ATTACHMENT
Text of Proposed New 19 TAC

Chapter 112. Texas Essential Knowledge and Skills for Science

Subchapter C. High School

§112.46. Implementation of Texas Essential Knowledge and Skills for Science, High School, Adopted 2021.

(a) The provisions of §§112.47-112.50 of this subchapter shall be implemented by school districts beginning with the 2023-2024 school year.

(b) The provisions of §112.51 of this subchapter shall be implemented by school districts beginning with the 2022-2023 school year.

(c) No later than July 31, 2022, the commissioner of education shall determine whether instructional materials funding has been made available to Texas public schools for materials that cover the essential knowledge and skills for science as adopted in §§112.47-112.50 of this subchapter.

(d) If the commissioner makes the determination that instructional materials funding has been made available under subsection (c) of this section, §§112.47-112.50 of this subchapter shall be implemented beginning with the 2023-2024 school year and apply to the 2023-2024 and subsequent school years.

(e) If the commissioner does not make the determination that instructional materials funding has been made available under subsection (c) of this section, the commissioner shall determine no later than July 31 of each subsequent school year whether instructional materials funding has been made available. If the commissioner determines that instructional materials funding has been made available, the commissioner shall notify the State Board of Education and school districts that §§112.47-112.50 of this subchapter shall be implemented for the following school year.

(f) Sections 112.32, 112.33, 112.36, and 112.37 of this subchapter shall be superseded by the implementation of §§112.47-112.50 of this subchapter.

§112.47. Aquatic Science, Adopted 2021 (One Credit).

(a) General requirements. Students shall be awarded one credit for successful completion of this course. Prerequisite: one unit of high school biology. Recommended prerequisite: Integrated Physics and Chemistry, Chemistry, or concurrent enrollment in either course. This course is recommended for students in Grade 10, 11, or 12.

(b) Introduction.

(1) Aquatic Science. In Aquatic Science, students study the interactions of biotic and abiotic components in aquatic environments, including natural and human impacts on aquatic systems. Investigations and field work in this course may emphasize fresh water or marine aspects of aquatic science depending primarily upon the natural resources available for study near the school. Students who successfully complete Aquatic Science acquire knowledge about how the properties of water and fluid dynamics affect aquatic ecosystems and acquire knowledge about a variety of aquatic systems. Students who successfully complete Aquatic Science conduct investigations and observations of aquatic environments, work collaboratively with peers, and develop critical-thinking and problem-solving skills.

(2) Nature of science. Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.

(3) Scientific hypotheses and theories. Students are expected to know that:

(A) hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that have been tested over a wide variety of conditions are incorporated into theories; and

(B) scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established and highly reliable explanations, but they may be subject to change as new areas of science and new technologies are developed.

(4) Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world using scientific and engineering practices. Scientific methods of investigation are descriptive, comparative, or experimental. The method chosen should be appropriate to the question being asked. Student learning for different types of investigations include descriptive investigations, which involve collecting data and recording observations without making comparisons; comparative investigations, which involve collecting data with variables that are manipulated to compare results; and experimental investigations, which involve processes similar to comparative investigations but in which a control is identified.

(A) Scientific practices. Students should be able to ask questions, plan and conduct investigations to answer questions, and explain phenomena using appropriate tools and models.

(B) Engineering practices. Students should be able to identify problems and design solutions using appropriate tools and models.

(5) Science and social ethics. Scientific decision making is a way of answering questions about the natural world involving its own set of ethical standards about how the process of science should be carried out. Students should be able to distinguish between scientific decision-making methods (scientific methods) and ethical and social decisions that involve science (the application of scientific information).

(6) Science consists of recurring themes and making connections between overarching concepts. Recurring themes include systems, models, and patterns. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested, while models allow for boundary specification and provide tools for understanding the ideas presented. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.

(7) Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(c) Knowledge and skills.

(1) Scientific and engineering practices. The student, for at least 40% of instructional time, asks questions, identifies problems, and plans and safely conducts classroom, laboratory, and field investigations to explain phenomena or design solutions using appropriate tools and models. The student is expected to:

(A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations;

(B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems;

(C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards;

(D) use appropriate tools such as Global Positioning System (GPS), Geographic Information System (GIS), weather balloons, buoys, water testing kits, meter sticks, metric rulers, pipettes, graduated cylinders, standard laboratory glassware, balances, timing devices, pH meters or probes, various data collecting probes, thermometers, calculators, computers, internet access, turbidity testing devices, hand magnifiers, work and disposable gloves, compasses, first aid kits, field guides, water quality test kits or probes, 30-meter tape measures, tarps, ripple tanks, trowels, screens, buckets, sediment samples equipment, cameras, flow meters, cast nets, kick nets, seines, computer models, spectrophotometers, stereomicroscopes, compound microscopes, clinometers, and field journals, various prepared slides, hand lenses, hot plates, Petri dishes, sampling nets, waders, leveling grade rods (Jason sticks), protractors, inclination and height distance calculators, samples of biological specimens or structures, core sampling equipment, fish tanks and associated supplies, and hydrometers;

(E) collect quantitative data using the International System of Units (SI) and qualitative data as evidence;

(F) organize quantitative and qualitative data using probeware, spreadsheets, lab notebooks or journals, models, diagrams, graphs paper, computers, or cellphone applications;

(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and

(H) distinguish between scientific hypotheses, theories, and laws.

(2) Scientific and engineering practices. The student analyzes and interprets data to derive meaning, identify features and patterns, and discover relationships or correlations to develop evidence-based arguments or evaluate designs. The student is expected to:

(A) identify advantages and limitations of models such as their size, scale, properties, and materials;

(B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;

(C) use mathematical calculations to assess quantitative relationships in data; and

(D) evaluate experimental and engineering designs.

(3) Scientific and engineering practices. The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:

(A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories;

(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and

(C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence.

