CERTIFICATION EXAMINATIONS FOR OKLAHOMA EDUCATORS™ (CEOE™)

OKLAHOMA SUBJECT AREA TESTS™ (OSAT™)

FIELD 108: EARTH SCIENCE

TEST FRAMEWORK

September 2019

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SUBAREA I—SCIENCE PRACTICES AND THE ENGINEERING PROCESS

Competency 0001

Apply knowledge of scientific practices and techniques to earth science investigations.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of how to plan and conduct scientific lessons and investigations, including relating the instruction topics to students' prior knowledge and real-world situations.
- Apply knowledge of how to ask questions that arise from observation, how to identify relationships, and how to make a scientific claim that can be solved through investigation.
- Apply knowledge of methods and procedures for designing and carrying out scientific studies and for collecting data (e.g., identifying control and experimental groups, defining dependent and independent variables).
- Analyze the appropriateness of a specified experimental design in testing a scientific claim.
- Apply knowledge of basic safety concerns and proper procedures for dealing with accidents and injuries in the laboratory or in the field.

Competency 0002

Apply knowledge of the processes of gathering, organizing, and interpreting scientific data.

The following topics are examples of content that may be covered under this competency.

- Evaluate the appropriateness of a given method or procedure for collecting data for a specified purpose.
- Apply knowledge of mathematical and computational thinking to methods of data representation (e.g., graph, table, diagram), including their organization, relative ability to present given experimental data, and interpretation.
- Apply knowledge of different types of diagrams (e.g., stratigraphic sections), maps (e.g., topographic, geologic), and other figures that are used specifically in earth science to convey information.
- Evaluate the claims, evidence, and reasoning supporting or refuting scientific conclusions.

Competency 0003

Apply knowledge of engineering design to earth science.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of relationships between scientific concepts, technology, and engineering design.
- Analyze an engineering problem, including the criteria (e.g., size, weight, durability), benefits, and possible drawbacks of a design or solution.
- Evaluate a specific engineering design solution or compare design solutions based on constraints (e.g., economical, material, temporal, social, ethical).
- Apply knowledge of the extent to which different criteria are met for a given engineering design and the modifications needed to optimize a design solution.

Competency 0004

Apply crosscutting concepts to earth science concepts, processes, and phenomena.

The following topics are examples of content that may be covered under this competency.

- Analyze common patterns within or across earth science concepts (e.g., the organization and classification of weather patterns, the role of gravity in space systems).
- Differentiate causal and correlational relationships and identify the scientific principles behind causal relationships (e.g., thermodynamic principles responsible for air circulation, pressure changes responsible for rock formation).
- Apply knowledge of scale, proportion, and quantity in relation to earth science concepts (e.g., size, time, composition).
- Apply knowledge of system modeling (e.g., physical, mathematical, computer-based) to show correlations, solve problems, and predict outcomes.
- Apply knowledge of the general principles of matter and energy, including their conservation, movement, and relation to the inputs and outputs of a defined system.
- Apply knowledge of the relationships between structure and function in earth systems.
- Apply knowledge of stable and unstable systems, including feedback mechanisms and factors that affect the stability of a system.

SUBAREA II—SPACE SYSTEMS

Competency 0005

Analyze the evolution and structure of the universe and the objects within it.

The following topics are examples of content that may be covered under this competency.

- Analyze theories for the origin of the universe (e.g., big bang, inflation) and their supporting evidence (e.g., background radiation, red shift), including technologies used to study the universe (e.g., radio telescopes, X-ray telescopes).
- Analyze types of evidence used to infer the size, scale, and relative structure of the universe (e.g., stellar neighborhoods, galactic clusters, superclusters), including evidence for the continued evolving structure of the universe.
- Demonstrate knowledge of formation, types, and characteristics of universal matter (e.g., dark matter) and energy, galaxies (e.g., spiral, elliptical), and other objects in the universe (e.g., black holes, nebulae, quasars).
- Analyze types of evidence for inferring the size, structure, and motions of the Milky Way galaxy (e.g., star observations and counts), including in regards to the location of the solar system within the Milky Way galaxy.

Competency 0006

Apply knowledge of stellar characteristics.

The following topics are examples of content that may be covered under this competency.

