National Aeronautics and Space Administration

small worlds

NRC Framework Alignment Document Middle School

Where are the small worlds?

Middle School NRC Framework for Science Education Alignment Document

WHAT STUDENTS DO: Use a model to collect data in the solar system.

Learners will explore our solar system from the perspective of the Sun. They will observe the motion of different worlds to determine their location in the solar system. Then they will launch probes to search these small worlds for the caches hidden on them in order to collect the astrocoins inside.

NRC FRAMEWORK CORE & COMPONENT QUESTIONS	INSTRUCTIONAL OBJECTIVES (IO)
WHAT IS THE UNIVERSE, AND WHAT IS EARTH'S PLACE IN IT? *NGSS Core Question: ESS1: Earth's Place in the Universe* **What is the universe, and what goes on in stars?** *NGSS ESS1.A: The Universe and its Stars* **What are the predictable patterns caused by Earth's movement in the solar system?** *NGSS ESS1.B: Earth and the Solar System*	*Students will be able to* **IO1: Use a model to make observations, analyze, and interpret empirical evidence to identify patterns in the phenomena of solar system arrangement.**

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1.0 About This Activity

How Students Learn: Science in the Classroom (Donovan & Bransford, 2005) advocates the use of a research-based instructional model for improving students' grasp of central science concepts. Based on conceptual-change theory in science education, the 5E Instructional Model (BSCS, 2006) includes five steps for teaching and learning: Engage, Explore, Explain, Elaborate, and Evaluate. The Engage stage is used like a traditional warm-up to pique student curiosity, interest, and other motivation-related behaviors and to assess students' prior knowledge. The Explore step allows students to deepen their understanding and challenges existing preconceptions and misconceptions, offering alternative explanations that help them form new schemata. In Explain, students communicate what they have learned, illustrating initial conceptual change. The Elaborate phase gives students the opportunity to apply their newfound knowledge to novel situations and supports the reinforcement of new schemata or its transfer. Finally, the Evaluate stage serves as a time for students' own formative assessment, as well as for educators' diagnosis of areas of confusion and differentiation of further instruction. The 5E stages can be cyclical and iterative.

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2.0 Instructional Objectives, Learning Outcomes, Standards, & Rubrics

Visit https://infiniscope.org/lesson/where-are-the-small-worlds/ for access to the digital learning experience, lesson plans, standards alignment documents, and additional resources.

Instructional objectives and learning outcomes are aligned with

- National Research Council's, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*
- National Governors Association Center for Best Practices (NGA Center) and Council of Chief State School Officers (CCSSO)'s, *Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects*
- Partnership for 21st Century Skills, *A Framework for 21st Century Learning*

The following chart provides details on alignment among the core and component NRC questions, instructional objectives, learning outcomes, and educational standards.

- Your **instructional objectives (IO)** for this lesson align with the NRC Framework.
- You will know that you have achieved these instructional objectives if students demonstrate the related **learning outcomes (LO),** also aligned with the NRC Framework.
- You will know the level to which your students have achieved the learning outcomes by using the suggested **rubrics**.

Important Note: This lesson is color-coded to help teachers identify each of the three dimensions of the NRC Framework. The following identifying colors are used: Practices are blue, Cross-Cutting Concepts are green, and Disciplinary Core Ideas are orange.

This color-coding is consistent with the NRC Framework for K-12 Science Education.

Quick View of Standards Alignment:

This alignment document provides full details of the way in which instructional objectives, learning outcomes, 5E activity procedures, and rubric assessments were derived through, and align with the NRC Framework for K-12 Education. For convenience, a quick view follows:

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WHAT IS THE UNIVERSE, AND WHAT IS EARTH'S PLACE IN IT?

NRC Core Question: ESS1: Earth's Place in the Universe

What is the universe, and what goes on in stars?

NRC ESS1.A: The Universe and its Stars

What are the predictable patterns caused by Earth's movement in the solar system?