(4) Scientific and engineering practices. The student knows the contributions of scientists and recognizes the importance of scientific research and innovation on society. The student is expected to:

(A) analyze, evaluate, and critique scientific explanations and solutions by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student;

(B) relate the impact of past and current research on scientific thought and society, including research methodology, cost-benefit analysis, and contributions of diverse scientists as related to the content; and

(C) research and explore resources such as museums, planetariums, observatories, libraries, professional organizations, private companies, online platforms, and mentors employed in a science, technology, engineering, and mathematics (STEM) field in order to investigate STEM careers.

(5) The student understands how the properties of water build the foundation of aquatic ecosystems. The student is expected to:

(A) describe how the shape and polarity of the water molecule make it a "universal solvent" in aquatic systems;

(B) identify how aquatic ecosystems are affected by water's properties of adhesion, cohesion, surface tension, heat capacity, and thermal conductivity; and

(C) explain how the density of water is critical for organisms in cold environments.

(6) Students know that aquatic environments are the product of interactions among Earth systems. The student is expected to:

(A) identify key features and characteristics of atmospheric, geological, hydrological, and biological systems as they relate to aquatic environments;

(B) describe the interrelatedness of atmospheric, geological, hydrological, and biological systems in aquatic ecosystems, including positive and negative feedback loops; and

(C) evaluate environmental data using technology such as maps, visualizations, satellite data, Global Positioning System (GPS), Geographic Information System (GIS), weather balloons, and buoys to model the interactions that affect aquatic ecosystems.

(7) The student knows about the interdependence and interactions that occur in aquatic environments. The student is expected to:

(A) identify how energy flows and matter cycles through both freshwater and saltwater aquatic systems, including food webs, chains, and pyramids;

(B) identify biological, chemical, geological, and physical components of an aquatic life zone as they relate to the organisms in it;

(C) identify variables that affect the solubility of carbon dioxide and oxygen in water;

(D) evaluate factors affecting aquatic population cycles such as lunar cycles, temperature variations, hours of daylight, and predator-prey relationships; and

(E) identify the interdependence of organisms in an aquatic environment such as in a pond, a river, a lake, an ocean, or an aquifer and the biosphere.

(8) The student conducts short-term and long-term studies on local aquatic environments. Local natural environments are to be preferred over artificial or virtual environments. The student is expected to:

(A) evaluate data over a period of time from an established aquatic environment documenting seasonal changes and the behavior of organisms;

(B) collect and analyze pH, salinity, temperature, mineral content, nitrogen compounds, dissolved oxygen, and turbidity data periodically, starting with baseline measurements; and

(C) use data from short-term or long-term studies to analyze interrelationships between producers, consumers, and decomposers in aquatic ecosystems.

(9) The student knows the role of cycles in an aquatic environment. The student is expected to:

(A) identify the role of carbon, nitrogen, water, and nutrient cycles in an aquatic environment, including upwellings and turnovers;

(B) examine the interrelationships between aquatic systems and climate and weather, including El Niño and La Niña, currents, and hurricanes; and

(C) explain how tidal cycles influence intertidal ecology.

(10) The student knows the origin and potential uses of fresh water. The student is expected to:

(A) identify sources of water in a watershed, including rainfall, groundwater, and surface water;

(B) identify factors that contribute to how water flows through a watershed;

(C) analyze water quantity and quality in a local watershed or aquifer; and

(D) describe human uses of fresh water and how human freshwater use competes with that of other organisms.

(11) The student knows that geological phenomena and fluid dynamics affect aquatic systems. The student is expected to:

(A) examine basic principles of fluid dynamics, including hydrostatic pressure, density, salinity, and buoyancy;

(B) identify interrelationships between ocean currents, climates, and geologic features such as continental margins, active and passive margins, abyssal plains, island atolls, peninsulas, barrier islands, and hydrothermal vents;

(C) explain how fluid dynamics causes upwelling and lake turnover; and

(D) describe how erosion and deposition in river systems lead to formation of geologic features.

(12) The student understands the types of aquatic ecosystems. The student is expected to:

(A) differentiate among freshwater, brackish, and saltwater ecosystems; and

(B) identify the major properties and components of different marine and freshwater life zones.

(13) The student knows environmental adaptations of aquatic organisms. The student is expected to:

(A) compare different traits in aquatic organisms using tools such as dichotomous keys;

(B) describe how adaptations allow an organism to exist within an aquatic environment; and

(C) compare adaptations of freshwater and marine organisms.

(14) The student understands how human activities impact aquatic environments. The student is expected to:

(A) analyze the cumulative impact of human population growth on an aquatic ecosystem;

(B) predict effects of chemical, organic, physical, and thermal changes due to humans on the living and nonliving components of an aquatic ecosystem;

(C) investigate the role of humans in unbalanced systems involving phenomena such as invasive species, fish farming, cultural eutrophication, or red tides;

(D) analyze and discuss how human activities such as fishing, transportation, dams, and recreation influence aquatic environments;

(E) describe the impact of various laws and policies such as The Endangered Species Act, right of capture laws, or Clean Water Act on aquatic systems; and

(F) analyze the purpose and effectiveness of human efforts to restore aquatic ecosystems affected by human activities.

§112.48. Astronomy, Adopted 2021 (One Credit).

(a) General requirements. Students shall be awarded one credit for successful completion of this course. Prerequisites: Algebra I and Integrated Physics and Chemistry or Chemistry.

(b) Introduction.

(1) Astronomy. In Astronomy, students focus on patterns, processes, and relationships among astronomical objects in our universe. Students acquire basic astronomical knowledge and supporting evidence about sun-Earth-Moon relationships, the solar system, the Milky Way, the size and scale of the universe, and the benefits and limitations of exploration. Students conduct laboratory and field investigations to support their developing conceptual framework of our place in space and time. By the end of Grade 12, students are expected to gain sufficient knowledge of the scientific and engineering practices across the disciplines of science to make informed decisions using critical thinking and scientific problem solving.

(2) Nature of science. Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not scientifically testable.

(3) Scientific hypotheses and theories. Students are expected to know that:

(A) hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that have been tested over a wide variety of conditions are incorporated into theories; and

(B) scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established and highly reliable explanations, but they may be subject to change as new areas of science and new technologies are developed.

