Developing and Using Science and Engineering Practices (by Lesson)

Lesson	Elements of Science and Engineering Practice(s)	Rationale
1	Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.	Students develop questions for the DQB that arise from experiences, interactions, and observations of the sky.
1	Develop and/or use a model to predict and/or describe phenomena.	Students develop models individually and as a class to describe a variety of phenomena related to the sky.
2	Develop and/or use a model to predict and/or describe phenomena.	Students use 3-D and 2-D representations to model the Earth-Sun system in order to describe annual temperature variation over the surface of Earth.
2	Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.	Students revise their model based on evidence to include the tilt of Earth and its nearly circular orbit around the Sun.
2	Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	Students use data to refute the claim that distance from the Sun causes seasonal temperature variation on Earth.
3	Develop and/or use a model to predict and/or describe phenomena.	Students develop models in small groups to describe lunar phases.
4	Construct an explanation using models or representations.	Students explain eclipses and the phases of the Moon using 3-D representations of the system.
4	Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.	Students critique one another's explanations using a peer-feedback rubric.
4	Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or	Students create oral presentations or videos based on scientific information gathered through physical modeling, videos, and simulations.
5	Use and/or develop a model of simple systems with uncertain and less predictable factors.	Students use a computer interactive that simulates the Earth-Moon system to model the effect of varying certain factors (distance, mass, speed) on the gravity force and on the Moon's orbit of Earth. Investigating these relationships would be difficult without a mathematical or computer model.
5	Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.	Students construct a qualitative explanation for the factors that affect the gravity force pair acting on the Moon and Earth in the simulation of the Earth-Moon system.
6	Construct an explanation using models or representations.	Students construct an explanation for an orbiting object using a visual representation of the object, the Moon, the object's orbital path and speed, and the gravity force acting on the object.
6	Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	Students read a text adapted for the classroom telling the story of a thought experiment by Isaac Newton in order to obtain scientific information to describe the role of gravity in the orbit of the Moon and artificial satellites.

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7	Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	Students obtain the big ideas from a computer interactive and a video about the mechanics and origin of the solar system.
8	Develop a model to describe unobservable mechanisms.	Students develop a model to describe mechanisms that are on a scale that is too large to observe directly, such as the 3-D locations of the stars in space.
8	Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.	Students respectfully provide and receive critiques about their group's model, incorporate feedback into their model, and individually reflect on how they responded to this feedback.
9	Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument.	Students ask questions to identify evidence that will support an argument about the existence of extraterrestrial life in space and add these questions to the DQB.
10	Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.	Students construct written arguments for a solution to the problem of whether or not we should further investigate certain planets, moons, or other objects in our solar system using evidence and scientific reasoning from infographics.
10	Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	Students read infographics to determine the central ideas and obtain evidence about the existence of life in our solar system.
10	Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or	Students communicate scientific information from the infographics through oral presentations to the class about the potential for life in our solar system.
11	Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	Students critically read a scientific text adapted for classroom use to determine the central ideas and obtain evidence about what we can see orbiting stars beyond our Sun.
12	Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	Students use a model of a distant star system to generate data and determine what patterns in the data would indicate the presence of planets around a very distant star.
12	Evaluate the accuracy of various methods for collecting data.	Students compare photographic data to light meter data and weigh the advantages of each.
12	Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).	Students explore a limitation of the transit method of exoplanet detection and consider how this might affect the accuracy of conclusions made from the data.
12	Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.	Students compare two arguments about whether or not there are planets going around other stars and analyze how these fictional students use the same evidence to come to different conclusions.

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13	Analyze and interpret data to provide evidence for phenomena.	Students analyze and interpret spectral data to make predictions about what matter makes up an exoplanet.
13	Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.	Students develop an explanation for how light data can be used to determine the types of matter found on exoplanets.
14	Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).	Students conduct internet research and read scientific texts to determine the characteristics of exoplanets that could support potential extraterrestrial life.
14	Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.	Students gather, read, and synthesize information from multiple internet sources to use in their exoplanet podcast and evaluate each before synthesizing it to be used in the podcast production.
14	Communicate scientific and/or technical information (e.g. about a proposed object, tool, process, system) in writing and/or	Students communicate scientific information from reliable internet sources about the potential for extraterrestrial life on exoplanets by producing and exhibiting a podcast.
15	Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.	Students integrate information about galaxies from written text with that from a video to clarify their ideas about galaxies.
16	Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	Students develop a model of the universe at unobservable scales in order to create a mathematical model to test ideas about the probability of finding life in space.

