



Cogno Board Games' Alignment with the American Academy for the Advancement of Science's Project 2061 Benchmarks

The American Association for the Advancement of Science (AAAS) founded Project 2061 in 1985 to help all Americans become literate in science, mathematics, and technology. With its 1989 landmark publication *Science for All Americans*, Project 2061 set out recommendations for what all students should know and be able to do in science, mathematics, and technology by the time they graduate from high school. *Science for All Americans* laid the groundwork for the nationwide science standards movement of the 1990s. *Benchmarks for Science Literacy*, published in 1993, translated the science literacy goals in *Science for All Americans* into learning goals or benchmarks for grades K–12.

Highlighting Key

Indicates a significant amount of material addresses the standard

Indicates a moderate amount of material is present to develop student understanding of the standard

The Nature of Science: The Scientific Worldview, Scientific Inquiry, The Scientific Enterprise

The Scientific Worldview

By the end of the 5th grade, students should know that

- Sometimes similar investigations give different results because of differences in the things being investigated, the methods used, or the circumstances in which the investigation is carried out, and sometimes just because of uncertainties in observations. It is not always easy to tell which. 1A/E1*
- Science is a process of trying to figure out how the world works by making careful observations and trying to make sense of those observations. 1A/E2**

By the end of the 8th grade, students should know that

- When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, and it often takes further studies to decide. 1A/M1a
- Even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as correct. 1A/M1b
- Scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way. 1A/M2

- Some scientific knowledge is very old and yet is still applicable today. 1A/M3
- Some matters cannot be examined usefully in a scientific way. Among them are matters that by their nature cannot be tested against observations. 1A/M4ab*
- Science can sometimes be used to inform ethical decisions by identifying the likely consequences of particular actions, but science cannot be used by itself to establish that an action is moral or immoral. 1A/M4c*

Scientific Inquiry

By the end of the 5th grade, students should know that

- Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. 1B/E1*
- Because we expect science investigations that are done the same way to produce the same results, when they do not, it is important to try to figure out why. 1B/E2a*
- Scientists' explanations about what happens in the world come partly from what they observe, partly from what they think. 1B/E3a
- Sometimes scientists have different explanations for the same set of observations. That usually leads to their making more observations to resolve the differences. 1B/E3bc
- Scientists do not pay much attention to claims about how something they know about works unless the claims are backed up with evidence that can be confirmed, along with a logical argument. 1B/E4

By the end of the 8th grade, students should know that

- Scientists differ greatly in what phenomena they study and how they go about their work. 1B/M1a
- Scientific investigations usually involve the collection of relevant data, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected data. 1B/M1b*

The Scientific Enterprise

By the end of the 5th grade, students should know that

- Science is an adventure that people everywhere can take part in, as they have for many centuries. 1C/E1
- Clear communication is an essential part of doing science. It enables scientists to inform others about their work, expose their ideas to criticism by other scientists, and stay informed about scientific discoveries around the world. 1C/E2
- Doing science involves many different kinds of work and engages men and women of all ages and backgrounds. 1C/E3
- Many social practices and products of technology are shaped by scientific knowledge. 1C/E4**

By the end of the 8th grade, students should know that

- Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times. 1C/M1
- No matter who does science and mathematics or invents things, or when or where they do it, the knowledge and technology that result can eventually become available to everyone in the world. 1C/M3
- Computers have become invaluable in science, mathematics, and technology because they speed up and extend people's ability to collect, store, compile, and analyze data; prepare research reports; and share data and ideas with investigators all over the world. 1C/M6*
- Scientists are linked to other scientists worldwide both personally and through international scientific organizations. 1C/M9** (BSL)

The Nature of Mathematics: Patterns and Relationships, Mathematics, Science, and Technology, Mathematical Inquiry

Patterns and Relationships

By the end of the 5th grade, students should know that

- Mathematics is the study of quantity and shape and is useful for describing events and solving practical problems. 2A/E1*