NRC ESS1.B: Earth and the Solar System

Instructional Objective *Students will be able to*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*
IO1: Use a model to make observations, analyze, and interpret empirical evidence to identify patterns in the phenomena of solar system arrangement.	**LO1a: Use a model (Sun-based view and Bird's eye view) to observe the motion and relative speed of an object to predict its location in the solar system.** **LO1b: Explain the relationship of relative speed (pattern in the rate of change) vs distance of the object in the solar system.** **LO1c: Identify and evaluate limitations of the solar system model.** **LO1d: Develop a hypothesis to explain the origin of small world zones.**	**PRACTICES:** 1. Developing and Using Models 2. Analyzing and Interpreting Data 3. Constructing Explanations and Designing Solutions 4. Using Mathematics and Computational Thinking **DISCIPLINARY CORE IDEA:** ESS1.A: The Universe and Its Stars ESS1.B: Earth and the Solar System **CROSSCUTTING CONCEPTS:** 1. Patterns 2. Cause and Effect: Mechanism and Prediction 3. Scale, Proportion, and Quantity 4. Systems and System Models

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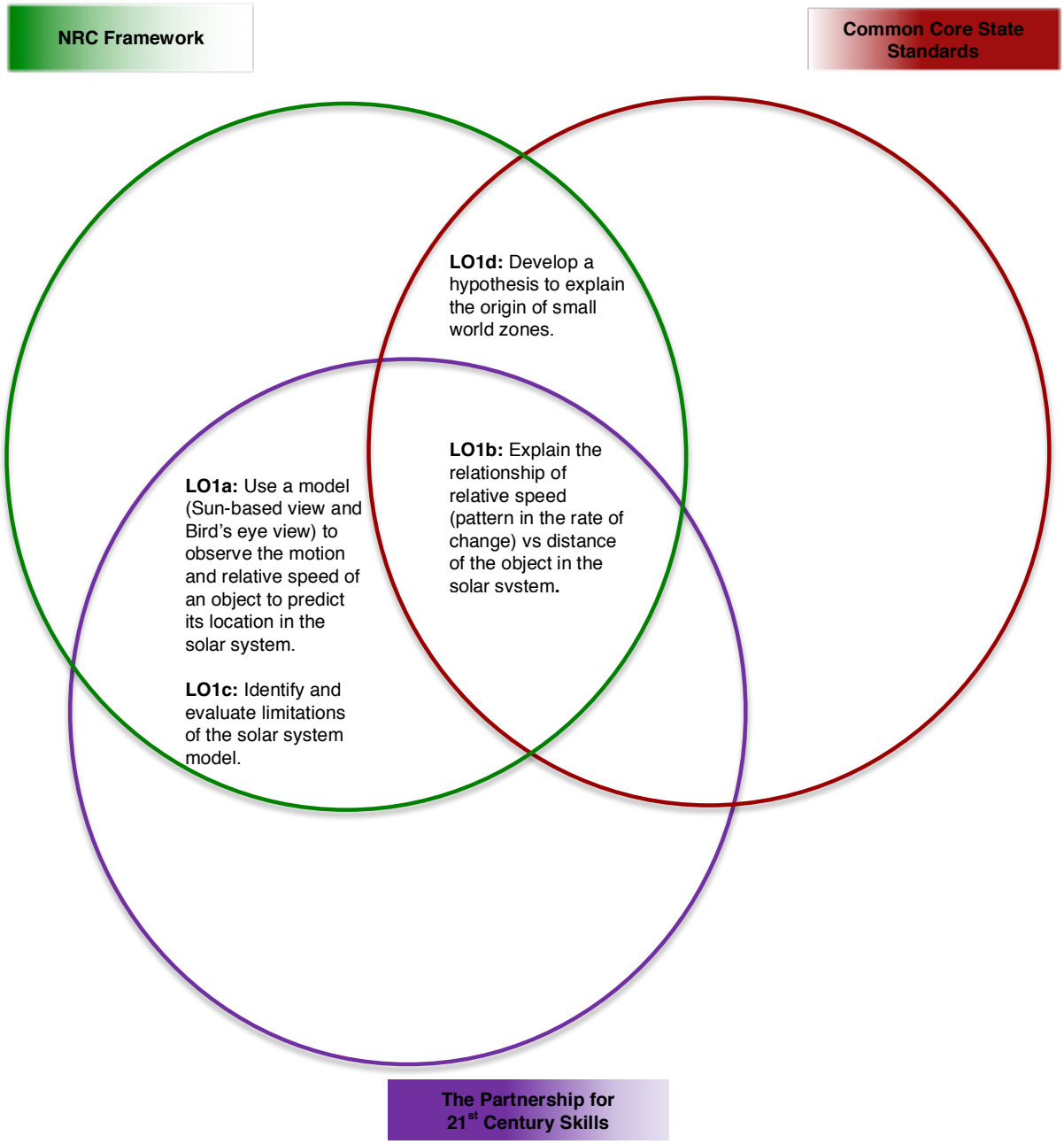
3.0 Learning Outcomes, NRC Framework, Common Core, & 21st Century Skills Connections

