

Earth & Space Learning Framework

The Earth & Space Learning Framework describes the intended actions of learners engaged with NISE Network hands-on activities and exhibition components based on the research, discoveries, and missions from NASA's Science Mission Directorate. The three principles of the Learning Framework—phenomena, process, and participation—support **six interrelated strands of learning** documented by the

National Research Council. To further illustrate each principle and its supporting statements, the following pages show example connections to the Explore Science: Earth & Space toolkits and the *Sun, Earth, Universe* exhibition. The Learning Framework is a companion to the Earth & Space Content Framework, which describes six ideas that represent a basic understanding of Earth and space science.



PRINCIPLES

Experience Earth and space **phenomena** and explore science findings

- Experiencing the joy of active learning, including play, discovery, invention, and experimentation
- Experiencing real phenomena, celestial events, and compelling imagery
- Exploring our place in the universe
- Investigating the big questions that drive Earth and space research



Exploring the Universe: Filtered Light

Use the scientific **process** and reflect on science as a way of knowing

- Using an iterative design process similar to engineering and scientific research
- Using a variety of tools and approaches to make discoveries
- Experiencing the power and limitations of data sets
- Making and using models to communicate and further our understanding
- Using our imagination and ingenuity to explore the universe



Exploring the Universe: Star Formation

Participate in the scientific community and identify as a science learner

- Working together in groups to accomplish goals and tackle challenges
- Exploring the relevance of Earth and space science
- Considering the social dimensions of Earth and space science
- Identifying as someone who learns about and sometimes participates in current research



Exploring the Solar System: Asteroid Mining

SUPPORTING STATEMENTS WITH EXAMPLE CONNECTIONS

STRANDS OF LEARNING

Developing interest in science: Experience excitement, interest, and motivation to learn about science

Understanding science knowledge: Generate, understand, and use explanations, arguments, models, and facts related to science

Engaging in scientific reasoning: Manipulate, predict, question, observe, and make sense of the natural and physical world

Reflecting on science: Reflect on science as a way of knowing and as a personal process of learning about phenomena

Engaging in scientific practice: Participate in scientific activities and learning practices with others using scientific language and tools

Identifying with the scientific enterprise: Develop an identity as someone who knows about, uses, and sometimes contributes to science



Earth & Space Product Matrix

The Earth & Space Product Matrix shows the alignment of NISE Network resources to the three principles of the Earth & Space Learning Framework as well as the six key science content ideas of the Earth & Space Content Framework, and includes the year each was added to

the Explore Science: Earth & Space Toolkits. The hands-on activities are listed in order of toolkit subcategories: Exploring Earth, Exploring Science Practices, Exploring the Solar System, and Exploring the Universe, with the *Sun, Earth, Universe* exhibition listed at the bottom.

