National Aeronautics and Space Administration

small worlds

Next Generation Science Standards Alignment Document Middle School

Where are the small worlds?

Middle School Next Generation Science Standards Alignment

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/NGSS CORE & COMPONENT QUESTIONS

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

INSTRUCTIONAL OBJECTIVES (IO)

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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Last edited: April 23, 2018

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

- Achieve Inc.'s, *Next Generation Science Standards (NGSS)*
- 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 NGSS questions, instructional objectives, learning outcomes, and educational standards.

- Your **instructional objectives (IO)** for this lesson align with the NRC Framework and NGSS.
- You will know that you have achieved these instructional objectives if students demonstrate the related **learning outcomes (LO),** also aligned with the NRC Framework and NGSS.
- 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 NGSS. 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 NGSS Performance Expectations and Foundation Boxes.

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 Next Generation Science Standards (NGSS). For convenience, a quick view follows:

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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

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. Planning and Carrying Out Investigations 3. Analyzing and Interpreting Data 4. Constructing Explanations and Designing Solutions **DISCIPLINARY CORE IDEAS:** 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 Scientific Knowledge Assumes an Order and Consistency in Natural Systems

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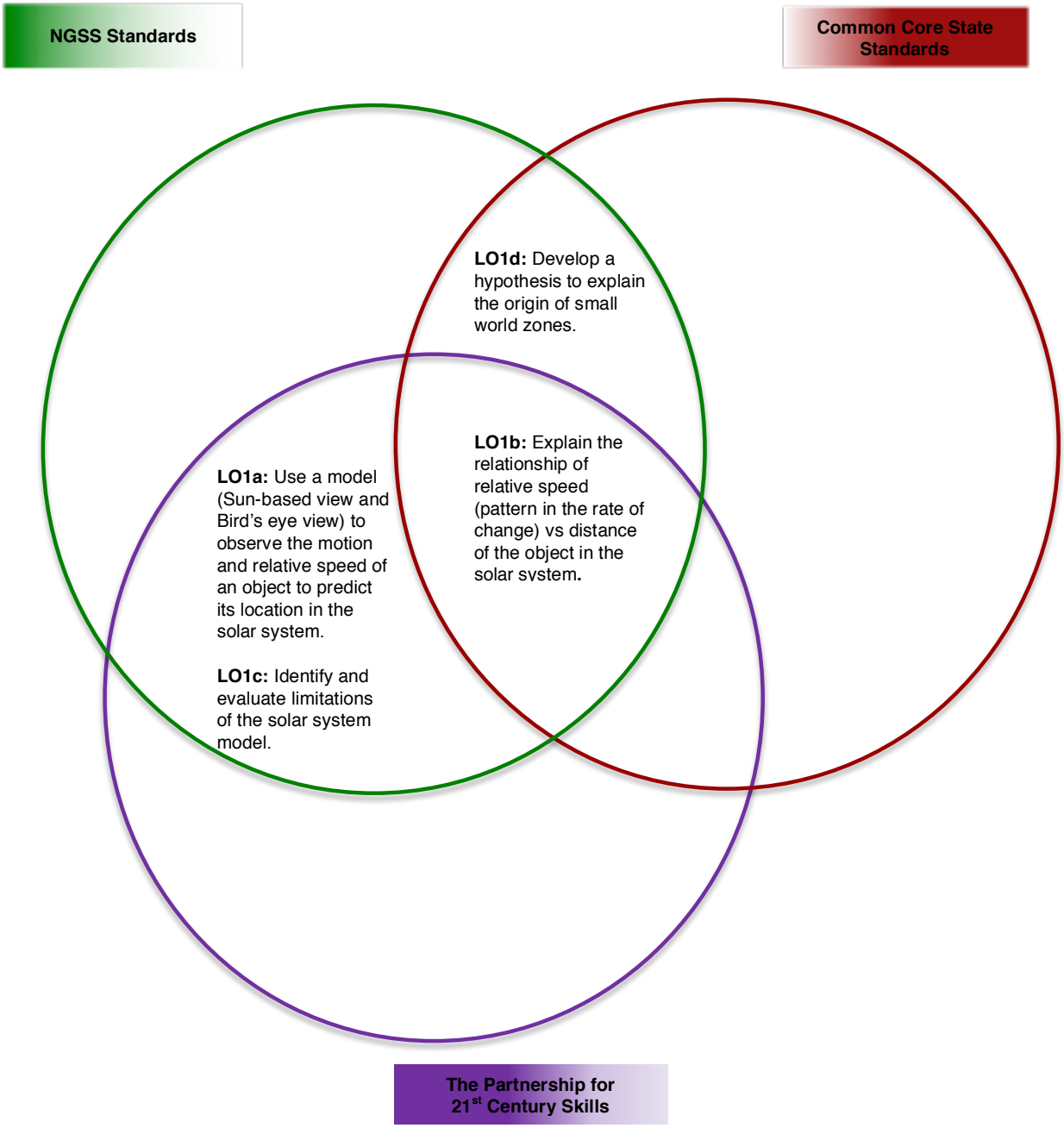
3.0 Learning Outcomes, NRC Framework, Common Core, & 21st Century Skills Connections

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



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4.0 Evaluation/Assessment

Use the *(N) Where are the small worlds? Alignment 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 Next Generation Science Standards (NGSS).