Mathematics, Science, and Technology

By the end of the 8th grade, students should know that

- Mathematics is helpful in almost every kind of human endeavor—from laying bricks to prescribing medicine or drawing a face. 2B/M1*

Mathematical Inquiry

By the end of the 5th grade, students should know that

- Quantities and shapes can be used to describe objects and events in the world around us. 2C/E1*

By the end of the 8th grade, students should know that

- Mathematicians often represent things with abstract ideas, such as numbers or perfectly straight lines, and then work with those ideas alone. The "things" from which they abstract can be ideas themselves (for example, a proposition about "all equal-sided triangles" or "all odd numbers"). 2C/M1
- Using mathematics to solve a problem requires choosing what mathematics to use; probably making some simplifying assumptions, estimates, or approximations; doing computations; and then checking to see whether the answer makes sense. 2C/M2b

The Nature of Technology: Technology & Science, Design & Systems, Issues in Technology

Technology and Science

By the end of the 5th grade, students should know that

- Technology enables scientists and others to observe things that are too small or too far away to be seen otherwise and to study the motion of objects that are moving very rapidly or are hardly moving at all. 3A/E2
- Measuring instruments can be used to gather accurate information for making scientific comparisons of objects and events and for designing and constructing things that will work properly. 3A/E3
- Technology extends the ability of people to change the world: to cut, shape, or put together materials; to move things from one place to another; and to reach farther with their hands, voices, senses, and minds. The changes may be for survival needs such as food, shelter, and defense; for communication and transportation; or to gain knowledge and express ideas. 3A/E4

By the end of the 8th grade, students should know that

- In earlier times, the accumulated information and techniques of each generation of workers were taught on the job directly to the next generation of workers. Today, the knowledge base for technology can be found as well in libraries of print and electronic resources and is often taught in the classroom. 3A/M1
- Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information. 3A/M2
- Engineers, architects, and others who engage in design and technology use scientific knowledge to solve practical problems. They also usually have to take human values and limitations into account. 3A/M3*

Design and Systems

By the end of the 5th grade, students should know that

- There is no perfect design. Designs that are best in one respect (safety or ease of use, for example) may be inferior in other ways (cost or appearance). Usually some features must be sacrificed to get others. 3B/E1*
- Even a good design may fail. Sometimes steps can be taken ahead of time to reduce the likelihood of failure, but it cannot be entirely eliminated. 3B/E2
- The solution to one problem may create other problems. 3B/E3

By the end of the 8th grade, students should know that

- Design usually requires taking into account not only physical and biological constraints, but also economic, political, social, ethical, and aesthetic ones. 3B/M1*

Issues in Technology

By the end of the 5th grade, students should know that

- Like language, ritual, commerce, and the arts, technology is an intrinsic part of human culture, and it both shapes society and is shaped by it. 3C/E1b
- The technology available to people greatly influences what their lives are like. 3C/E1c
- Any invention is likely to lead to other inventions. Once an invention exists, people are likely to think up ways of using it that were never imagined at first. 3C/E2
- Factors such as cost, safety, appearance, environmental impact, and what will happen if the solution fails must be considered in technological design. 3C/E4*
- Because of their ability to invent tools and processes, people have an enormous effect on the lives of other living things. 3C/E6

By the end of the 8th grade, students should know that

- The human ability to shape the future comes from a capacity for generating knowledge and developing new technologies—and for communicating ideas to others. 3C/M1
- Technology cannot always provide successful solutions to problems or fulfill all human needs. 3C/M2*
- Throughout history, people have carried out impressive technological feats, some of which would be hard to duplicate today even with modern tools. The purposes served by these achievements have sometimes been practical, sometimes ceremonial. 3C/M3
- Rarely are technology issues simple and one-sided. Relevant facts alone, even when known and available, usually do not settle matters. That is because contending groups may have different values and priorities. They may stand to gain or lose in different degrees, or may make very different predictions about what the future consequences of the proposed action will be. 3C/M6*
- Societies influence what aspects of technology are developed and how these are used. People control technology (as well as science) and are responsible for its effects. 3C/M7
- Scientific laws, engineering principles, properties of materials, and construction techniques must be taken into account in designing engineering solutions to problems. 3C/M8** (BSL)