(4) Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world using scientific and engineering practices. Scientific methods of investigation are descriptive, comparative, or experimental. The method chosen should be appropriate to the question being asked. Student learning for different types of investigations include descriptive investigations, which involve collecting data and recording observations without making comparisons; comparative investigations, which involve collecting data with variables that are manipulated to compare results; and experimental investigations, which involve processes similar to comparative investigations but in which a control is identified.

(A) Scientific practices. Students should be able to ask questions, plan and conduct investigations to answer questions, and explain phenomena using appropriate tools and models.

(B) Engineering practices. Students should be able to identify problems and design solutions using appropriate tools and models.

(5) Science and social ethics. Scientific decision making is a way of answering questions about the natural world involving its own set of ethical standards about how the process of science should be carried out. Students should be able to distinguish between scientific decision-making methods (scientific methods) and ethical and social decisions that involve science (the application of scientific information).

(6) Science consists of recurring themes and making connections between overarching concepts. Recurring themes include systems, models, and patterns. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested, while models allow for boundary specification and provide tools for understanding the ideas presented. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.

(7) Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(c) Knowledge and skills.

(1) Scientific and engineering practices. The student, for at least 40% of instructional time, asks questions, identifies problems, and plans and safely conducts classroom, laboratory, and field investigations to explain phenomena or design solutions using appropriate tools and models. The student is expected to:

(A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations;

(B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems;

(C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards;

(D) use appropriate tools such as gnomons; sundials; Planisphere; star charts; globe of the Earth; diffraction gratings; spectroscopes; color filters; lenses of multiple focal lengths; concave, plane, and convex mirrors; binoculars; telescopes; celestial sphere; online astronomical databases; and online access to observatories;

(E) collect quantitative data using the International System of Units (SI) and qualitative data as evidence;

(F) organize quantitative and qualitative data using graphs, charts, spreadsheets, and computer software;

(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and

(H) distinguish between scientific hypotheses, theories, and laws.

(2) Scientific and engineering practices. The student analyzes and interprets data to derive meaning, identify features and patterns, and discover relationships or correlations to develop evidence-based arguments or evaluate designs. The student is expected to:

(A) identify advantages and limitations of models such as their size, scale, properties, and materials;

(B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;

(C) use mathematical calculations to assess quantitative relationships in data; and

(D) evaluate experimental and engineering designs.

(3) Scientific and engineering practices. The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:

(A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories;

(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and

(C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence.

(4) Scientific and engineering practices. The student knows the contributions of scientists and recognizes the importance of scientific research and innovation on society. The student is expected to:

(A) analyze, evaluate, and critique scientific explanations and solutions by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student;

(B) relate the impact of past and current research on scientific thought and society, including research methodology, cost-benefit analysis, and contributions of diverse scientists as related to the content; and

(C) research and explore resources such as museums, planetariums, observatories, libraries, professional organizations, private companies, online platforms, and mentors employed in a science, technology, engineering, and mathematics (STEM) field in order to investigate STEM careers.

(5) Science concepts. The student understands how astronomy influenced and advanced civilizations. The student is expected to:

(A) evaluate and communicate how ancient civilizations developed models of the universe using astronomical structures, instruments, and tools, including the astrolabe, gnomons, and charts, and how those models influenced society, time keeping, and navigation;

(B) research and evaluate the contributions of scientists, including Ptolemy, Copernicus, Tycho Brahe, Kepler, Galileo, and Newton, as astronomy progressed from a geocentric model to a heliocentric model; and

(C) describe and explain the historical origins of the perceived patterns of constellations and the role of constellations in ancient and modern navigation.

(6) Science concepts. The student conducts and explains astronomical observations made from the point of reference of Earth. The student is expected to:

(A) observe, record, and analyze the apparent movement of the Sun, Moon, and stars and predict sunrise and sunset;

(B) observe the movement of planets throughout the year and measure how their positions change relative to the constellations;

(C) identify constellations such as Ursa Major, Ursa Minor, Orion, Cassiopeia, and constellations along the ecliptic and describe their importance; and

(D) understand the difference between astronomy and astrology, the reasons for their historical conflation, and their eventual separation.

(7) Science concepts. The student knows our relative place in the solar system. The student is expected to:

(A) demonstrate the use of units of measurement in astronomy, including astronomical units and light years, minutes, and seconds;

(B) model the scale, size, and distance of the Sun, Earth, and Moon system and identify the limitations of physical models; and

(C) model the scale, sizes, and distances of the Sun and the planets in our solar system and identify the limitations of physical models.

(8) Science concepts. The student observes and models the interactions within the Sun, Earth, and Moon system. The student is expected to:

(A) model how the orbit and relative position of the Moon cause lunar phases and predict the timing of moonrise and moonset during each phase;

(B) model how the orbit and relative position of the Moon cause lunar and solar eclipses; and

(C) examine and investigate the dynamics of tides using the Sun, Earth, and Moon model.

(9) Science concepts. The student models the cause of planetary seasons. The student is expected to:

(A) examine the relationship of a planet's axial tilt to its potential seasons;

(B) predict how changing latitudinal position affects the length of day and night throughout a planet's orbital year;

(C) investigate the relationship between a planet's axial tilt, angle of incidence of sunlight, and concentration of solar energy; and

(D) explain the significance of Earth's solstices and equinoxes.

(10) Science concepts. The student knows how astronomical tools collect and record information about celestial objects. The student is expected to:

(A) investigate the use of black body radiation curves and emission, absorption, and continuous spectra in the identification and classification of celestial objects;

(B) calculate the relative light-gathering power of different-sized telescopes to compare telescopes for different applications;

(C) analyze the importance and limitations of optical, infrared, and radio telescopes, gravitational wave detectors, and other ground-based technology; and

(D) analyze the importance and limitations of space telescopes in the collection of astronomical data across the electromagnetic spectrum.

