6.1 Implementing assessments that show all students have learned and can apply disciplinary knowledge, nature of science, science and engineering practices, and crosscutting concepts in practical, authentic, and real-world situations

6.2 Collecting, organizing, analyzing, and reflecting on formative and summative evidence and use those data to inform future planning and teaching

6.3 Analyzing science-specific assessment data based upon student demographics, categorizing the levels of learner knowledge, and reflect on results for subsequent lesson plans

7. PROFESSIONAL KNOWLEDGE AND SKILLS

NSTA/ASTE Standards

NSTA/ASTE Standard 6: *Effective teachers of science strive to continuously improve their knowledge of both science content and pedagogy, including approaches for addressing inequities and inclusion for all students in science. They identify with and conduct themselves as part of the science education community.*

7.1 Engaging in critical reflection on their own science teaching to continually improve their instructional effectiveness

7.2 Participating in professional development opportunities to deepen their science content knowledge and practices

7.3 Participating in professional development opportunities to expand their science-specific pedagogical knowledge

8. NATURE AND IMPACT OF SCIENCE AND ENGINEERING

Praxis 5442: Section I

AR K-12 State Standards

NGSS

NRC Framework

Nature of Science and Engineering

8.1 Nature of scientific knowledge

a. Use of a variety of methods
b. Based on empirical evidence
c. Models, laws, and theories explain natural phenomena
d. Major concepts developed over time/subject to revision in light of new evidence
e. Crosscutting concepts and processes

8.2 Engineering Design

a. Define problems and identify criteria and constraints
b. Design, test, and evaluate possible solutions with respect to how well they meet the criteria and constraints
c. Optimize the design solution through a systematic process of modification and testing

COMPETENCIES FOR MIDDLE CHILDHOOD TEACHERS OF SCIENCE, GRADES 4-8

d. Demonstrate a deep understanding following active investigations in the principles of the engineering design cycle in the context grades 4-8 science including
   - Defining and delimiting an engineering problem
   - Developing possible solutions
   - Optimizing the design solution

e. Demonstrate a deep understanding following active investigations in the principles of links among engineering, technology, science, and society in the context of grades 4-8 science including
   - Interdependence of science, engineering, and technology
   - Influence of engineering, technology, and science on society and the natural world

Science, Technology, Society, and the Environment

8.3 Interdependence of science, engineering, and technology
   a. Engineering advances lead to important discoveries in science
   b. Science and technology drive each other forward

8.4 Impact on engineering, science, and technology on the environment and society
   a. Air and water pollution
   b. Greenhouse gases
   c. Global climate and sea level change
   d. Waste disposal
   e. Acid rain
   f. Loss of biodiversity
   g. Ozone depletion
   h. Urban development and land use

8.5 Major issues associated with energy production and the management of natural resources
   a. Conservation and recycling
   b. Renewable and nonrenewable energy resources
   c. Pros and cons of power generation based on sources
   d. Distribution, extraction, and use of Earth's resources

8.6 Applications of science and technology in daily life
   a. Chemistry (e.g., properties of household products)
   b. Physics (e.g., batteries, communications technology)
   c. Life science (e.g., public health, selective breeding, genetic modification)
   d. Earth and space (e.g., agricultural practices, space technology)

9. PHYSICAL SCIENCE

Praxis 5442: Section II

NSTA/ASTA-M Standards

Matter and Its Interactions

9.1 Structure and properties of matter
   a. Atomic structure, including atomic models (protons, neutrons, electrons), atomic number, atomic mass, isotopes/radioactive isotopes (carbon 14), and electron arrangements
   b. How the periodic table is organized in groups with similar chemical and physical properties (e.g., metals, nonmetals, noble gases)

c. States of matter (e.g., solids, liquids, gases)
   - Use the particle model to describe solids, liquids and gases
   - Describe the effect that changes in temperature/kinetic energy have on particle motion

d. Classification of matter: elements, compounds, and mixtures
e. Characteristics of mixtures: heterogeneous and homogeneous, saturated and unsaturated solutions, dilute and concentrated solutions, acids and bases (pH), and factors that affect the dissolving process (e.g., temperature, particle size)
f. Elements and simple compounds: formulas and structures, ionic, covalent, and metallic bonding
g. Phase changes and the effect of transfer of thermal energy on matter (e.g., melting evaporation, freezing, condensation, cooling and heating curves)