The Physical Setting: The Universe, The Earth, Processes that Shape the Earth, The Structure of Matter, Energy Transformations, Motion, Forces of Nature

The Universe

By the end of the 5th grade, students should know that

- The patterns of stars in the sky stay the same, although they appear to move across the sky nightly, and different stars can be seen in different seasons. 4A/E1

- Telescopes magnify the appearance of some distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye. 4A/E2
- Planets change their positions against the background of stars. 4A/E3
- The earth is one of several planets that orbit the sun, and the moon orbits around the earth. 4A/E4
- Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light. 4A/E5
- A large light source at a great distance looks like a small light source that is much closer. 4A/E6** (BSL)

By the end of the 8th grade, students should know that

- The sun is a medium-sized star located near the edge of a disc-shaped galaxy of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night. 4A/M1a
- The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot. 4A/M1bc
- The sun is many thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth, but light from the next nearest star takes a few years to arrive. The trip to that star would take the fastest rocket thousands of years. 4A/M2abc
- Some distant galaxies are so far away that their light takes several billion years to reach the earth. People on earth, therefore, see them as they were that long ago in the past. 4A/M2de
- Nine planets of very different size, composition, and surface features move around the sun in nearly circular orbits. Some planets have a variety of moons and even flat rings of rock and ice particles orbiting around them. Some of these planets and moons show evidence of geologic activity. The earth is orbited by one moon, many artificial satellites, and debris. 4A/M3

The Earth

By the end of the 5th grade, students should know that

- Things on or near the earth are pulled toward it by the earth's gravity. 4B/E1
- The earth is approximately spherical in shape. Like the earth, the sun and planets are spheres. 4B/E2a
- When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets or frozen crystals of water. 4B/E3*
- Air is a material that surrounds us and takes up space and whose movement we feel as wind. 4B/E4*
- The weather is always changing and can be described by measurable quantities such as temperature, wind direction and speed, and precipitation. Large masses of air with certain properties move across the surface of the earth. The movement and interaction of these air masses is used to forecast the weather. 4B/E5** (NSES)

By the end of the 8th grade, students should know that

- The earth is mostly rock. Three-fourths of the earth's surface is covered by a relatively thin layer of water (some of it frozen), and the entire planet is surrounded by a relatively thin layer of air. 4B/M2ab*
- Earth is the only body in the solar system that appears able to support life. The other planets have compositions and conditions very different from the earth's. 4B/M2cd
- Everything on or anywhere near the earth is pulled toward the earth's center by gravitational force. 4B/M3

- Climates have sometimes changed abruptly in the past as a result of volcanic eruptions or impacts of huge rocks from space. 4B/M6*
- Fresh water, limited in supply, is essential for some organisms and industrial processes. Water in rivers, lakes, and underground can be depleted or polluted, making it unavailable or unsuitable for life. 4B/M8*
- Some material resources are very rare and some exist in great quantities. The ability to obtain and process resources depends on where they are located and the form they are in. As resources are depleted, they may become more difficult to obtain. 4B/M10ab*
- The atmosphere is a mixture of nitrogen, oxygen, and trace amounts of water vapor, carbon dioxide, and other gases. 4B/M15** (NSES)

Processes that Shape the Earth

By the end of the 5th grade, students should know that

- Waves, wind, water, and ice shape and reshape the earth's land surface by eroding rock and soil in some areas and depositing them in other areas, sometimes in seasonal layers. 4C/E1

By the end of the 8th grade, students should know that

- The interior of the earth is hot. Heat flow and movement of material within the earth cause earthquakes and volcanic eruptions and create mountains and ocean basins. Gas and dust from large volcanoes can change the atmosphere. 4C/M1
- The earth's plates sit on a dense, hot, somewhat melted layer of the earth. The plates move very slowly, pressing against one another in some places and pulling apart in other places, sometimes scraping alongside each other as they do. Mountains form as two continental plates, or an ocean plate and a continental plate, press together. 4C/M12** (BSL)