The connections diagram is used to organize the learning outcomes addressed in the lesson to establish where each will meet the NRC Framework for K-12 Science Education, Common Core Standards, and the 21st Century Skills and visually determine where there are overlaps in these documents. See Common Core State Standards Alignment Document and 21st Century Skills Alignment for details on their specific alignments.



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4.0 Evaluation/Assessment

Use the *(N) Where are the small worlds? Rubric* as a formative and summative assessment, allowing students to improve their work and learn from mistakes during class. The rubric evaluates the activities using the NRC Framework for Science Education.

5.0 References

Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Carson Powell, J., Westbrook, A., Landes, N. (2006) *The BSCS 5E instructional model: origins, effectiveness, and applications.* Colorado Springs: BSCS.

Donovan, S. & Bransford, J. D. (2005). *How Students Learn: History, Mathematics, and Science in the Classroom.* Washington, DC: The National Academies Press.

Miller, Linn, & Gronlund. (2009). *Measurement and assessment in teaching*. Upper Saddle River, NJ: Pearson.

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(M) Teacher Resource. Where are the small worlds? NRC Framework Alignment (1 of 3)

You will know the level to which your students have achieved the **Learning Outcomes**, and thus the **Instructional Objective(s)**, by using the suggested **Rubrics** below.

NRC Framework for K-12 Science Education			
Instructional Objective	**Science and Engineering Practices Benchmark by Grade 12**	**Disciplinary Core Idea Grade Band Endpoints**	**Crosscutting Concepts**
IO1: **Use a model to make observations, analyze, and interpret empirical evidence to identify patterns in the phenomena of solar system arrangement.**	**Developing and Using Models** Use (provided) computer simulations or simulations developed with simple simulation tools as a tool for understanding and investigating aspects of a system, particularly those not readily visible to the naked eye. **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships. **Constructing Explanations and Designing Solutions** Construct their own explanations of phenomena using their knowledge of accepted scientific theory and linking it to models and evidence.	**ESS1.A: The Universe and Its Stars** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Patterns** Students should begin to analyze patterns in rates of change. **Cause and Effect: Mechanism and Prediction** Students ask about cause-and-effect relationships in the system studied, particularly when something occurs that is unexpected. **Scale, Proportion, and Quantity** Students develop an understanding of estimation across scales and contexts, which is important for making sense of data. Students develop a sense of the size and time scales relevant to various objects, systems, and processes and also to consider whether a numerical result sounds reasonable. Students acquire the ability as well to move back and forth between models at various scales, depending on the question being considered.

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(M) Teacher Resource. Where are the small worlds? NRC Framework Alignment (2 of 3)

NRC Framework for K-12 Science Education

Learning Outcomes	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
LO1a: **Use a model (Sun-based view and Bird's eye view) to observe the motion and relative speed of an object to predict its location in the solar system.**	**Developing and Using Models** Use (provided) computer simulations or simulations developed with simple simulation tools as a tool for understanding and investigating aspects of a system, particularly those not readily visible to the naked eye. **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.	**ESS1.A: The Universe and Its Stars** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Patterns** Students should begin to analyze patterns in rates of change. **Cause and Effect: Mechanism and Prediction** Students ask about cause-and-effect relationships in the system studied, particularly when something occurs that is unexpected. **Scale, Proportion, and Quantity** Students develop an understanding of estimation across scales and contexts, which is important for making sense of data. Students develop a sense of the size and time scales relevant to various objects, systems, and processes but also to consider whether a numerical result sounds reasonable. Students acquire the ability as well to move back and forth between models at various scales, depending on the question being considered.