- Demonstrate knowledge of types of stars (e.g., pulsars, supernovae, white dwarfs), their characteristics, and the technologies used to examine stars (e.g., radio telescopes, red shift, spectroscopy).
- Analyze the characteristics of main sequence stars and the life cycle of stars, including through the use of the Hertzsprung–Russell (H–R) diagram.
- Apply knowledge of the nucleosynthesis of light and heavy elements and the processes and outcomes of nuclear fusion, including how nuclear fusion in a star affects orbiting objects in the solar system.
- Apply knowledge of stellar life cycles to understand the formation, early development, and evolution of stars.

Competency 0007

Apply knowledge of the solar system.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of the origin, evolution, and scale of the solar system (e.g., planets, comets, asteroids, Oort cloud, Kuiper belt, asteroid belt), including supporting evidence.
- Apply Newton's and Kepler's laws to describe the roles of gravity and inertia and to predict the positions and real and apparent motions of the planets and other celestial bodies.
- Apply knowledge of characteristics (e.g., size, composition, rotation, surface temperature, potential to support life) and properties (e.g., magnetic field, density) of the planets and other celestial bodies (e.g., comets, asteroids, protoplanets, planetesimals).
- Demonstrate knowledge of technologies used to study the solar system (e.g., optical telescopes, infrared telescopes, space probes, manned spaceflight) and the history of these technologies in advancing knowledge of the solar system.

Competency 0008

Apply knowledge of the earth, moon, and sun system.

The following topics are examples of content that may be covered under this competency.

- Analyze theories of the development of the earth, moon, and sun system and theories of the origin and evolution of the moon, including supporting evidence (e.g., maria, craters, mountains, meteorites).
- Apply knowledge of the celestial sphere model of the earth, moon, and sun system (e.g., path of the ecliptic, orbital characteristics) and relationships of the earth, moon, and sun (e.g., tilt of the earth's axis, rotation of the earth and moon, distance between the earth and sun).
- Apply knowledge of the effects of the earth's relative position and motion with respect to the sun (e.g., length of day, change of seasons, length of year) and the effects of the relative positions and motions of the earth, moon, and sun (e.g., phases of the moon, tides, eclipses).
- Apply knowledge of the sun's properties (e.g., diameter, surface temperature, chemical composition, sunspot cycle, energy source), the role that nuclear fusion plays in warming the earth, and methods by which the sun is studied, including the possible effects that changes in solar variables (e.g., charged particles, solar flares) have on the earth's atmosphere, biosphere, climate, and weather.

SUBAREA III—GEOLOGICAL SYSTEMS

Competency 0009

Apply knowledge of the history of the earth.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of the origin, evolution, and key events in the history of the earth's atmosphere, lithosphere, hydrosphere, and biosphere.
- Apply knowledge of the origin and evolution of life and major events in the history of life, including how living organisms have modified the earth's systems over time (e.g., increasing atmospheric oxygen).
- Apply knowledge of the geologic time scale and fossilization processes, including how the fossil record can be used to reconstruct past environments and climatic conditions or to infer events in the geologic history of a given area.
- Apply knowledge of methods and technologies used to study the history of the earth, including relative dating techniques and the theory and application of various radiometric dating techniques.
- Apply principles of stratigraphy (e.g., law of original horizontality, law of superposition) to analyze the geologic history of a region.

Competency 0010

Apply knowledge of plate tectonics.

The following topics are examples of content that may be covered under this competency.

- Demonstrate knowledge of the layered structure and composition of the earth; the sources of the earth's internal energy; and the technologies, data, and methods used to infer the earth's internal structure (e.g., seismic waves).
- Analyze major processes affecting the earth's interior that drive and shape the movement of tectonic plates (e.g., thermal convection, ridge push, slab pull).
- Analyze evidence for seafloor spreading and plate tectonics (e.g., paleomagnetism, continent/ocean basin shape, fossil assemblages, glacial striations).
- Apply the theory of plate tectonics to explain topographic features (e.g., island chains, seamounts, faults, volcanoes, mountain ranges) and geologic phenomena (e.g., volcanism, earthquakes) and to predict the future movements of landmasses.