(11) Science concepts. The student uses models to explain the formation, development, organization, and significance of solar system bodies. The student is expected to:

(A) relate Newton's law of universal gravitation and Kepler's laws of planetary motion to the formation and motion of the planets and their satellites;

(B) explore and communicate the origins and significance of planets, planetary rings, satellites, asteroids, comets, Oort cloud, and Kuiper belt objects;

(C) compare the planets in terms of orbit, size, composition, rotation, atmosphere, natural satellites, magnetic fields, and geological activity; and

(D) compare the factors essential to life on Earth such as temperature, water, mass, gases, and magnetic field to conditions on other planets and their satellites.

(12) Science concepts. The student knows that our Sun serves as a model for stellar activity. The student is expected to:

(A) identify the approximate mass, size, motion, temperature, structure, and composition of the Sun;

(B) distinguish between nuclear fusion and nuclear fission and identify the source of energy within the Sun as nuclear fusion of hydrogen to helium;

(C) describe the eleven-year solar cycle and the significance of sunspots; and

(D) analyze the origins and effects of space weather, including the solar wind, coronal mass ejections, prominences, flares, and sunspots.

(13) Science concepts. The student understands the characteristics and life cycle of stars. The student is expected to:

(A) identify the characteristics of main sequence stars, including surface temperature, age, relative size, and composition;

(B) describe and communicate star formation from nebulae to protostars to the development of main sequence stars;

(C) evaluate the relationship between mass and fusion on stellar evolution;

(D) compare how the mass of a main sequence star will determine its end state as a white dwarf, neutron star, or black hole;

(E) describe the use of spectroscopy in obtaining physical data on celestial objects such as temperature, chemical composition, and relative motion;

(F) use the Hertzsprung-Russell diagram to classify stars and plot and examine the life cycle of stars from birth to death;

(G) illustrate how astronomers use geometric parallax to determine stellar distances and intrinsic luminosities; and

(H) describe how stellar distances are determined by comparing apparent brightness and intrinsic luminosity when using spectroscopic parallax and the Leavitt relation for variable stars.

(14) Science concepts. The student knows the structure of the universe and our relative place in it. The student is expected to:

(A) illustrate the structure and components of our Milky Way galaxy and model the size, location, and movement of our solar system within it;

(B) compare spiral, elliptical, irregular, dwarf, and active galaxies;

(C) develop and use models to explain how galactic evolution occurs through mergers and collisions;

(D) describe the Local Group and its relation to larger-scale structures in the universe; and

(E) evaluate the indirect evidence for the existence of dark matter.

(15) Science concepts. The student knows the scientific theories of cosmology. The student is expected to:

(A) describe and evaluate the historical development of evidence supporting the Big Bang Theory;

(B) evaluate the limits of observational astronomy methods used to formulate the distance ladder;

(C) evaluate the indirect evidence for the existence of dark energy;

(D) describe the current scientific understanding of the evolution of the universe, including estimates for the age of the universe; and

(E) describe current scientific hypotheses about the fate of the universe, including open and closed universes.

(16) Science concepts. The student understands the benefits and challenges of expanding our knowledge of the universe. The student is expected to:

(A) describe and communicate the historical development of human space flight and its challenges;

(B) describe and communicate the uses and challenges of robotic space flight;

(C) evaluate the evidence of the existence of habitable zones and potentially habitable planetary bodies in extrasolar planetary systems;

(D) evaluate the impact on astronomy from light pollution, radio interference, and space debris;

(E) examine and describe current developments and discoveries in astronomy; and

(F) explore and explain careers that involve astronomy, space exploration, and the technologies developed through them.

§112.49. Earth Systems Science, Adopted 2021 (One Credit).

(a) General requirements. Students shall be awarded one credit for successful completion of this course. Prerequisites: Algebra I and two credits of high school science.

(b) Introduction.

(1) Earth Systems Science. The Earth Systems Science course is designed to build on students' prior scientific and academic knowledge and skills to develop their understanding of Earth's systems. These systems (the atmosphere, hydrosphere, geosphere, and biosphere) interact through time to produce the Earth's landscapes, climate, and resources. Students explore the geologic history of individual dynamic systems through the flow of energy and matter, their current states, and how these systems affect and are affected by human use.

(2) Nature of science. Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.

(3) Scientific hypotheses and theories. Students are expected to know that:

(A) hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that have been tested over a wide variety of conditions are incorporated into theories; and

(B) scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established and highly reliable explanations, but they may be subject to change as new areas of science and new technologies are developed.

(4) Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world using scientific and engineering practices. Scientific methods of investigation are descriptive, comparative, or experimental. The method chosen should be appropriate to the question being asked. Student learning for different types of investigations include descriptive investigations, which involve collecting data and recording observations without making comparisons; comparative investigations, which involve collecting data with variables that are manipulated to compare results; and experimental investigations, which involve processes similar to comparative investigations but in which a control is identified.

(A) Scientific practices. Students should be able to ask questions, plan and conduct investigations to answer questions, and explain phenomena using appropriate tools and models.

(B) Engineering practices. Students should be able to identify problems and design solutions using appropriate tools and models.

(5) Science and social ethics. Scientific decision making is a way of answering questions about the natural world involving its own set of ethical standards about how the process of science should be carried out. Students should be able to distinguish between scientific decision-making methods (scientific methods) and ethical and social decisions that involve science (the application of scientific information).

(6) Science consists of recurring themes and making connections between overarching concepts. Recurring themes include systems, models, and patterns. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested, while models allow for boundary specification and provide tools for understanding the ideas presented. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.

(7) Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(c) Knowledge and skills.

(1) Scientific and engineering practices. The student, for at least 40% of instructional time, asks questions, identifies problems, and plans and safely conducts classroom, laboratory, and field investigations to explain phenomena or design solutions using appropriate tools and models. The student is expected to:

(A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations;

(B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems;

(C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards;

(D) use appropriate tools such as a drawing compass, magnetic compass, bar magnets, topographical and geological maps, satellite imagery and other remote sensing data, Geographic Information Systems (GIS), Global Positioning System (GPS), hand lenses, and fossil and rock sample kits;

(E) collect quantitative data using the International System of Units (SI) and qualitative data as evidence;

(F) organize quantitative and qualitative data using scatter plots, line graphs, bar graphs, charts, data tables, digital tools, diagrams, scientific drawings, and student-prepared models;

(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and

(H) distinguish between scientific hypotheses, theories, and laws.