The Structure of Matter

By the end of the 5th grade, students should know that

- No matter how parts of an object are assembled, the weight of the whole object is always the same as the sum of the parts; and when an object is broken into parts, the parts have the same total weight as the original object. 4D/E2*
- Materials may be composed of parts that are too small to be seen without magnification. 4D/E3
- A lot of different materials can be made from a small number of basic kinds of materials. 4D/E5** (BSL)
- Substances may move from place to place, but they never appear out of nowhere and never just disappear. 4D/E8** (ASL)

By the end of the 8th grade, students should know that

- All matter is made up of atoms, which are far too small to see directly through a microscope. 4D/M1a
- Equal volumes of different materials usually have different masses. 4D/M2*
- Carbon and hydrogen are common elements of living matter. 4D/M6c*
- No matter how substances within a closed system interact with one another, or how they combine or break apart, the total mass of the system remains the same. 4D/M7a*
- The idea of atoms explains the conservation of matter: If the number of atoms stays the same no matter how the same atoms are rearranged, then their total mass stays the same. 4D/M7b

Energy Transformations

By the end of the 8th grade, students should know that

- Whenever energy appears in one place, it must have disappeared from another. Whenever energy is lost from somewhere, it must have gone somewhere else. Sometimes when

energy appears to be lost, it actually has been transferred to a system that is so large that the effect of the transferred energy is imperceptible. 4E/M1*

- Energy appears in different forms and can be transformed within a system. Motion energy is associated with the speed of an object. Thermal energy is associated with the temperature of an object. Gravitational energy is associated with the height of an object above a reference point. Elastic energy is associated with the stretching or compressing of an elastic object. Chemical energy is associated with the composition of a substance. Electrical energy is associated with an electric current in a circuit. Light energy is associated with the frequency of electromagnetic waves. 4E/M4*
- Light and other electromagnetic waves can warm objects. How much an object's temperature increases depends on how intense the light striking its surface is, how long the light shines on the object, and how much of the light is absorbed. 4E/M6**

Motion

By the end of the 5th grade, students should know that

- Changes in speed or direction of motion are caused by forces. 4F/E1a
- The greater the force is, the greater the change in motion will be. The more massive an object is, the less effect a given force will have. 4F/E1bc
- How fast things move differs greatly. Some things are so slow that their journey takes a long time; others move too fast for people to even see them. 4F/E2
- Light travels and tends to maintain its direction of motion until it interacts with an object or material. Light can be absorbed, redirected, bounced back, or allowed to pass through. 4F/E3** (ASL)

By the end of the 8th grade, students should know that

- Light from the sun is made up of a mixture of many different colors of light, even though to the eye the light looks almost white. Other things that give off or reflect light have a different mix of colors. 4F/M1
- Something can be "seen" when light waves emitted or reflected by it enter the eye—just as something can be "heard" when sound waves from it enter the ear. 4F/M2
- An unbalanced force acting on an object changes its speed or direction of motion, or both. 4F/M3a
- If a force acts towards a single center, the object's path may curve into an orbit around the center. 4F/M3b
- Vibrations in materials set up wavelike disturbances that spread away from the source. Sound and earthquake waves are examples. These and other waves move at different speeds in different materials. 4F/M4
- Human eyes respond to only a narrow range of wavelengths of electromagnetic waves—visible light. Differences of wavelength within that range are perceived as differences of color. 4F/M5*
- Light acts like a wave in many ways. And waves can explain how light behaves. 4F/M6** (ASL)
- There are a great variety of electromagnetic waves: radio waves, microwaves, infrared waves, visible light, ultraviolet rays, X-rays, and gamma rays. These wavelengths vary from radio waves, the longest, to gamma rays, the shortest. 4F/M8** (BSL)