9.2 **Chemical reactions**

a. Identifying the difference between chemical and physical changes
b. Conservation of matter in chemical reactions (e.g., balancing simple chemical reactions using visual and mathematical models)
c. Types of chemical reactions (e.g., combustion, acid- base, synthesis, decomposition)
d. Energy in chemical reactions (e.g., exothermic and endothermic)

Motion and Stability: Forces and Interactions

9.3 Forces and motion

a. Descriptions of motion
   - Distance and displacement
   - Speed and velocity
   - Acceleration

b. Forces
   - Newton's laws of motion and their applications
   - Coulomb's Law of Electrostatic Forces
   - Buoyancy (e.g., sink or float, relative density)
   - Gravitational forces related to mass and distance (e.g., weight vs. mass on Earth vs. Moon)
   - Vector nature of force (e.g., magnitude and direction)

9.4 Electricity and magnetism

a. Electricity
   - Electrostatics (attraction and repulsion between charges)
   - Simple circuits (identifying series and parallel circuits)
   - Conductors and insulators

b. Magnetism
   - Magnets
   - Magnetic fields

c. Applications of electricity and magnetism (e.g., electromagnets, generators, electrical motors)

COMPETENCIES FOR MIDDLE CHILDHOOD TEACHERS OF SCIENCE, GRADES 4-8

Energy Waves

9.5 Energy

- What is energy
  - a. Types of energy
    - Kinetic energy (e.g., its relationship to speed and mass)
    - Potential energy
  - b. Forms of energy (e.g., sound, light, thermal, electrical, chemical)
  - c. Conservation of energy (e.g., pendulums, springs, roller coasters)
  - d. Energy transfer between the system and its surroundings
  - e. Thermal energy transfer (e.g., convection, conduction, radiation)
  - f. Energy transformations (e.g., chemical to electrical and electrical to mechanical)

9.6 Waves and Their Application

- a. Properties of waves (e.g., frequency, wavelength, amplitude, period, speed)
- b. Basic characteristics and types of waves
  - Longitudinal, transverse
  - Electromagnetic waves (e.g., visible light, microwave, infrared, ultraviolet)
  - Mechanical (e.g., sound, water, seismic)
- c. Wave phenomena (e.g., absorption, transmission, reflection, refraction, the Doppler effect)
- d. Information technology and instrumentation (e.g., advantages and disadvantages of digital and analog signals)

10. LIFE SCIENCE

Praxis 5442: Section III

NSTA/ASTA-M Standards

From Molecules to Organisms: Structures and Processes

10.1 Structure and function

- Cells
  - Organelles (e.g., nucleus, mitochondria, chloroplasts)
  - Cell membranes and cell walls (e.g., passive and active transport)
- Cell types
  - Prokaryotes/eukaryotes (e.g., bacteria, plants, animals)
  - Unicellular/multicellular
- Characteristics of viruses
  - Levels of organization in multicellular organisms
    - Specialized cells and tissues
    - Organs and organ systems (circulatory, excretory, digestive, respiratory, muscular, and nervous systems)
    - Focus on system and subsystem interactions
    - Homeostasis
- Growth and development
  - Cell reproduction
    - Role of mitosis
    - Role of meiosis
- Effect on environmental and genetic factors on plant and animal growth