(2) Scientific and engineering practices. The student analyzes and interprets data to derive meaning, identify features and patterns, and discover relationships or correlations to develop evidence-based arguments or evaluate designs. The student is expected to:

(A) identify advantages and limitations of models such as their size, scale, properties, and materials;

(B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;

(C) use mathematical calculations to assess quantitative relationships in data; and

(D) evaluate experimental and engineering designs.

(3) Scientific and engineering practices. The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:

(A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories;

(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and

(C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence.

(4) Scientific and engineering practices. The student knows the contributions of scientists and recognizes the importance of scientific research and innovation on society. The student is expected to:

(A) analyze, evaluate, and critique scientific explanations and solutions by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student;

(B) relate the impact of past and current research on scientific thought and society, including research methodology, cost-benefit analysis, and contributions of diverse scientists as related to the content; and

(C) research and explore resources such as museums, planetariums, observatories, libraries, professional organizations, private companies, online platforms, and mentors employed in a science, technology, engineering, and mathematics (STEM) field in order to investigate STEM careers.

(5) Science concepts. The student understands the formation of the Earth and how objects in the solar system affect Earth's systems. The student is expected to:

(A) analyze how gravitational condensation of solar nebular gas and dust can lead to the accretion of planetesimals and protoplanets;

(B) identify comets, asteroids, meteoroids, and planets in the solar system and describe how they affect the Earth and Earth's systems; and

(C) explore the historical and current hypotheses for the origin of the Moon, including the collision of Earth with a Mars-sized planetesimal.

(6) Science concepts. The student knows the evidence for the formation and composition of Earth's atmosphere, hydrosphere, biosphere, and geosphere. The student is expected to:

(A) describe how impact accretion, gravitational compression, radioactive decay, and cooling differentiated proto-Earth into layers;

(B) evaluate the roles of volcanic outgassing and water-bearing comets in developing Earth's atmosphere and hydrosphere;

(C) evaluate the evidence for changes to the chemical composition of Earth's atmosphere prior to the introduction of oxygen;

(D) evaluate scientific hypotheses for the origin of life through abiotic chemical processes; and

(E) describe how the production of oxygen by photosynthesis affected the development of the atmosphere, hydrosphere, geosphere, and biosphere.

(7) Science concepts. The student knows that rocks and fossils provide evidence for geologic chronology, biological evolution, and environmental changes. The student is expected to:

(A) describe the development of multiple radiometric dating methods and analyze their precision, reliability, and limitations in calculating the ages of igneous rocks from Earth, the Moon, and meteorites;

(B) apply relative dating methods, principles of stratigraphy, and index fossils to determine the chronological order of rock layers;

(C) construct a model of the geological time scale using relative and absolute dating methods to represent Earth's approximate 4.6-billion-year history;

(D) explain how sedimentation, fossilization, and speciation affect the degree of completeness of the fossil record;

(E) describe how evidence of biozones and faunal succession in rock layers reveal information about the environment at the time those rocks were deposited and the dynamic nature of the Earth; and

(F) analyze data from rock and fossil succession to evaluate the evidence for and significance of mass extinctions, major climatic changes, and tectonic events.

(8) Science concepts. The student knows how the Earth's interior dynamics and energy flow drive geological processes on Earth's surface. The student is expected to:

(A) evaluate heat transfer through Earth's systems by convection and conduction and include its role in plate tectonics and volcanism;

(B) develop a model of the physical, mechanical, and chemical composition of Earth's layers using evidence from Earth's magnetic field, the composition of meteorites, and seismic waves;

(C) investigate how new conceptual interpretations of data and innovative geophysical technologies led to the current theory of plate tectonics;

(D) describe how heat and rock composition affect density within Earth's interior and how density influences the development and motion of Earth's tectonic plates;

(E) explain how plate tectonics accounts for geologic processes and features, including sea floor spreading, ocean ridges and rift valleys, subduction zones, earthquakes, volcanoes, mountain ranges, hot spots, and hydrothermal vents;

(F) calculate the motion history of tectonic plates using equations relating rate, time, and distance to predict future motions, locations, and resulting geologic features;

(G) distinguish the location, type, and relative motion of convergent, divergent, and transform plate boundaries using evidence from the distribution of earthquakes and volcanoes; and

(H) evaluate the role of plate tectonics with respect to long-term global changes in Earth's subsystems such as continental buildup, glaciation, sea level fluctuations, mass extinctions, and climate change.

(9) Science concepts. The student knows that the lithosphere continuously changes as a result of dynamic and complex interactions among Earth's systems. The student is expected to:

(A) interpret Earth surface features using a variety of methods such as satellite imagery, aerial photography, and topographic and geologic maps using appropriate technologies;

(B) investigate and model how surface water and ground water change the lithosphere through chemical and physical weathering and how they serve as valuable natural resources;

(C) model the processes of mass wasting, erosion, and deposition by water, wind, ice, glaciation, gravity, and volcanism in constantly reshaping Earth's surface; and

(D) evaluate how weather and human activity affect the location, quality, and supply of available freshwater resources.

(10) Science concepts. The student knows how the physical and chemical properties of the ocean affect its structure and flow of energy. The student is expected to:

(A) describe how the composition and structure of the oceans leads to thermohaline circulation and its periodicity;

(B) model and explain how changes to the composition, structure, and circulation of deep oceans affect thermohaline circulation using data on energy flow, ocean basin structure, and changes in polar ice caps and glaciers; and

(C) analyze how global surface ocean circulation is the result of wind, tides, the Coriolis effect, water density differences, and the shape of the ocean basins.