Forces of Nature

By the end of the 5th grade, students should know that

- The earth's gravity pulls any object on or near the earth toward it without touching it. 4G/E1*
- Without touching them, a magnet pulls on all things made of iron and either pushes or pulls on other magnets. 4G/E2
- Without touching them, an object that has been electrically charged pulls on all other uncharged objects and may either push or pull other charged objects. 4G/E3*

By the end of the 8th grade, students should know that

- Every object exerts gravitational force on every other object. The force depends on how much mass the objects have and on how far apart they are. The force is hard to detect unless at least one of the objects has a lot of mass. 4G/M1
- The sun's gravitational pull holds the earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them. 4G/M2
- A charged object can be charged in one of two ways, which we call either positively charged or negatively charged. Two objects that are charged in the same manner exert a force of repulsion on each other, while oppositely charged objects exert a force of attraction on each other. 4G/M5** (BSL)

The Living Environment: Diversity of Life, Heredity, Cells, Interdependence of Life, Flow of Matter and Energy, Evolution of Life

Diversity of Life

By the end of the 5th grade, students should know that

- A great variety of kinds of living things can be sorted into groups in many ways using various features to decide which things belong to which group. 5A/E1
- There are millions of different kinds of individual organisms that inhabit the earth at any one time—some very similar to each other, some very different. 5A/E3** (SFAA)

By the end of the 8th grade, students should know that

- One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy-rich foods. Some kinds of organisms, many of them microscopic, cannot be neatly classified as either plants or animals. 5A/M1

Heredity

By the end of the 8th grade, students should know that

- In sexual reproduction, a single specialized cell from a female merges with a specialized cell from a male. 5B/M2a

Cells

By the end of the 5th grade, students should know that

- Some living things consist of a single cell. Like familiar organisms, they need food, water, and air; a way to dispose of waste; and an environment they can live in. 5C/E1

By the end of the 8th grade, students should know that

- About two thirds of the weight of cells is accounted for by water, which gives cells many of their properties. 5C/M4

Interdependence of Life

By the end of the 5th grade, students should know that

- For any particular environment, some kinds of plants and animals thrive, some do not live as well, and some do not survive at all. 5D/E1*
- Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful. 5D/E4
- Most microorganisms do not cause disease, and many are beneficial. 5D/E5

By the end of the 8th grade, students should know that

- In all environments, organisms with similar needs may compete with one another for limited resources, including food, space, water, air, and shelter. 5D/M1a*
- The world contains a wide diversity of physical conditions, which creates a wide variety of environments: freshwater, marine, forest, desert, grassland, mountain, and others. In any

particular environment, the growth and survival of organisms depend on the physical conditions. 5D/M1b*

Flow of Matter and Energy

By the end of the 5th grade, students should know that

- Almost all kinds of animals' food can be traced back to plants. 5E/E1
- Some source of "energy" is needed for all organisms to stay alive and grow. 5E/E2

By the end of the 8th grade, students should know that

- Food provides molecules that serve as fuel and building material for all organisms. 5E/M1a
- Plants use the energy from light to make sugars from carbon dioxide and water. 5E/M1b
- Over a long time, matter is transferred from one organism to another repeatedly and between organisms and their physical environment. As in all material systems, the total amount of matter remains constant, even though its form and location change. 5E/M2
- Energy can change from one form to another in living things. 5E/M3a
- Almost all food energy comes originally from sunlight. 5E/M3c

Evolution of Life

By the end of the 8th grade, students should know that

- Most species that have lived on the earth are now extinct. Extinction of species occurs when the environment changes and the individual organisms of that species do not have the traits necessary to survive and reproduce in the changed environment. 5F/M4** (NSES)

The Human Organism: Human Identity, Human Development, Basic Functions, Learning, Physical Health, Mental Health

Human Identity

By the end of the 5th grade, students should know that

- Human beings have made tools and machines to sense and do things that they could not otherwise sense or do at all, as quickly, or as well. 6A/E2*