	PRINCIPLES			TOOLKIT YEAR				CONTENT AREA					
	PHENOMENA	PROCESS	PARTICIPATE	2017	2018	2019	2020	SUN	EARTH	PLANETS	UNIVERSE	SOCIETY	FORCES + ENERGY
EXPLORING EARTH													
Exploring Earth: Bear's Shadow*	X			X			X	X	X				
Exploring Earth: Investigating Clouds	X	X	X	X			X		X			X	
Exploring Earth: Land Cover	X	X	X			X			X			X	X
Exploring Earth: Paper Mountains	X	X	X		X				X			X	X
Exploring Earth: Rising Sea		X	X	X		X			X			X	
Exploring Earth: Temperature Mapping	X	X				X		X	X			X	X
EXPLORING SCIENCE PRACTICES													
Exploring Science Practices: Early Explorations*	X	X					X		X				
Exploring Science Practices: Measure Up*	X	X					X		X				
EXPLORING THE SOLAR SYSTEM													
Exploring the Solar System: Asteroid Mining	X	X	X				X			X		X	
Exploring the Solar System: Big Sun, Small Moon	X	X		X				X	X				
Exploring the Solar System: Craters	X	X			X		X		X	X			X
Exploring the Solar System: Design, Build, Test		X	X				X					X	X
Exploring the Solar System: Hide and Seek Moon*	X	X	X		X	X			X			X	
Exploring the Solar System: Magnetic Fields	X	X			X			X	X	X			X
Exploring the Solar System: Mars Rovers		X	X		X					X		X	
Exploring the Solar System: Mission to Space		X	X				X	X	X	X	X	X	
Exploring the Solar System: Moonquakes	X	X					X		X	X			X
Exploring the Solar System: Observe the Moon	X	X	X				X	X	X				
Exploring the Solar System: Observe the Sun	X	X	X			X		X	X				X
Exploring the Solar System: Pocket Solar System		X		X		X				X		X	
Exploring the Solar System: Solar Eclipse	X	X		X				X	X				
Exploring the Solar System: Stomp Rockets		X	X		X	X						X	X
Exploring the Solar System: Story Blocks*		X	X				X					X	
EXPLORING THE UNIVERSE													
Exploring the Universe: Exoplanet Transits	X	X			X					X	X	X	X
Exploring the Universe: Expanding Universe	X	X				X					X		X
Exploring the Universe: Filtered Light	X	X			X	X					X		X
Exploring the Universe: Ice Orbs	X	X		X						X			
Exploring the Universe: Imagining Life		X	X	X					X	X		X	
Exploring the Universe: Nebula Spin Art	X	X					X				X		X
Exploring the Universe: Objects in Motion	X	X			X				X	X	X		X
Exploring the Universe: Orbiting Objects	X	X		X			X	X		X	X		X
Exploring the Universe: Pack a Space Telescope		X			X						X	X	X
Exploring the Universe: Space Guess Quest Game		X				X	X			X	X		
Exploring the Universe: Star Formation	X	X					X				X		X
Exploring the Universe: Static Electricity	X	X				X			X	X			X
<i>Sun, Earth, Universe</i> Exhibition	X	X	X					X	X	X	X	X	X

* These activities were specially designed for young learners.

Experience Earth and space phenomena and explore science findings

Experiencing the joy of active learning, including play, discovery, invention, and experimentation

Being excited by seeing or understanding something for the first time, regardless of content knowledge.

At the universe component of the *Sun, Earth, Universe* exhibition, visitors see just how small a speck of sky is represented in an image captured by the Hubble Space Telescope.



Sun, Earth, Universe exhibition

Recognizing that new knowledge or skills can come from working alone or in a group.

In *Exploring the Universe: Ice Orbs*, learners can explore their icy worlds themselves or compare and contrast with a group.



Exploring the Universe: Ice Orbs

Connecting and building on past and future experiences.

In *Exploring Earth: Bear's Shadow*, learners experiment with shadows while recalling how their own shadows look different depending on the time of day.



Exploring Earth: Bear's Shadow

Learning and overcoming common misconceptions about our planet Earth and the solar system.

In *Exploring the Solar System: Big Sun, Small Moon*, learners discover that the Sun and Moon only appear to be the same size from Earth, but are actually remarkably different in size.



Exploring the Solar System: Big Sun, Small Moon

Experience Earth and space phenomena and explore science findings

Experiencing real phenomena, celestial events, and compelling imagery

Appreciating that the universe can be very beautiful.

At the universe component of the *Sun, Earth, Universe* exhibition, visitors see a beautiful image of the Sombrero Galaxy taken by the Hubble Space telescope, and can take a closer look at the Hubble Deep Field image to discover the amazing variety of galaxies in the universe.



Sun, Earth, Universe exhibition



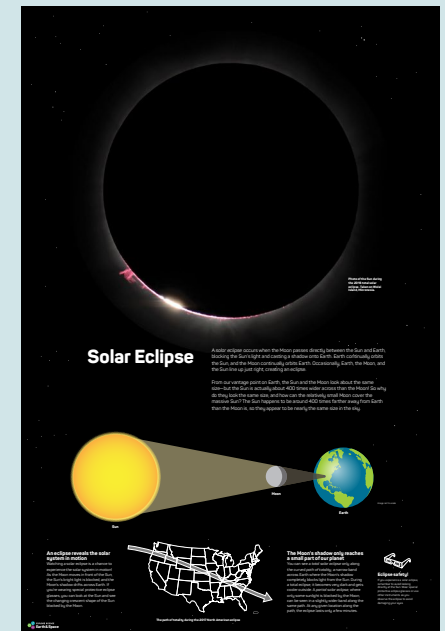
Exploring Earth: Investigating Clouds

Realizing that we can directly observe many phenomena related to Earth and space science.