(11) Science concepts. The student knows that dynamic and complex interactions among Earth's systems produce climate and weather. The student is expected to:

(A) analyze how energy transfer through Milankovitch cycles, albedo, and differences in atmospheric and surface absorption are mechanisms of climate;

(B) describe how Earth's atmosphere is chemically and thermally stratified and how solar radiation interacts with the layers to cause the ozone layer, the jet stream, Hadley and Ferrel cells, and other atmospheric phenomena;

(C) model how greenhouse gases trap thermal energy near Earth's surface;

(D) evaluate how the combination of multiple feedback loops alter global climate;

(E) investigate and analyze evidence for climate changes over Earth's history using paleoclimate data, historical records, and measured greenhouse gas levels;

(F) explain how the transfer of thermal energy among the hydrosphere, lithosphere, and atmosphere influences weather; and

(G) describe how changing surface-ocean conditions, including El Niño-Southern Oscillation, affect global weather and climate patterns.

(12) Science concepts. The student understands how Earth's systems affect and are affected by human activities, including resource use and management. The student is expected to:

(A) evaluate the impact on humans of natural changes in Earth's systems such as earthquakes, tsunamis, and volcanic eruptions;

(B) analyze the impact on humans of naturally occurring extreme weather events such as flooding, hurricanes, tornadoes, and thunderstorms;

(C) analyze the natural and anthropogenic factors that affect the severity and frequency of extreme weather events and the hazards associated with these events;

(D) analyze recent global ocean temperature data to predict the consequences of changing ocean temperature on evaporation, sea level, algal growth, coral bleaching, and biodiversity;

(E) predict how human use of Texas's naturally occurring resources such as fossil fuels, minerals, soil, solar energy, and wind energy directly and indirectly changes the cycling of matter and energy through Earth's systems; and

(F) explain the cycling of carbon through different forms among Earth's systems and how biological processes have caused major changes to the carbon cycle in those systems over Earth's history.

(13) Science concepts. The student explores global policies and careers related to the life cycles of Earth's resources. The student is expected to:

(A) analyze the policies related to resources from discovery to disposal, including economics, health, technological advances, resource type, concentration and location, waste disposal and recycling, mitigation efforts, and environmental impacts; and

(B) explore global and Texas-based careers that involve the exploration, extraction, production, use, disposal, regulation, and protection of Earth's resources.

§112.50. Environmental Systems, Adopted 2021 (One Credit).

(a) General requirements. Students shall be awarded one credit for successful completion of this course. Prerequisite: one unit of high school biology. Recommended prerequisite: Integrated Physics and Chemistry, Chemistry, or concurrent enrollment in either course. This course is recommended for students in Grade 10, 11, or 12.

(b) Introduction.

(1) Environmental Systems. In Environmental Systems, students conduct laboratory and field investigations, use scientific methods during investigations, and make informed decisions using critical thinking and scientific problem solving. Students study a variety of topics that include biotic and abiotic factors in habitats, ecosystems and biomes, interrelationships among resources and an environmental system, sources and flow of energy through an environmental system, relationship between carrying capacity and changes in populations and ecosystems, natural changes in the environment, and human activities that impact the natural environment.

(2) Nature of science. Science, as defined by the National Academy of Sciences, is the "use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process." This vast body of changing and increasing knowledge is described by physical, mathematical, and conceptual models. Students should know that some questions are outside the realm of science because they deal with phenomena that are not currently scientifically testable.

(3) Scientific hypotheses and theories. Students are expected to know that:

(A) hypotheses are tentative and testable statements that must be capable of being supported or not supported by observational evidence. Hypotheses of durable explanatory power that have been tested over a wide variety of conditions are incorporated into theories; and

(B) scientific theories are based on natural and physical phenomena and are capable of being tested by multiple independent researchers. Unlike hypotheses, scientific theories are well established and highly reliable explanations, but they may be subject to change as new areas of science and new technologies are developed.

(4) Scientific inquiry. Scientific inquiry is the planned and deliberate investigation of the natural world using scientific and engineering practices. Scientific methods of investigation are descriptive, comparative, or experimental. The method chosen should be appropriate to the question being asked. Student learning for different types of investigations include descriptive investigations, which involve collecting data and recording observations without making comparisons; comparative investigations, which involve collecting data with variables that are manipulated to compare results; and experimental investigations, which involve processes similar to comparative investigations but in which a control is identified.

(A) Scientific practices. Students should be able to ask questions, plan and conduct investigations to answer questions, and explain phenomena using appropriate tools and models.

(B) Engineering practices. Students should be able to identify problems and design solutions using appropriate tools and models.

(5) Science and social ethics. Scientific decision making is a way of answering questions about the natural world involving its own set of ethical standards about how the process of science should be carried out. Students should be able to distinguish between scientific decision-making methods (scientific methods) and ethical and social decisions that involve science (the application of scientific information).

(6) Science consists of recurring themes and making connections between overarching concepts. Recurring themes include systems, models, and patterns. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested, while models allow for boundary specification and provide tools for understanding the ideas presented. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.

(7) Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(c) Knowledge and skills.

(1) Scientific and engineering practices. The student, for at least 40% of instructional time, asks questions, identifies problems, and plans and safely conducts classroom, laboratory, and field investigations to explain phenomena or design solutions using appropriate tools and models. The student is expected to:

(A) ask questions and define problems based on observations or information from text, phenomena, models, or investigations;

(B) apply scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems;

(C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards;

(D) use appropriate tools such as meter sticks, metric rulers, pipettes, graduated cylinders, standard laboratory glassware, balances, timing devices, pH meters or probes, various data collecting probes, thermometers, calculators, computers, internet access, turbidity testing devices, hand magnifiers, work and disposable gloves, compasses, first aid kits, binoculars, field guides, water quality test kits or probes, soil test kits or probes, 30 meter tape measures, tarps, shovels, trowels, screens, buckets, rock and mineral samples equipment, air quality testing devices, cameras, flow meters, Global Positioning System (GPS) units, Geographic Information System (GIS) software, computer models, densiometers, spectrophotometers, stereomicroscopes, compound microscopes, clinometers, field journals, various prepared slides, hand lenses, hot plates, Petri dishes, sampling nets, waders, leveling grade rods (Jason sticks), protractors, inclination and height distance calculators, samples of biological specimens or structures, core sampling equipment, and kick nets;

(E) collect quantitative data using the International System of Units (SI) and qualitative data as evidence;

(F) organize quantitative and qualitative data using probeware, spreadsheets, lab notebooks or journals, models, diagrams, graphs paper, computers, or cellphone applications;

(G) develop and use models to represent phenomena, systems, processes, or solutions to engineering problems; and

(H) distinguish between scientific hypotheses, theories, and laws.