By the end of the 8th grade, students should know that

- Human beings use technology to match or exceed many of the abilities of other species. 6A/M5a*
- Technologies having to do with food production, sanitation, and health care have dramatically changed how people live and work and have resulted in rapid increases in the human population. 6A/M6*

Basic Functions

By the end of the 5th grade, students should know that

- The brain gets signals from all parts of the body telling it what is going on there. The brain also sends signals to parts of the body to influence what they do. 6C/E4*

Learning

By the end of the 5th grade, students should know that

- Learning means using what one already knows to make sense out of new experiences or information, not just storing the new information in one's head. 6D/E5

By the end of the 8th grade, students should know that

- Some animal species are limited to a repertoire of genetically determined behaviors; others have more complex brains and can learn and modify a wide variety of behaviors. 6D/M1a
- Language and tools enable human beings to learn complicated and varied things from others. 6D/M6

Human Society: Cultural Effects on Behavior, Group Behavior, Social Change, Social Trade-Offs, Political and Economic Systems, Social Conflict, Global Interdependence

Social Trade-Offs

By the end of the 5th grade, students should know that

- In making decisions, it helps to take time to consider benefits and drawbacks of alternatives. 7D/E1

The Designed World: Agriculture, Materials and Manufacturing, Energy Sources and Use, Communication, Information Processing, Health Technology

Agriculture

By the end of the 8th grade, students should know that

- People control some characteristics of plants and animals they raise by selective breeding. 8A/M2a
- In all technologies, there are always trade-offs to be made. 8A/M3a

Materials and Manufacturing

By the end of the 8th grade, students should know that

- The choice of materials for a job depends on their properties. 8B/M1*

Energy Sources and Use

By the end of the 5th grade, students should know that

- Sunlight is used to run many devices. 8C/E2*

By the end of the 8th grade, students should know that

- Transformations and transfers of energy within a system usually result in some energy escaping into its surrounding environment. Some systems transfer less energy to their environment than others during these transformations and transfers. 8C/M1*
- People have invented ingenious ways of deliberately bringing about energy transformations that are useful to them. 8C/M8** (SFAA)
- By burning fuels, people are releasing large amounts of carbon dioxide into the atmosphere and transforming chemical energy into thermal energy which spreads throughout the environment. 8C/M11** (BSL)

Communication

By the end of the 5th grade, students should know that

- Communication involves coding and decoding information. In any language, both the sender and receiver have to know the same code, which means that secret codes can be used to keep communication private. 8D/E2
- Communication technologies make it possible to send and receive information more and more reliably, quickly, and cheaply over long distances. 8D/E4

By the end of the 8th grade, students should know that

- Information can be carried by many media, including sound, light, and objects. In the 1900s, the ability to code information as electric currents in wires, electromagnetic waves in space, and light in glass fibers has made communication millions of times faster than mail or sound. 8D/M2

Information Processing

By the end of the 5th grade, students should know that

- Computers can be programmed to store, retrieve, and perform operations on information. These operations include mathematical calculations, word processing, diagram drawing, and modeling complex events. 8E/E2

Health Technology

By the end of the 8th grade, students should know that

- Many diseases are caused by bacteria or viruses. 8F/M5** (SFAA)

The Mathematical World: Numbers, Symbolic Relationships, Shapes, Uncertainty, Reasoning

Numbers

By the end of the 5th grade, students should know that

- Specifying a quantity requires both a number and a unit. 9A/E3*
- Symbols are used to signify which operations to perform on numbers. The most common are +, -, \times , and \div . 9A/E6** (SFAA)
- It is possible (and often useful) to estimate quantities without determining them exactly. 9A/E7** (BSL)

By the end of the 8th grade, students should know that

- The system of using the Arabic numerals 0-9 is just one way of representing numbers.