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LO1b: **Explain the relationship of relative speed (pattern in the rate of change) vs distance of the object in the solar system**	**Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships. **Constructing Explanations and Designing Solutions** Construct their own explanations of phenomena using their knowledge of accepted scientific theory and linking it to models and evidence. Offer causal explanations appropriate to their level of scientific knowledge.	**ESS1.A: The Universe and Its Stars** Patterns of the relative motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Patterns** Students should begin to analyze patterns in rates of change. **Cause and Effect: Mechanism and Prediction** Students ask about cause-and-effect relationships in the system studied, particularly when something occurs that is unexpected **Scale, Proportion, and Quantity** Students develop an understanding of estimation across scales and contexts, which is important for making sense of data. Students develop a sense of the size and time scales relevant to various objects, systems, and processes but also to consider whether a numerical result sounds reasonable. Students acquire the ability as well to move back and forth between models at various scales, depending on the question being considered.
LO1c: **Identify and evaluate limitations of the solar system model**	**Using Mathematics and Computational Thinking** Recognize that computer simulations are built on mathematical models that incorporate underlying assumptions about the phenomena or systems being studied.	**ESS1.A: The Universe and Its Stars** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth	**Systems and System Models** Students should be able to identify the assumptions and approximations that have been built into a model and discuss how they limit the precision and reliability of its predictions. *(Connect to High School*

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		and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	*Crosscutting Statements)*
LO1d: **Develop a hypothesis to explain the origin of small world zones**	**Planning and Carrying Out Investigations** Formulate a question that can be investigated within the scope of the classroom, school laboratory, or field with available resources and, when appropriate, frame a hypothesis (that is, a possible explanation that predicts a particular and stable outcome) based on a model or theory. **Constructing Explanations and Designing Solutions** Construct their own explanations of phenomena using their knowledge of accepted scientific theory and linking	**ESS1.A: The Universe and Its Stars** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on	**Cause and Effect: Mechanism and Prediction** Students ask about cause-and-effect relationships in the system studied, particularly when something occurs that is unexpected.

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	it to models and evidence. Offer causal explanations appropriate to their level of scientific knowledge.	them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	

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(M) Teacher Resource. Where are the small worlds? NRC Framework Individual Activity Alignment (3 of 3)

NRC Framework Activity Alignments				
Activity	**Phases of 5E Instructional Model**	**Science and Engineering Practices**	**Disciplinary Core Idea**	**Crosscutting Concepts**
(A) Where are the small worlds? Prediction Worksheet	**Engage**		**ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	
		Developing and Using Models Use (provided) computer simulations or simulations developed with simple simulation tools as a tool for understanding and investigating aspects of a	**ESS1.A: The Universe and Its Stars** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with	**Patterns** Students should begin to analyze patterns in rates of change. **Scale, Proportion, and Quantity** Students develop an

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Where are the small worlds? Exploratory Activity	**Explore**	system, particularly those not readily visible to the naked eye. **Planning and Carrying Out Investigations** Formulate a question that can be investigated within the scope of the classroom, school laboratory, or field with available resources and, when appropriate, frame a hypothesis (that is, a possible explanation that predicts a particular and stable outcome) based on a model or theory. **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.	models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	understanding of estimation across scales and contexts, which is important for making sense of data. Students develop a sense of the size and time scales relevant to various objects, systems, and processes but also to consider whether a numerical result sounds reasonable. Students acquire the ability as well to move back and forth between models at various scales, depending on the question being considered. **Systems and System Models** Students should be able to identify the assumptions and approximations that have been built into a model and discuss how they limit the precision and reliability of its predictions. *(Connect to High School Crosscutting Statements)* **Cause and Effect: Mechanism and Prediction** Students ask about cause-and-effect relationships in the system studied, particularly when something occurs that is unexpected.

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(B) Speed vs Distance Results Worksheet	**Explain**	**Developing and Using Models** Use (provided) computer simulations or simulations developed with simple simulation tools as a tool for understanding and investigating aspects of a system, particularly those not readily visible to the naked eye. **Constructing Explanations and Designing Solutions** Offer causal explanations appropriate to their level of scientific knowledge.	**ESS1.A: The Universe and Its Stars** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Patterns** Students should begin to analyze patterns in rates of change. **Cause and Effect: Mechanism and Prediction** Students ask about cause-and-effect relationships in the system studied, particularly when something occurs that is unexpected.
		Developing and Using Models Use (provided) computer simulations or simulations	**ESS1.A: The Universe and Its Stars** Patterns of the apparent motion of	**Patterns** Students should begin to analyze patterns in rates of change.