(2) Scientific and engineering practices. The student analyzes and interprets data to derive meaning, identify features and patterns, and discover relationships or correlations to develop evidence-based arguments or evaluate designs. The student is expected to:

(A) identify advantages and limitations of models such as their size, scale, properties, and materials;

(B) analyze data by identifying significant statistical features, patterns, sources of error, and limitations;

(C) use mathematical calculations to assess quantitative relationships in data; and

(D) evaluate experimental and engineering designs.

(3) Scientific and engineering practices. The student develops evidence-based explanations and communicates findings, conclusions, and proposed solutions. The student is expected to:

(A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories;

(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats; and

(C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence.

(4) Scientific and engineering practices. The student knows the contributions of scientists and recognizes the importance of scientific research and innovation on society. The student is expected to:

(A) analyze, evaluate, and critique scientific explanations and solutions by using empirical evidence, logical reasoning, and experimental and observational testing, so as to encourage critical thinking by the student;

(B) relate the impact of past and current research on scientific thought and society, including research methodology, cost-benefit analysis, and contributions of diverse scientists as related to the content; and

(C) research and explore resources such as museums, planetariums, observatories, libraries, professional organizations, private companies, online platforms, and mentors employed in a science, technology, engineering, and mathematics (STEM) field in order to investigate STEM careers.

(5) Science concepts. The student knows the relationships of biotic and abiotic factors within habitats, ecosystems, and biomes. The student is expected to:

(A) identify native plants and animals within a local ecosystem and compare their roles to those of plants and animals in other biomes, including aquatic, grassland, forest, desert, and tundra;

(B) explain the cycling of water, phosphorus, carbon, silicon, and nitrogen through ecosystems, including sinks and human interactions that alter these cycles, using tools such as models;

(C) evaluate the effects of fluctuations in abiotic factors on local ecosystems and local biomes;

(D) measure the concentration of dissolved substances such as dissolved oxygen, chlorides, and nitrates and describe their impacts on an ecosystem;

(E) use models to predict how the introduction of an invasive species may alter the food chain and affect existing populations in an ecosystem;

(F) use models to predict how species extinction may alter the food chain and affect existing populations in an ecosystem; and

(G) predict changes that may occur in an ecosystem if genetic diversity is increased or decreased.

(6) Science concepts. The student knows the interrelationships among the resources within the local environmental system. The student is expected to:

(A) compare and contrast land use and management methods and how they affect land attributes such as fertility, productivity, economic value, and ecological stability;

(B) relate how water sources, management, and conservation affect water uses and quality;

(C) document the use and conservation of both renewable and non-renewable resources as they pertain to sustainability;

(D) identify how changes in limiting resources such as water, food, and energy affect local ecosystems;

(E) analyze and evaluate the economic significance and interdependence of resources within the local environmental system; and

(F) evaluate the impact of waste management methods such as reduction, reuse, recycling, upcycling, and composting on resource availability in the local environment.

(7) Science concepts. The student knows the sources and flow of energy through an environmental system. The student is expected to:

(A) describe the interactions between the components of the geosphere, hydrosphere, cryosphere, atmosphere, and biosphere;

(B) relate biogeochemical cycles to the flow of energy in ecosystems, including energy sinks such as oil, natural gas, and coal deposits;

(C) explain the flow of heat energy in an ecosystem, including conduction, convection, and radiation; and

(D) identify and describe how energy is used, transformed, and conserved as it flows through ecosystems.

(8) Science concepts. The student knows the relationship between carrying capacity and changes in populations and ecosystems. The student is expected to:

(A) compare exponential and logistical population growth using graphical representations;

(B) identify factors that may alter carrying capacity such as disease; natural disaster; available food, water, and livable space; habitat fragmentation; and periodic changes in weather;

(C) calculate changes in population size in ecosystems; and

(D) analyze and make predictions about the impact on populations of geographic locales due to diseases, birth and death rates, urbanization, and natural events such as migration and seasonal changes.

(9) Science concepts. The student knows that environments change naturally. The student is expected to:

(A) analyze and describe how natural events such as tectonic movement, volcanic events, fires, tornadoes, hurricanes, flooding, and tsunamis affect natural populations;

(B) explain how regional changes in the environment may have global effects;

(C) examine how natural processes such as succession and feedback loops can restore habitats and ecosystems;

(D) describe how temperature inversions have short-term and long-term effects, including El Niño and La Niña oscillations, ice cap and glacial melting, and changes in ocean surface temperatures; and

(E) analyze the impact of natural global climate change on ice caps, glaciers, ocean currents, and surface temperatures.

(10) Science concepts. The student knows how humans impact environmental systems through emissions and pollutants. The student is expected to:

(A) identify sources of emissions in air, soil, and water, including point and nonpoint sources;

(B) distinguish how an emission becomes a pollutant based on its concentration, toxicity, reactivity, and location within the environment;

(C) investigate the effects of pollutants such as chlorofluorocarbons, greenhouse gases, pesticide runoff, nuclear waste, aerosols, metallic ions, and heavy metals, as well as thermal, light, and noise pollution;

(D) evaluate indicators of air, soil, and water quality against regulatory standards to determine the health of an ecosystem; and

(E) distinguish between the causes and effects of global warming and ozone depletion, including the causes, the chemicals involved, the atmospheric layer, the environmental effects, the human health effects, and the relevant wavelengths on the electromagnetic spectrum (IR and UV).