Developing and Using Crosscutting Concepts (by Lesson)

Lesson	Elements of Crosscutting Concept(s)	Rationale
1	Patterns can be used to identify cause and effect relationships.	Students consider how the patterns they see might be used to identify cause and effect relationships related to the objects in the solar system.
1	Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.	Students consider the Earth-Sun system as a subsystem of our solar system. They generate a list of systems and subsystems that they would like to model to answer questions about various phenomena.
2	Graphs, charts, and images can be used to identify patterns in data.	Students use data that they record on images to identify patterns in the movement of the Sun.
2	Models are limited in that they only represent certain aspects of the system under study.	Students use a model map to record the limitations of the models they are using and then make a public record of these limitations as a class.
3	Graphs, charts, and images can be used to identify patterns in data.	Images of the Moon over time can be used to identify patterns of lunar phases.

Lesson	Elements of Crosscutting Concept(s)	Rationale
4	Models can be used to represent systems and their interactions—such as inputs, processes andoutputs—and energy, matter, and information flows within systems.	Students use models to explain several phenomena related to the Earth-Sun-Moon system.
5	Cause and effect relationships may be used to predict phenomena in natural or designed systems.	Students use cause and effect relationships like those among distance, mass, and the strength of the force of gravity to predict whether an object will orbit another object in space.
5	Small changes in one part of a system might cause large changes in another part.	Students note how small changes in one part of a system, such as the strength of the gravity force or speed of an orbiting object like the Moon, cause large changes in another part, such as the pathway of the Moon around Earth.
6	Models can be used to represent systems and their interactions—such as inputs, processes andoutputs—and energy, matter, and information flows within systems.	Students use models to represent two-body systems of Earth and nearby objects, explaining how gravity force, speed, and distance affect an object's motion with respect to Earth.
6	Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.	Students observe that dynamic but stable orbits can be achieved for objects that have the right balance of speed and gravity force acting on them.
7	Stability might be disturbed either by sudden events or gradual changes that accumulate over time.	Students watch a video and use a computer interactive to explain the role of gravity in creating the solar system we see today.
8	Macroscopic patterns are related to the nature of microscopic and atomic-level structure.	Students observe changes in the patterns of motion for two Ojibwe constellations at different times of year.
8	Grades 3-5: A system can be described in terms of its components and their interactions.	Students use models of the solar system and stars at multiple scales to describe space phenomena that are too large to view.
8	Phenomena that can be observed at one scale may not be observable at another scale.	Students begin to describe multiple scales in their models to account for the fact that phenomena that can be observed at one scale may not be observable at another scale.
9	Phenomena that can be observed at one scale may not be observable at another scale.	Students begin to consider what evidence they might collect about life in space given the constraints introduced by great distances.
10	Grades 3-5: A system can be described in terms of its components and their interactions.	Students consider and compare scale properties of planets, moons, and other objects in our solar system in order to make a compelling argument for where we should look for life.
11	Phenomena that can be observed at one scale may not be observable at another scale.	Students use images and information from the reading to figure out that even though planets within our solar system are clearly visible from Earth, we cannot observe planets around other stars because the distance between those planets and Earth is too vast.
12	Graphs, charts, and images can be used to identify patterns in data.	Students use a model of a star system to generate light curve data to test ideas about what patterns in the data could indicate the presence of planets around a star. They use the patterns they see in the data as evidence to support an argument.

Lesson	Elements of Crosscutting Concept(s)	Rationale
12	Grades 3-5: A system can be described in terms of its components and their interactions.	Students use a model to study star systems that are too far away to observe directly.
12	Phenomena that can be observed at one scale may not be observable at another scale.	Students consider the possibility that there may be planets around stars that are so distant we cannot see the system directly.
13	Phenomena that can be observed at one scale may not be observable at another scale.	Students use exoplanet light data measurements to make predictions about the types of matter contained on an exoplanet too far away to be observed directly.
13	Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.	Students use spectral data to identify exactly which wavelengths of light are present in the starlight passing through the atmosphere of K2-18b during a transit.
14	Phenomena that can be observed at one scale may not be observable at another scale.	Students research the characteristics of exoplanets that might make it possible for extraterrestrial life to exist on these planets even though we can not physically see the exoplanets from Earth.
15	Grades 3-5: A system can be described in terms of its components and their interactions.	Students watch a movie that demonstrates the scale of the universe by zooming outward from the human scale, to the galactic scale by powers of ten.
15	Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.	Students watch a movie modeling the organization of our universe into systems.
16	Scientific relationships can be represented through the use of algebraic expressions and equations.	Students estimate how many planetary systems are out there; they compare this mathematical model to the Drake equation.