- Reproduction
  - Plant structures and adaptations
  - Animal behaviors and adaptations and energy flow in organisms
- Important biomolecules (e.g., ATP, sugars)
  - Biological molecules- Carbohydrates, Lipids… Nucleic Acids (DNA and RNA)
  - Nucleic acids are on the same level as Carbohydrates.
  - DNA and RNA are types of nucleic acids.
    Sucrose is a type of Carbohydrate
- Photosynthesis in plants
- Cellular respiration in plants and animals
- Fermentation (e.g., by yeast)
- Differentiation between matter and energy
- Sensory information processing in animals
  - Stimuli (e.g., light, sound, chemical) and sensory receptors (e.g., eyes, ears)
  - Transmissions and processing (e.g., nerve, brain) and responses (e.g., behavior or memory)

Ecosystems: Interactions, Energy, and Dynamics

10.2 Interdependent relationships in ecosystems
  - Impact of resources on population growth
  - Relationships and behavior (e.g., competition, , predator-prey)

10.3 Cycling of matter and energy transfer in ecosystems
- Energy flow
  - Energy transfer between producers, consumers, and decomposers
  - Food webs as models
- Cycling of atoms (e.g., carbon, nitrogen) between living and nonliving components

10.4 Ecosystem dynamics, functioning, and resilience
  - Biotic and abiotic factors
  - Distinguish between biomes and ecosystems
  - Relationships between biodiversity and human resources
  - Stability, sustainability, and change within ecosystems

Heredity and Biological Evolution

10.5 Heredity: Inheritance and Variation of Traits
- Inheritance of traits
  - Basic structure and function of DNA and RNA
  - Conceptual understanding of replication, transcription, and translation
  - Relationship between chromosomes, genes, alleles, and proteins
  - Sexual and asexual reproduction (advantages and disadvantages)
- Variation of traits
  - Mendelian inheritance (simple Punnett squares)
  - Mutations (harmful, beneficial, neutral)

COMPETENCIES FOR MIDDLE CHILDHOOD TEACHERS OF SCIENCE, GRADES 4-8

- Biological Evolution: Unity and Diversity
  - Evidence of common ancestry and diversity
    - Patterns in fossil record within sedimentary layers (e.g. major extinction events and emergence of new organisms)
    - Anatomical similarities and differences among modern and fossil organisms
    - Similarities in embryological development
    - Classification of organisms according to shared characteristics
  - Natural selection and adaptation
    - Mechanisms of evolution (e.g., mutation, natural selection)
    - Distribution of traits in a population can change over time in response to environment

10.6 Earth and Human Activity

- Humans depend on the Earth for natural resources (e.g., land, ocean, atmosphere, biosphere)
- Natural resources are limited (nonrenewable/sustainability)
- Renewable energy resources
- Natural hazards (e.g., volcanic eruptions, severe weather, earthquakes)

10. EARTH AND SPACE SCIENCE

Praxis 5442: Section IV

NSTA/ASTA-M Standards

Earth's Place in the Universe

11.1 The universe and its stars

- Basic characteristics and life cycles of stars (e.g. for example, composition, apparent brightness and distance from Earth)
- Basic types, characteristics, and motion of galaxies
- Observed motions of stars from Earth
- Formation and evidence (e.g., Big Bang Theory)

11.2 Earth and the solar system

- Formation of the solar system and the role of gravity
- Properties of objects in the solar system (e.g., models, scales, structure, composition, surface features)
- Patterns of movement in the Sun-Earth-Moon system (e.g., Moon phases, eclipses, tides)
- Effect of Earth's tilt on seasons and climate

11.3 The history of planet Earth

- Basic principles of historical geology and the geological timescale
  - Stratigraphy (e.g., superposition, intrusive relationships, crosscutting relationships, fossil succession)
  - Major events (e.g., extinction events, volcanic eruptions, glaciation, asteroid impacts, earthquakes, and other catastrophic events)
- Relative and absolute dating (e.g., fossil record, radiometric dating)

B. Earth's Systems

11.4 Earth's materials and systems

- Rock types and their formation processes (e.g., energy flow, the rock cycle)
- Minerals and their properties (e.g., color, streak, hardness, acid test)