(11) Science concepts. The student understands how individual and collective actions impact environmental systems. The student is expected to:

(A) evaluate the negative effects of human activities on the environment, including overhunting, overfishing, ecotourism, all-terrain vehicles, and personal watercraft;

(B) evaluate the positive effects of human activities on the environment, including habitat restoration projects, species preservation efforts, nature conservancy groups, game and wildlife management, and ecotourism; and

(C) research the advantages and disadvantages of "going green" such as organic gardening and farming, natural methods of pest control, hydroponics, xeriscaping, energy-efficient homes and appliances, and hybrid cars.

(12) Science concepts. The student understands how ethics and economic priorities influence environmental decisions. The student is expected to:

(A) evaluate cost-benefit trade-offs of commercial activities such as municipal development, food production, deforestation, over-harvesting, mining, and use of renewable and non-renewable energy sources;

(B) evaluate the economic impacts of individual actions on the environment such as overbuilding, habitat destruction, poaching, and improper waste disposal;

(C) analyze how ethical beliefs influence environmental scientific and engineering practices such as methods for food production, water distribution, energy production, and the extraction of minerals;

(D) discuss the impact of research and technology on social ethics and legal practices in situations such as the design of new buildings, recycling, or emission standards; and

(E) argue from evidence whether or not a healthy economy and a healthy environment are mutually exclusive.

(13) Science concepts. The student knows how legislation mediates human impacts on the environment. The student is expected to:

(A) describe past and present state and national legislation, including Texas automobile emissions regulations, the National Park Service Act, the Clean Air Act, the Clean Water Act, the Soil and Water Resources Conservation Act, and the Endangered Species Act; and

(B) evaluate the goals and effectiveness of past and present international agreements such as the environmental Antarctic Treaty System, the Montreal Protocol, the Kyoto Protocol, and the Paris Climate Accord.

§112.51. Specialized Topics in Science, Adopted 2021 (One Credit).

(a) General requirements. Students shall be awarded one credit for successful completion of this course. Students may repeat this course with different course content for up to three credits. Recommended prerequisite: one credit of high school science.

(b) Introduction.

(1) Specialized Topics in Science is intended to diversify programs of science study and give students the opportunity to study scientific topics in greater detail and with deeper understanding rather than provide remediation.

(A) In Specialized Topics in Science, students have the opportunity to develop greater understanding of science content beyond what is taught in other Texas Essential Knowledge and Skills-based science courses while utilizing science and engineering practices. Students understand the value and role of curiosity in any discipline of science. The specialized topic of study may originate from local or global phenomena, student interest, or teacher specialties. The emphasis of study may vary such as theoretical science, citizen science, science investigations, science careers, specialized disciplines of science, designing innovations, the ethics of science, or history of science.

(B) By the end of Grade 12, students are expected to gain sufficient knowledge of the scientific and engineering practices across the disciplines of science to make informed decisions using critical thinking and scientific problem solving.

(2) Statements containing the word "including" reference content that must be mastered, while those containing the phrase "such as" are intended as possible illustrative examples.

(c) Knowledge and skills.

(1) Scientific and engineering practices. The student, for at least 40% of instructional time, asks questions, identifies problems, and plans and safely conducts classroom, laboratory, and field investigations to explain phenomena or design solutions using appropriate tools and models. The student is expected to:

(A) ask questions and define problems related to specialized topics of study based on observations or information from text, phenomena, models, or investigations;

(B) apply science practices related to specialized topics of study to plan and conduct investigations or use engineering practices to design solutions to problems;

(C) use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards;

(D) use tools appropriate to the specialized topic of study;

(E) collect quantitative data using the International System of Units (SI) or qualitative data as evidence as appropriate to the specialized topic of study;

(F) organize quantitative or qualitative data using representations appropriate to the specialized topic of study such as scatter plots, line graphs, bar graphs, charts, data tables, diagrams, scientific drawings, and student-prepared models;

(G) develop and use models to represent phenomena, systems, processes, or solutions to problems as appropriate to the specialized topic of study; and

(H) distinguish among scientific hypotheses, theories, and laws as appropriate to the specialized topic of study.

(2) Scientific and engineering practices. The student analyzes and interprets data to derive meaning, identify features and patterns, and discover relationships or correlations to develop evidence-based arguments or evaluate designs. The student is expected to:

(A) identify advantages and limitations of models such as their size, scale, properties, and materials as appropriate to the specialized topic of study;

(B) analyze data appropriate to the specialized topic of study by identifying significant statistical features, patterns, sources of error, and limitations;

(C) use mathematical calculations to assess quantitative relationships in data as appropriate to the specialized topic of study; and

(D) evaluate experimental or engineering designs as appropriate to the specialized topic of study.

(3) Scientific and engineering practices. The student develops evidence-based explanations and communicates findings, conclusions, or proposed solutions. The student is expected to:

(A) develop explanations or propose solutions supported by data and models and consistent with scientific ideas, principles, and theories as appropriate to the specialized topic of study;

(B) communicate explanations or solutions individually and collaboratively in a variety of settings and formats as appropriate to the specialized topic of study; and

(C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence as appropriate to the specialized topic of study.

(4) Scientific and engineering practices. The student knows the contributions of scientists and recognizes the importance of scientific research and innovation on society. The student is expected to:

(A) analyze, evaluate, and critique scientific explanations and solutions by using empirical evidence, logical reasoning, and experimental or observational testing as appropriate to the specialized topic of study, so as to encourage critical thinking by the student;

(B) relate the impact of past and current research on scientific thought and society, including research methodology, cost-benefit analysis, and contributions of diverse scientists as appropriate to the specialized topic of study; and

(C) research and explore resources such as museums, libraries, professional organizations, private companies, online platforms, and mentors employed in a science, technology, engineering, and mathematics (STEM) field in order to investigate STEM careers as appropriate to the specialized topic of study.