Symbolic Relationships

By the end of the 8th grade, students should know that

- Rates of change can be computed from differences in magnitudes and vice versa. 9B/M2*

Shapes

By the end of the 5th grade, students should know that

- Length can be thought of as unit lengths joined together, area as a collection of unit squares, and volume as a set of unit cubes. 9C/E1

By the end of the 8th grade, students should know that

- Some of the properties an object has depend on its shape: triangular shapes tend to make structures rigid, and spheres give the least possible boundary for a given amount of interior volume. 9C/M1*
- For regularly shaped objects, relationships exist between the linear dimensions, surface area, and volume. 9C/M7** (BSL)

Uncertainty

By the end of the 5th grade, students should know that

- Some predictions can be based on what is known about the past, assuming that conditions are pretty much the same now. 9D/E1
- Even very unlikely events may occur fairly often in very large populations. 9D/E3b

Reasoning

By the end of the 5th grade, students should know that

- One way to think about something is to compare it to something more familiar. 9E/E1*
- The claims people make are sometimes based on how they feel about something rather than on what they observe. 9E/E2*

By the end of the 8th grade, students should know that

- If people have generalizations that always hold, and good information about a particular situation, then logic can help them to figure out what is true about it. This kind of formal logic requires care in the use of key words such as if, then, and, not, or, all, and some. 9E/M1*

- Sometimes people invent a generalization to summarize a set of observations. But sometimes people overgeneralize, imagining generalizations on the basis of too few observations. 9E/M3*

Historical Perspectives: Displacing the Earth from the Center of the Universe, Understanding Fire, Discovering Germs, Harnessing Power

Displacing the Earth from the Center of the Universe

By the end of the 8th grade, students should know that

- Because every object is moving relative to some other object, no object has a unique claim to be at rest. Therefore, the idea of absolute motion or rest is misleading. 10A/M1*
- Telescopes reveal that there are many more stars in the night sky than are evident to the unaided eye, the surface of the moon has many craters and mountains, the sun has dark spots, and Jupiter and some other planets have their own moons. 10A/M2

Discovering Germs

By the end of the 8th grade, students should know that

- Vaccines induce the body to build immunity to a disease without actually causing the disease itself. 10I/M3b

Common Themes: Systems, Models, Constancy and Change, Scale, Systems

Systems

By the end of the 5th grade, students should know that

- In something that consists of many parts, the parts usually influence one another. 11A/E1

By the end of the 8th grade, students should know that

- A system can include processes as well as things. 11A/M1
- Thinking about things as systems means looking for how every part relates to others.
- Any system is usually connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a sub-system of a larger system. 11A/M3

Models

By the end of the 5th grade, students should know that

- Geometric figures, number sequences, graphs, diagrams, sketches, number lines, maps, and oral and written descriptions can be used to represent objects, events, and processes in the real world. 11B/E2*
- A model of something is similar to, but not exactly like, the thing being modeled. Some models are physically similar to what they are representing, but others are not. 11B/E3** (SFAA)
- Models are very useful for communicating ideas about objects, events, and processes. When using a model to communicate about something, it is important to keep in mind how it is different from the thing being modeled. 11B/E4**

By the end of the 8th grade, students should know that

- Models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly. They are also used for processes that are too vast, too complex, or too dangerous to study. 11B/M1*
- A model can sometimes be used to get ideas about how the thing being modeled actually works, but there is no guarantee that these ideas are correct if they are based on the model alone. 11B/M6** (SFAA)

Constancy and Change

By the end of the 5th grade, students should know that

- Some features of things may stay the same even when other features change. 11C/E1*
- Things change in steady, repetitive, or erratic ways—or sometimes in more than one way at the same time. 11C/E2a*
- Some things in nature have a repeating pattern, such as the day-night cycle, the phases of the moon, and seasons. 11C/E4** (BSL)

By the end of the 8th grade, students should know that

- The way some systems behave is so erratic that patterns of change are not apparent. 11C/M8**
- Trends based on what has happened in the past can be used to make predictions about what things will be like in the future. However, these predictions may not always match what actually happens. 11C/M10**