- Weathering, erosion, and deposition
  - Chemical, biological, and physical weathering
  - Agents of erosion (e.g., water, ice, wind)
  - Effects on surface features and the origin of major landforms (e.g., valleys, canyons, caves, coastline, topography)
  - Prediction of natural hazards (e.g., landslides) and mitigation of their impact on humans (e.g., retaining walls)

11.5 Plate tectonics and large-scale system interactions

- Earth's structure (e.g., layers, composition, properties, and processes, such as convection)
- Plate tectonics theory and supporting evidence
  - Types of plate boundaries (e.g., convergent, divergent, transform)
  - Folding and faulting (e.g., normal, reverse, strike-slip)
  - Supporting evidence (e.g., ages of crustal rocks, hot-spot volcanoes, distribution of rocks and fossils, continental shapes)
- Landforms (e.g., mountain ranges, rift valleys, mid- ocean ridges)
- Prediction of natural hazards (e.g., earthquakes, volcanoes, tsunamis) and mitigation of their impact on humans (e.g., earthquake-resistant structures)

11.6 Roles of water in Earth's surface processes

- Distribution of water
  - Oceans
  - Freshwater (e.g., lakes, rivers, streams, polar, ice, icebergs, glaciers)
- Water cycle, including the transfer of energy and the role of gravity
  - Evaporation, sublimation, transpiration
  - Condensation and crystallization
  - Precipitation
  - Runoff and infiltration
- Oceanography
  - Tides, waves, currents
  - Global ocean circulation (e.g., driven by seawater density, transfer of heat)
  - Ocean floor topography (e.g., continental shelf, continental slope, abyssal plain, islands, reefs)
- Surface features and underground formations (e.g., watersheds, deltas, groundwater features)
- Prediction of natural hazards (e.g., floods, storm surge) and mitigation of their impact on humans (e.g. for example, dams and levees)

11.7 Weather and climate

- Meteorology
  - Elements of weather and their measurement (e.g., temperature, pressure, humidity, precipitation, wind)
  - Interpretation of basic weather data (e.g., maps, radar, probability, predictions)
  - Effects of thermal energy transfer on the atmosphere

- Properties, motions, and interactions of air masses, including the Coriolis effect
- Prediction of severe weather events (e.g., hurricanes, tornadoes) and mitigation of their impact on humans (e.g., basements in tornado- prone regions)

- Climate
  - Effect of Earth's tilt, latitude, and elevation on climatic zones
  - Atmospheric patterns due to uneven heating and rotation of Earth
  - Effect of landforms (e.g., rain show effect)
  - Proximity to water (e.g., heat capacity of land and water, sea and land breezes, lake effect, ocean currents)
  - Climate change (e.g., natural and human causes, greenhouse effect, and other effects and management)
- Biogeology
  - Evolution is shaped by Earth's varying geological conditions
  - Evolution and proliferation of living things over geological time have in turn changed the rates of weathering and erosion of land surfaces, altered the composition of Earth's soils and atmosphere, and affected the distribution of water in the hydrosphere

12. COMPUTING CONCEPTS

AR K-8 State Standards

12.1 Demonstrating understanding of computational thinking and problem solving by
- Analyzing problem solving strategies
- Analyzing connections between elements of mathematics and computer science
- Solving problems

12.2 Demonstrating understanding of data and information by
- Analyzing various ways in which data is represented
- Collecting, arranging, and representing data
- Interpreting and analyzing data and information

12.3 Demonstrating understanding of algorithms and computer programs by
- Creating, evaluating, and modifying algorithms
- Creating computer programs to solve problems

12.4 Demonstrating an understanding of data and information
- Analyzing the utilization of computers
- Utilizing appropriate digital tools for various applications
- Analyzing various components and functions of computers

12.5 Demonstrating an understanding of community, global, and ethical impacts by analyzing appropriate uses of technology