In *Exploring Earth: Investigating Clouds*, learners observe a cloud forming when alcohol vapor condenses.

Understanding that being curious about celestial events can contribute to both personal and collective knowledge.

In *Exploring the Solar System: Solar Eclipse*, learners model a solar eclipse and use resources like the solar eclipse poster to gain more knowledge about future solar eclipses.



Exploring the Solar System: Solar Eclipse

Experience Earth and space **phenomena** and explore science findings

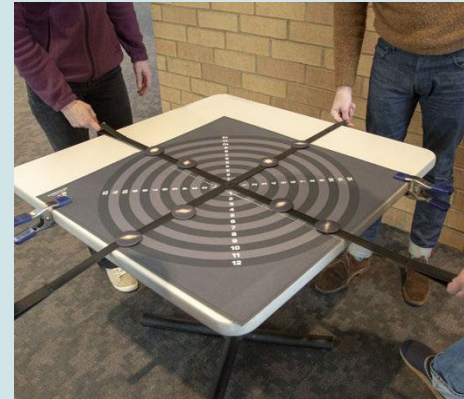
Exploring our place in the universe

Understanding that the universe is always changing: galaxies are colliding, stars are forming and dying, and Earth and the solar system are hurtling through space.

In Exploring the Universe: Nebula Spin Art, learners spin paint to simulate a dying star's transformation into a nebula.



Exploring the Universe: Nebula Spin Art



Exploring the Universe: Expanding Universe

Realizing that the universe is very large and can be difficult to conceptualize.

In Exploring the Universe: Expanding Universe, learners explore how the universe is expanding while the galaxies within are not.

Recognizing that space has many dangerous environments that can be harmful to both humans and robotic instruments.

In Exploring the Universe: Static Electricity, learners create a tool to detect static electricity and discover it can harm rovers.



Exploring the Universe: Static Electricity

Experience Earth and space **phenomena** and explore science findings

Investigating the big questions that drive Earth and space research



Exploring the Universe: Pack a Space Telescope

Asking how life on Earth started, and if we are alone in the universe.

In Exploring the Universe: Pack a Space Telescope, learners discover that the James Webb Space Telescope will be used to analyze the atmospheres of distant exoplanets for conditions that could support life.

Asking how the universe began, and how our galaxy, solar system, and planet were formed.

Exploring the Universe: Orbiting Objects, learners model gravitational attraction in space and discover its role in the birth of the solar system.



Exploring the Universe: Orbiting Objects

Asking what protects life on Earth and how humans change these conditions.

At the Earth component of the *Sun, Earth, Universe* exhibition, visitors examine before and after images on flip panels to see the effects of climate change due to human society.



Sun, Earth, Universe exhibition

Use the scientific **process** and reflect on science as a way of knowing

Using an iterative design process similar to engineering and scientific research



Exploring the Solar System: Mission to Space

Understanding that planning and executing a NASA mission is a long process with many steps.

Learning that missions do not always go as planned and sometimes have unanticipated results, but all missions provide valuable information and data that inform future missions.

In Exploring the Solar System: Mission to Space, learners play a game as a team of scientists and engineers sending a spacecraft on a mission to space. They'll meet with the surprises, setbacks, and successes that accompany every scientific mission, but all players are encouraged to complete their mission and discuss their results.



Exploring Earth: Rising Seas

Observing that grand challenges in Earth and space research are often broken down into simpler problems to be tackled one at a time.

In Exploring Earth: Rising Seas, learners create a model for sea level rise and observe the role of Earth-observing satellites. Understanding and addressing climate change starts with data collection and predictive models to help define future challenges.

Recognizing that while quantitative methods and critical thinking are important in solving problems, ingenuity and imagination are also helpful in advancing us to the next stage of knowing.