5.0 References

Achieve, Inc. (2013). *Next generation science standards*. Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS.

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.

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(M) Teacher Resource. Where are the small worlds? NGSS 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.

Related Standard(s)

This lesson supports the preparation of students toward achieving Performance Expectations using the Practices, Cross-Cutting Concepts and Disciplinary Core Ideas defined below: (MS-ESS1-1), (MS-ESS1-2), (MS-ESS1-3)

Next Generation Science Standards

Instructional Objective	Science and Engineering Practices	Disciplinary Core Idea	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** 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 in unobservable scales. **Planning and Carrying Out Investigations** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data** Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. *(Reconnection to 3-5 Condensed Practices)*	**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. (MS-ESS1-1) **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. (MS-ESS1-2),(MS-ESS1-3)	**Patterns** Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena and designed products. *(Reconnection to 3-5 Crosscutting Statements)* Empirical evidence is needed to identify patterns. *(Connect to 9-12 Crosscutting Statements)* **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

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

Next Generation Science Standards

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** 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 in unobservable scales. **Planning and Carrying Out Investigations** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data** Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. *(Reconnection to 3-5 Condensed Practices)*	**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. (MS-ESS1-1) **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. (MS-ESS1-2),(MS-ESS1-3)	**Scale, Proportion, and Quantity** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
LO1b: **Explain the relationship of relative speed**	**Constructing Explanations and Designing Solutions** Construct an explanation using models or representations.	**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	**Patterns** Patterns in rates of change and other numerical relationships can provide information about natural and human

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(pattern in the rate of change) vs distance of the object in the solar system.		explained with models. (MS-ESS1-1) **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. (MS-ESS1-2),(MS-ESS1-3)	designed systems. Patterns can be used to identify cause and effect relationships. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
LO1c: **Identify and evaluate limitations of the solar system model.**	**Developing and Using Models** Evaluate limitations of a model for a proposed object or tool.	**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. (MS-ESS1-1)	**Systems and System Models** Models are limited in that they only represent certain aspects of the system under study.
LO1d: **Develop a hypothesis to explain the origin of small world zones.**	**Constructing Explanations and Designing Solutions** Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.	**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. (MS-ESS1-1) **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. (MS-ESS1-2),(MS-ESS1-3)	**Cause and Effect: Mechanism and Prediction** Cause and effect relationships may be used to predict phenomena in natural and designed systems.

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

Next Generation Science Standards Activity Alignments (NGSS)

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. (MS-ESS1-2),(MS-ESS1-3)	
Where are the small worlds? Exploratory Activity	**Explore**	**Developing and Using Models** 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 in unobservable scales. **Planning and Carrying Out Investigations** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. *(Reconnection to 3-5 Condensed Practices)*	**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. (MS-ESS1-1) **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. (MS-ESS1-2),(MS-	**Patterns** Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. Patterns can be used to identify cause and effect relationships. **Scale, Proportion, and Quantity** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Systems and System Models** Models are limited in that they only

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		Analyzing and Interpreting Data Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. *(Reconnection to 3-5 Condensed Practices)*	ESS1-3)	represent certain aspects of the system under study. **Cause and Effect: Mechanism and Prediction** Cause and effect relationships may be used to predict phenomena in natural and designed systems. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
(B) Speed vs Distance Results Worksheet	**Explain**	**Developing and Using Models** 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 in unobservable scales. **Planning and Carrying Out Investigations** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data** Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or	**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. (MS-ESS1-1) **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. (MS-ESS1-2),(MS-ESS1-3)	**Patterns** Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. Patterns can be used to identify cause and effect relationships. **Cause and Effect: Mechanism and Prediction** Cause and effect relationships may be used to predict phenomena in natural and designed systems. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through

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		computation. *(Reconnection to 3-5 Condensed Practices)*		measurement and observation.
(C) Where is the Oort Cloud?	**Elaborate**	**Developing and Using Models** 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 in unobservable scales. **Planning and Carrying Out Investigations** Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon. *(Reconnection to 3-5 Condensed Practices)* **Analyzing and Interpreting Data** Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. *(Reconnection to 3-5 Condensed Practices)* **Constructing Explanations and Designing Solutions** Construct an explanation using models or representations. Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.	**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. (MS-ESS1-1) **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. (MS-ESS1-2),(MS-ESS1-3)	**Patterns** Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. Patterns can be used to identify cause and effect relationships. **Scale, Proportion, and Quantity** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Cause and Effect: Mechanism and Prediction** Cause and effect relationships may be used to predict phenomena in natural and designed systems. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

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(D) Where are the small worlds? Evaluation	**Evaluate**	**Developing and Using Models** Evaluate limitations of a model for a proposed object or tool. **Analyzing and Interpreting Data** Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation. *(Reconnection to 3-5 Condensed Practices)* **Constructing Explanations and Designing Solutions** Construct an explanation using models or representations. Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.	**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. (MS-ESS1-1) **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. (MS-ESS1-2),(MS-ESS1-3)	**Patterns** Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. Patterns can be used to identify cause and effect relationships. **Systems and System Models** Models are limited in that they only represent certain aspects of the system under study. **Cause and Effect: Mechanism and Prediction** Cause and effect relationships may be used to predict phenomena in natural and designed systems. **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.

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(N) Teacher Resource. Where are the small worlds? NGSS Alignment Rubric

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

Next Generation Science Standards Alignment (NGSS)

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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