Competency 0011

Apply knowledge of rocks, minerals, and geological processes.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of classification schemes to identify common rock-forming minerals using physical properties (e.g., hardness, density).
- Analyze the characteristics and properties of sedimentary, igneous, and metamorphic rock and the processes by which different kinds of rocks are formed.
- Apply knowledge of the processes of weathering (e.g., mechanical, chemical, biological) and factors that affect the rate at which rocks weather and soils are produced.
- Apply knowledge of the processes of erosion by various agents (e.g., wind, water, glaciers) and factors that affect erosion rates and patterns.
- Apply knowledge of the characteristics of different types of terrestrial topographic features (e.g., mountains, beaches, dunes, mesas, valleys, eskers), including understanding the processes by which they are formed.

SUBAREA IV—ATMOSPHERIC AND HYDROLOGICAL SYSTEMS

Competency 0012

Analyze the structure and function of the earth's atmosphere.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of the properties of the atmosphere from the earth's surface through the thermosphere (e.g., density, composition, temperature) and the relation of these properties to the structure and function of layers within the earth's atmosphere.
- Analyze how various wavelengths of solar radiation (e.g., ultraviolet, visible light, infrared) could be affected as they enter and pass through the atmosphere and are absorbed and reradiated from the earth's surface.
- Analyze the processes by which energy is transferred to and within the atmosphere (e.g., radiation, evaporation, convection, conduction) and the effect of variations in the atmosphere and the earth's surface (e.g., albedo, topography) on these processes.
- Analyze global wind patterns, including latitudinal variations in insolation and the Coriolis effect.

Competency 0013

Apply knowledge of the relationship between water and atmospheric processes.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of the chemical and physical properties of water (e.g., high specific heat, surface tension), the phase changes of water (e.g., evaporation, sublimation), and changes in physical properties of water that occur with phase change.
- Describe energy changes involved in the transition between phases of water (e.g., latent heat) and its significance for energy transfer in the atmosphere.
- Analyze atmospheric conditions under which fog and clouds form (e.g., adiabatic temperature changes, dew point, atmospheric stability) and relate those conditions to the characteristics of different cloud types.
- Apply understanding of conditions under which precipitation forms and predict the type of precipitation that will fall to the earth's surface under given conditions.

Competency 0014

Analyze weather and climate.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of the dynamic between the biosphere and other earth systems and the continual coevolution of the earth's surface and life on earth.
- Analyze factors that affect the climate in a given region (e.g., insolation, wind patterns, topography, proximity to large bodies of water) and the relationship between the climate of a region and its weather.
- Analyze types and characteristics of air masses, their movements, fronts that form between air masses, and the horizontal and vertical movements of air in high- and low-pressure areas.
- Analyze the use of weather models and atmospheric data (e.g., temperature, barometric pressure, dew point, lapse rate) in weather forecasting, including to predict weather in a given location.
- Apply knowledge of the use of weather instruments for collecting weather data (e.g., thermometer, psychrometer, barometer, anemometer), symbols used on weather maps, and methods used to generate weather maps and forecasts (e.g., computer models).

Competency 0015

Analyze the hydrologic system, freshwater, and ocean characteristics.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of the processes of the hydrologic system (e.g., evaporation, transpiration, infiltration), including the role of the hydrologic system in shaping the earth's surface and subsurface.
- Evaluate factors affecting the volume and flow of water (e.g., gradient, sediment load, temperature, substrate, cross-sectional shape).
- Apply knowledge of the characteristics of surface freshwater systems (e.g., lakes, wetlands, rivers, glaciers) and natural processes that change freshwater systems through time (e.g., seasonal overturning, flooding, drought, snowfall patterns).
- Analyze factors that affect the presence and movement of groundwater and aquifers (e.g., porosity, gradient) and the interrelationship between groundwater and surface water.
- Demonstrate knowledge of structure and formation of the coastlines, ocean zones, and ocean floor.
- Apply knowledge of ocean processes (e.g., currents, tides, upwelling) and how these processes affect ocean circulation, including the role of ocean temperature and circulation in climate systems (e.g., how thermohaline circulation affects climate).

SUBAREA V—NATURAL HAZARDS AND HUMAN ENVIRONMENTAL INTERACTION

Competency 0016

Apply knowledge of natural hazards and processes and their impact on human societies.

The following topics are examples of content that may be covered under this competency.