In Exploring the Universe: Imagining Life, learners imagine and draw a living thing that could thrive in an extreme environment beyond Earth. Thinking about strange possibilities for life, in dangerous conditions for humans, may help scientists design space missions to discover life on distant planets and moons in our solar system.



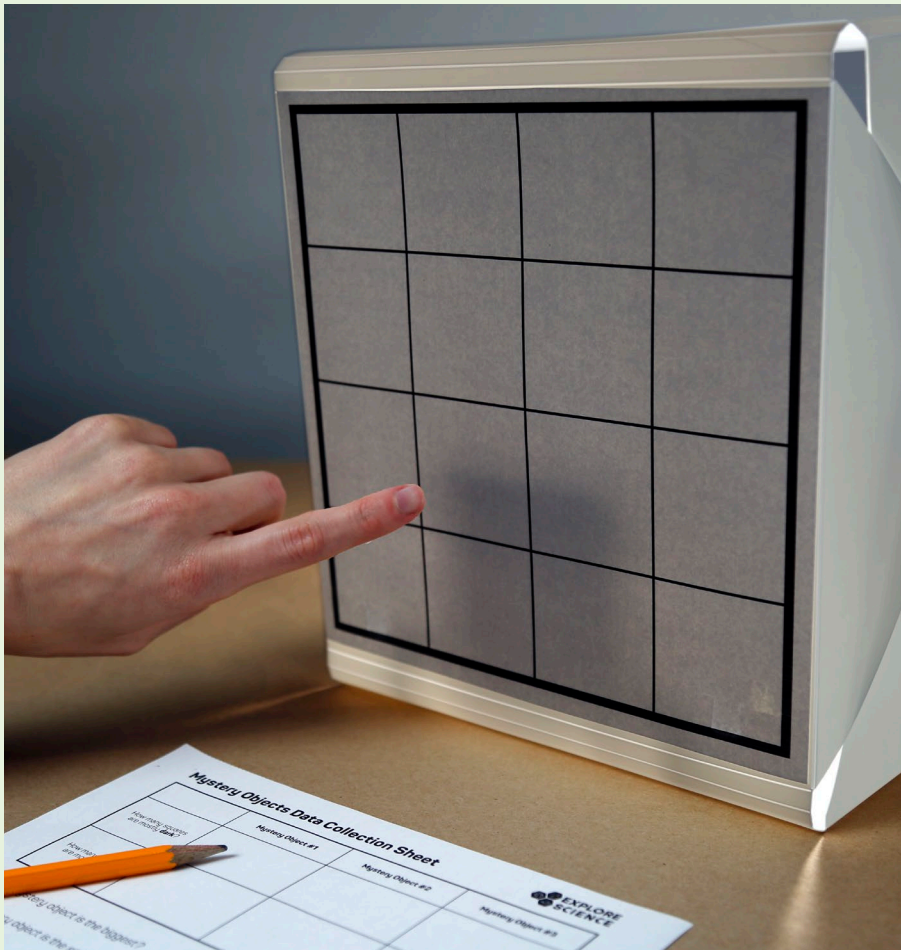
Exploring the Universe: Imagining Life

Use the scientific **process** and reflect on science as a way of knowing

Experiencing the power and limitations of data sets

Understanding that data about Earth and space can be analyzed in different ways to support multiple theories.

In Exploring the Universe: Exoplanet Transits, learners measure dips in brightness of a light to model how scientists find planets orbiting stars outside our solar system.



Exploring the Universe: Exoplanet Transits



Exploring the Universe: Star Formation

Recognizing that data are interpreted and weighed as evidence for or against theories in Earth and space science. Whether or not data support previous ideas, they increase our understanding of big scientific questions and lead to new ideas to investigate.

In Exploring the Universe: Star Formation, learners model the star-formation process by adding energy to matter floating in space. By doing multiple experiments and checking the results with the measuring tube, learners can begin to theorize if low or high mass stars are more common in the universe.