Scale

By the end of the 8th grade, students should know that

- Some properties of an object depend on its length, some depend on its area, and some depend on its volume. 11D/M1*
- Natural phenomena often involve sizes, durations, and speeds that are extremely small or extremely large. These phenomena may be difficult to appreciate because they involve magnitudes far outside human experience. 11D/M3*

Habits of Mind: Values and Attitudes, Computation and Estimation, Manipulation and Observation, Communication Skills, Critical-Response Skills

Values and Attitudes

By the end of the 5th grade, students should

- Keep clear and accurate records of investigations and observations. 12A/E1*
- Offer reasons for claims and consider reasons suggested by others. 12A/E2*

By the end of the 8th grade, students should know that

- Hypotheses are valuable, even if they turn out not to be true, if they lead to fruitful investigations. 12A/M2
- Often different explanations can be given for the same observations, and it is not always possible to tell which one is correct. 12A/M3*

Computation and Estimation

By the end of the 5th grade, students should be able to

- Make calculations when necessary to solve real-world problems and decide whether to make the calculation mentally, on paper, or with the help of a calculator or computer. 12B/E1*
- Judge whether measurements and computations of quantities such as length, weight, or time are reasonable by comparing them to familiar values. 12B/E3
- State the purpose of each step in a calculation. 12B/E4
- Add or subtract any two whole numbers between 1 and 100. 12B/E6** (SFAA)
- Multiply any two whole numbers between 1 and 10 and multiply or divide any number by 2, 10, or 100. 12B/E7** (SFAA)
- Use a calculator to add, subtract, multiply, and divide any two whole or decimal numbers. 12B/E8** (SFAA)
- Use appropriate units when describing quantities. 12B/E9**
- Make rough estimates of numerical calculations and use them to judge whether the results of a calculation done on a calculator are reasonable. 12B/E11** (BSL)

By the end of the 8th grade, students should be able to

- Use, interpret, and compare numbers in several equivalent forms such as integers, fractions, decimals, and percents. 12B/M2
- Use the units of the inputs to a calculation to determine what units (such as seconds, square inches, or dollars per tankful) should be used in expressing an answer. 12B/M7a*
- Convert quantities expressed in one unit of measurement into another unit of measurement when necessary to solve a real-world problem. 12B/M7b*
- Estimate probabilities of outcomes in familiar situations on the basis of history or the number of possible outcomes. 12B/M10

Communication Skills

By the end of the 5th grade, students should be able to

- Give written and oral instructions that others can follow to carry out a procedure. 12D/E1*
- Use numerical data in describing and comparing objects and events. 12D/E3
- Interpret written descriptions of real-world objects and events. 12D/E6**

By the end of the 8th grade, students should be able to

- Locate information in reference books, back issues of newspapers and magazines, compact disks, and computer databases. 12D/M3
- Present a brief scientific explanation orally or in writing that includes a claim and the evidence and reasoning that supports the claim. 12D/M6**
- Seek to gain a better understanding of a scientific idea by asking for an explanation, restating an explanation in a different way, and asking questions when some aspect of an explanation is not clear. 12D/M7**
- Explain a scientific idea to someone else, checking understanding and responding to questions. 12D/M8**

Critical-Response Skills

By the end of the 5th grade, students should

- Buttress their statements with facts found in books, articles, and databases, and identify the sources used and expect others to do the same. 12E/E1
- Seek reasons for believing something rather than just claiming "Everybody knows that..." or "I just know" and discount such claims when made by others. 12E/E3*

By the end of the 8th grade, students should

- Notice and criticize the reasoning in arguments in which fact and opinion are intermingled. 12E/M5a
- Notice and criticize the reasoning in arguments in which the claims are not consistent with the evidence given. 12E/M5b*
- Be skeptical of claims based only on analogies. 12E/M5c*
- Be skeptical of arguments in which all members of a group (such as teenagers or chemists) are implied to have nearly identical characteristics that differ from those of other groups. 12E/M5e