- Analyze the geochemical cycles of elements and compounds (e.g., nitrogen, carbon, phosphorus, sulfur), including the factors that affect their movement.
- Apply knowledge of the causes, characteristics, and impacts of natural hazards (e.g., tornadoes, tsunamis, droughts, volcanic eruptions), including their current and historical impacts on human communities and populations.
- Analyze the mechanisms behind, evidence for, and impacts of global climate change, including understanding the greenhouse effect and its positive and negative attributes.
- Apply knowledge of models and technologies (e.g., tiltmeters, satellite imagery) that can be used to predict the occurrence or effects of natural hazards, catastrophic events, and climate change in a given region.
- Apply knowledge of engineering solutions and strategies (e.g., flood barriers, restoration of wetlands, tsunami early warning systems) to mitigate the effects of natural hazards and catastrophic events on communities.

Competency 0017

Apply knowledge of energy and natural resources.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of the various forms of renewable and nonrenewable energy and natural resources, including understanding their characteristics, uses, availability, and sustainability potential.
- Apply knowledge of the uneven distribution of natural resources and energy sources and understand the methods for locating, obtaining, producing, and managing renewable and nonrenewable energy and natural resources.
- Compare and contrast the advantages and disadvantages of renewable (e.g., solar, wind, geothermal, hydropower) and nonrenewable (e.g., coal, oil, natural gas, nuclear) sources of energy.
- Analyze the effects of the use and extraction of natural resources on human health and human societies.

Competency 0018

Analyze the effect of human activities on Earth systems.

The following topics are examples of content that may be covered under this competency.

- Analyze human activities that affect the atmosphere (e.g., release of greenhouse gases, chlorofluorocarbons, sulfur dioxide) and their effects (e.g., trapping heat, destroying stratospheric ozone, acid rain, increased ground-level ozone).
- Analyze human activities that affect the hydrosphere (e.g., nutrient-laden runoff, soluble toxic or mutanagenic compounds, pumping groundwater) and their effects (e.g., eutrophication of lakes, contamination of drinking water supplies, depletion of aquifers).
- Analyze human activities that affect the lithosphere (e.g., fracking, mining, intensive agriculture) and their effects (e.g., increased earthquakes, toxic metal accumulation, nutrient depletion, erosion).
- Analyze human activities that affect the biosphere (e.g., urbanization, introduction of invasive species, overfishing) and their effects (e.g., habitat loss, reduction in biodiversity, native population decline, extinction).
- Analyze how a change in one Earth system due to human activities may influence changes in other Earth systems (e.g., permafrost melting leading to increased methane release, mountaintop mining leading to erosion and silting of streams, increased atmospheric CO_2 leading to ocean acidification, climate change leading to life cycle changes in animals and plants).

Competency 0019

Apply knowledge of monitoring and changing human impacts on Earth systems.

The following topics are examples of content that may be covered under this competency.

- Correlate environmental issues with factors that could be causing or affecting them (e.g., chemicals, point source or diffuse pollution, an interaction between Earth systems, changes in timescale).
- Apply knowledge of strategies and methods for monitoring and for mitigating the effects of human activities on the environment (e.g., climate change models, satellite monitoring, toxic waste cleanup, strip mine reclamation, cover cropping).
- Apply knowledge of strategies and methods for using individual, municipal, small business, and corporate actions to minimize, prevent, and mitigate human impact on the environment (e.g., recycling waste, use of "green" products, installation of solar panels or windmills, sustainable agriculture).

SUBAREA VI—PEDAGOGICAL CONTENT KNOWLEDGE

Competency 0020

Analyze a lesson plan for a given learning standard in the Oklahoma Academic Standards for Science or in the Next Generation Science Standards, including examples of student work and/or assessments, and describe subsequent activities that address student needs.

The following topics are examples of content that may be covered under this competency.

- Apply knowledge of standards-based learning goals for earth science content and processes.
- Analyze assessment results of student learning and/or samples of student work for a particular lesson in earth science, citing specific evidence from the exhibits that identifies a significant scientific strength as well as a significant area of need shown by the student or students.
- Describe an appropriate instructional strategy or intervention that would help the student or students improve in the identified area of need.
- Describe how your analysis of assessment data and/or student work can be used to inform future instruction with respect to this content area and the development and reinforcement of sound scientific practice.