Use the scientific **process** and reflect on science as a way of knowing

Using a variety of tools and approaches to make discoveries

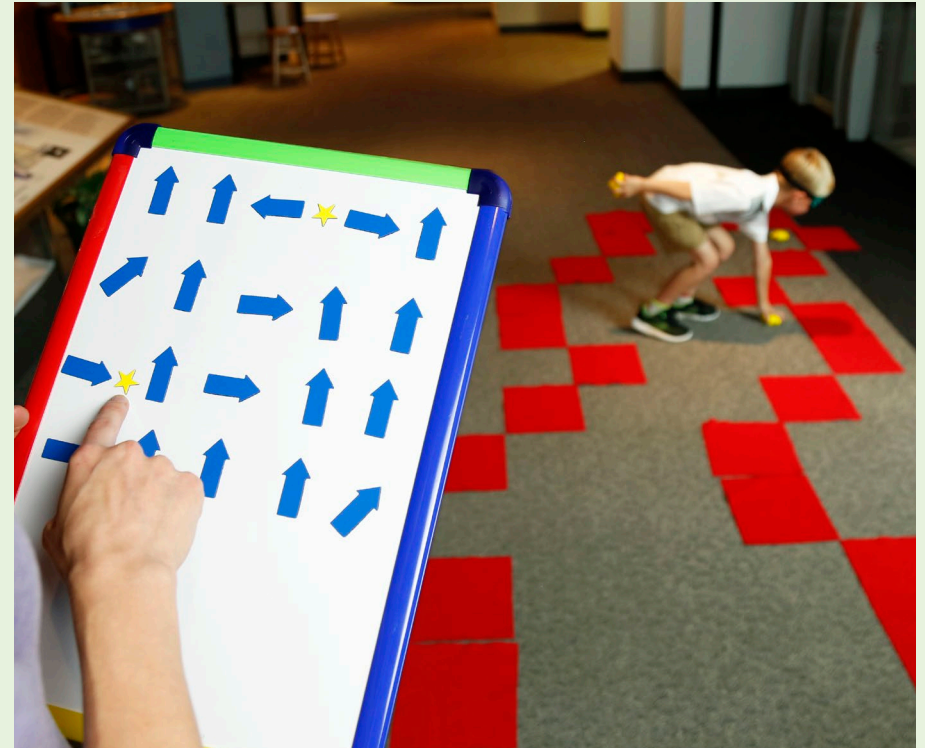
Learning that NASA science teams collect important data using satellites and other instruments to look out into space as well as back at Earth.

Understanding that we need many different kinds of information and perspectives to answer the big questions that drive Earth and space science research, which means we need both diverse teams and tools.

At the selection of tools to detect the invisible in the *Sun, Earth, Universe* exhibition, learners use an infrared camera, an ultraviolet light, a magnifying glass, and a magnetic field detector to reveal information that's not visible to human eyes. The exhibition signage helps connect these tools to NASA's Juno spacecraft orbiting Jupiter.



Sun, Earth, Universe exhibition



Exploring the Solar System: Mars Rovers

Recognizing that people use scientific tools such as robot explorers and remote-controlled instruments as extensions of their senses to observe and collect data about Earth and space.

In Exploring the Solar System: Mars Rovers, learners act as mission control and a rover to simulate navigating a robotic explorer across the surface of a planet millions of miles away.

Use the scientific **process** and reflect on science as a way of knowing

Making and using models to communicate and further our understanding



Exploring the Solar System: Magnetic Fields

Observing how models can demonstrate invisible forces like gravity and magnetism.

In Exploring the Solar System: Magnetic Fields, learners use a strong magnet and paper clips to visualize the invisible magnetic fields of Earth with a simple model.

Recognizing that models can be refined, improved, or rejected as we gain new data and increase our understanding.

In Exploring the Solar System: Stomp Rockets, learners build, launch, and refine their own air rockets to model the challenges and triumphs of engineering spacecraft.



Exploring the Solar System: Stomp Rockets

Use the scientific **process** and reflect on science as a way of knowing

Using our imagination and ingenuity to explore the universe



Exploring the Solar System: Story Blocks

Understanding that narrative, science fiction, and visions of the future can inspire us to ask new questions and motivate us to take on grand challenges.

Recognizing that dreaming about space and exploring new frontiers have motivated many scientists to become who they are today.

In Exploring the Solar System: Story Blocks, learners use blocks to tell a story about a mission to the Moon. The activity uses images from artists to assist learners in dreaming up new technologies.