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(C) Where is the Oort Cloud?	**Elaborate**	developed with simple simulation tools as a tool for understanding and investigating aspects of a system, particularly those not readily visible to the naked eye. **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships. **Constructing Explanations and Designing Solutions** Construct their own explanations of phenomena using their knowledge of accepted scientific theory and linking it to models and evidence. Offer causal explanations appropriate to their level of scientific knowledge.	the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	**Scale, Proportion, and Quantity** Students develop an understanding of estimation across scales and contexts, which is important for making sense of data. Students develop a sense of the size and time scales relevant to various objects, systems, and processes but also to consider whether a numerical result sounds reasonable. Students acquire the ability as well to move back and forth between models at various scales, depending on the question being considered. **Cause and Effect: Mechanism and Prediction** Students ask about cause-and-effect relationships in the system studied, particularly when something occurs that is unexpected.
		Developing and Using Models Use (provided) computer simulations or simulations developed with simple simulation tools as a tool for understanding and investigating aspects of a system, particularly those not	**ESS1.A: The Universe and Its Stars** Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a	**Patterns** Students should begin to analyze patterns in rates of change. **Systems and System Models** Students should be able to identify the assumptions and

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(D) Where are the small worlds? Evaluation	**Evaluate**	readily visible to the naked eye. **Using Mathematics and Computational Thinking** Recognize that computer simulations are built on mathematical models that incorporate underlying assumptions about the phenomena or systems being studied. **Analyzing and Interpreting Data** Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships. **Constructing Explanations and Designing Solutions** Construct their own explanations of phenomena using their knowledge of accepted scientific theory and linking it to models and evidence. Offer causal explanations appropriate to their level of scientific knowledge.	period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. **ESS1.B: Earth and the Solar System** The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.	approximations that have been built into a model and discuss how they limit the precision and reliability of its predictions. *(Connect to High School Crosscutting Statements)* **Cause and Effect: Mechanism and Prediction** Students ask about cause-and-effect relationships in the system studied, particularly when something occurs that is unexpected.

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(N) Teacher Resource. Where are the small worlds? NRC Framework Rubric

Related Rubrics for the Assessment of Learning Outcomes Associated with the Above Standard(s):

NRC Framework for Science Education Alignment

Learning Outcome	Expert	Proficient	Intermediate	Beginner
LO1a: Use a model (Sun-based view and Bird's eye view) to observe the motion and relative speed of an object to predict its location in the solar system.	Clearly articulates the distance is related to speed of the object and applies the concept early and consistently in the experience, locating the three small world zones relatively quickly.	Concludes the distance is related to speed of the object and consistently applies the concept in the experience, locating the three small world zones.	Concludes the distance is related to speed of the object but inconsistently applies the concept to the experience, eventually locating the three small worlds zones.	Randomly drops the test object and relies on feedback to locate the small world zones in the solar system.
LO1b: Explain the relationship of relative speed (pattern in the rate of change) vs distance of the object in the solar system.	Fully explains the relationship of speed of the object using multiple lines of evidence from the "Where are the small worlds?" exploratory activity to describe the distance of an object based on the speed.	Explains the relationship of speed of the object using at least 2 lines of evidence from the "Where are the small worlds?" exploratory activity to describe the distance of an object based on the speed.	States the relationship between distance and speed of the object using one line of evidence from the "Where are the small worlds?" exploratory activity.	States the relationship between distance and speed of the object.
LO1c: Identify and evaluate limitations of the solar system model.	Names at least one relevant limitation to the solar system model provided and clearly and correctly articulates how the limitation affected exploration.	Names at least one relevant limitation to the solar system model provided and attempts to articulate how the limitation affected exploration.	Names at least one relevant limitation to the solar system model provided.	Attempts to name a limitation.
LO1d: Develop a hypothesis to explain the origin of small world zones.	Focuses hypothesis on the formation of small world zones and uses evidence from the activity and prior knowledge to support the hypothesis.	Focuses hypothesis on the formation of small world zones and references evidence from the activity or prior knowledge to support the hypothesis.	Discusses small world formation in hypothesis.	Attempts to provide a hypothesis.

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