Sun, Earth, Universe exhibition

Realizing that play can lead to innovative new methods and tools to explore Earth and space.

At the Design, Build, Test station of the *Sun, Earth, Universe* exhibition, learners play with model components to design resilient space probes.

Appreciating that imagination, play, and practical ingenuity can all lead to creative solutions for big challenges in Earth and space science exploration.

In Exploring the Solar System: Asteroid Mining, learners draw their own asteroid mining machines and use their imagination to consider how they would function.



Exploring the Solar System: Asteroid Mining

Participate in the scientific community and identify as a science learner

Working together in groups to accomplish goals and tackle challenges



Exploring the Solar System: Design, Build, Test

Discovering that missions require many different tools, instruments, and methods—all designed to work together.

In Exploring the Solar System: Design, Build, Test, learners are asked to add equipment from four categories—communication, navigation, power generation, and scientific research—so their spacecraft can successfully complete a mission.

Understanding that major discoveries in Earth and space science can take many years of work by many different people, including scientists and citizens.

In Exploring the Solar System: Mission to Space, learners encounter lengthy tasks and long setbacks commonly faced by groups of scientists and engineers while working on a mission to space.

Recognizing that mission teams must cooperate, communicate, and take advantage of their diversity of experience, expertise, and perspectives.



Exploring the Solar System: Mars Rovers

In Exploring the Solar System: Mars Rovers, learners playing the roles of mission control and the rover must work together to succeed in their mission.



Exploring the Solar System: Mission to Space

Participate in the scientific community and identify as a science learner

Exploring the relevance of Earth and space science



Exploring Earth: Paper Mountains

Observing connections between Earth and space science and our everyday lives.

In Exploring Earth: Paper Mountains, learners are asked to imagine what the marker ink could be in their model, and where they would want to live on the paper and why. While landslides and flooding might not be relatable for all learners, rain and runoff might be a more accessible entry point for the paper mountains model.

Appreciating that diverse cultures and communities have their own ways of observing nature and passing down knowledge about Earth and space, which influence the perceived relevance of Earth and space science.

Exploring the Solar System: Hide and Seek Moon, learners discover how different cultures see different shapes in the Moon and how all communities have stories about the Moon.



Exploring the Solar System: Hide and Seek Moon

Participate in the scientific community and identify as a science learner

Considering the social dimensions of Earth and space science

Recognizing that as individuals and as a society, we make decisions about what kinds of science to pursue and fund.

Understanding that our individual and cultural values influence the science and technologies we develop, and the ways we use them.

In Exploring the Solar System: Asteroid Mining, learners are challenged to pretend they are the person on the card while designing their asteroid mining machine. Learners will consider if they think differently about mining asteroids in their new role or maybe come up with a new idea from a different perspective.



Exploring the Solar System: Asteroid Mining



Exploring the Solar System: Observe the Sun

Realizing that some scientific questions can be pursued by individuals with relatively few resources, while other questions require commitment from many people and resources.

In Exploring the Solar System: Observe the Sun, learners use low-cost tools to detect the same sunspots on the Sun found by NASA's Solar Dynamics Observatory space telescope.

Participate in the scientific community and identify as a science learner

Identifying as someone who learns about and sometimes participates in current research

Discovering that there are many opportunities to learn about Earth and space science—at home, in school, and in the community.

Learning that citizen scientists are contributing data to ongoing Earth and space science research projects.

In Exploring Earth: Investigating Clouds, learners see a real cloud form in a bottle before receiving a cloud observation worksheet with tips on identifying shapes, sky quadrant, and cloud cover. By recording their sky observations in the GLOBE Observer app, learners can help scientists gain a new perspective on clouds that satellites just can't provide: from the ground looking up.



Exploring Earth: Investigating Clouds



Exploring Earth: Land Cover

Believing that we can all participate in Earth and space science as citizen scientists, by recording data from our home planet.

In Exploring Earth: Land Cover, learners experiment with an erosion simulation before creating their own land cover map of their backyard or public space. Recognizing differences in land cover prepares learners to assist scientists verifying satellite imagery by using the GLOBE Observer app.