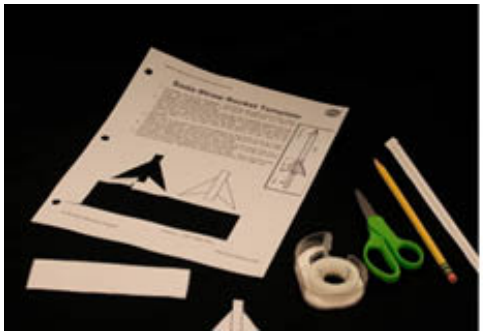
Soda Straw Rockets

K -2nd Grade Alignment Document
National Resource Council Framework, Next Generation Science Standards, Common Core State Standards, and 21st Century Skills



WHAT STUDENTS DO: Test a rocket model and predict its motion.

Curiosity about what lies beyond our home planet led to the first rocket launches from Earth and to many exploration missions since. Using simple materials (soda straws and paper), students will experience the processes involved in engineering a rocket. Conducting engineering tests, students will have the opportunity to answer a research question by collecting and analyzing data related to finding out the best nose cone length and predicting the motion of their model rockets.

NRC FRAMEWORK / NGSS CORE & COMPONENT QUESTIONS

HOW CAN ONE EXPLAIN AND PREDICT INTERACTIONS BETWEEN OBJECTS AND WITHIN SYSTEMS OF OBJECTS?

NRC Core Question: PS2: Motion and Stability: Forces and Interactions

How can one predict an object's continued motion, changes in motion, or stability?

NRC PS2.A: Forces and Motions

HOW DO ENGINEERS SOLVE PROBLEMS?

NRC Core Question: ETS1: Engineering Design

What is a design for? What are the criteria and constraints of a successful solution?

NRC ETS1.A: Defining and Delimiting an Engineering Problem

What is the process for developing potential design solutions?

INSTRUCTIONAL OBJECTIVES (IO)

Students will be able to

IO1: Plan and conduct an investigation through construction of a model rocket using soda straws and paper to test the effects of a push and of design changes of a rocket on the distance of the traveled

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NRC ETS1.B: Developing Possible Solutions

How can the various proposed design solutions be compared and improved?

NRC ETS1.C: Optimizing the Design Solution

Last edited: January 27, 2016

1.0 About This Activity

The Mars lessons leverage *A Taxonomy for Learning, Teaching, and Assessing* by Anderson and Krathwohl (2001) (see *Section 4* and *Teacher Guide* at the end of this document). This taxonomy provides a framework to help organize and align learning objectives, activities, and assessments. The taxonomy has two dimensions. The first dimension, cognitive process, provides categories for classifying lesson objectives along a continuum, at increasingly higher levels of thinking; these verbs allow educators to align their instructional objectives and assessments of learning outcomes to an appropriate level in the framework in order to build and support student cognitive processes. The second dimension, knowledge, allows educators to place objectives along a scale from concrete to abstract. By employing Anderson and Krathwohl's (2001) taxonomy, educators can better understand the construction of instructional objectives and learning outcomes in terms of the types of student knowledge and cognitive processes they intend to support. All activities provide a mapping to this taxonomy in the Teacher Guide (at the end of this lesson), which carries additional educator resources. Combined with the aforementioned taxonomy, the lesson design also draws upon Miller, Linn, and Gronlund's (2009) methods for (a) constructing a general, overarching, instructional objective with specific, supporting, and measurable learning outcomes that help assure the instructional objective is met, and (b) appropriately assessing student performance in the intended learning-outcome areas through rubrics and other measures. Construction of rubrics also draws upon Lanz's (2004) guidance, designed to measure science achievement.

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. This five-part sequence is the organizing tool for the Mars instructional series. The 5E stages can be cyclical and iterative.

2.0 Instructional Objectives, Learning Outcomes, & Standards

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*
- Achieve Inc.'s, *Next Generation Science Standards (NGSS)*
- 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 NGSS Framework and NGSS.
- You will know that you have achieved these instructional objectives if students demonstrate the related **learning outcomes (LO)**.
- You will know the level to which your students have achieved the learning outcomes by using the suggested **rubrics** (see Teacher Guide at the end of this document).

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:

The Teacher Guide at the end of this lesson provides full details of standards alignment, rubrics, and the way in which instructional objectives, learning outcomes, 5E activity procedures, and assessments were derived through, and align with, Anderson and Krathwohl's (2001) taxonomy of knowledge and cognitive process types. For convenience, a quick view follows:

HOW CAN ONE EXPLAIN AND PREDICT INTERACTIONS BETWEEN OBJECTS AND WITHIN SYSTEMS OF OBJECTS?

NGSS Core Question: PS2: Motion and Stability: Forces and Interactions

How can one predict an object's continued motion, changes in motion, or stability?

NGSS PS2.A: Forces and Motion

HOW DO ENGINEERS SOLVE PROBLEMS?

NGSS Core Question: ETS1: Engineering Design

What is a design for? What are the criteria and constraints of a successful solution?

NGSS ETS1.A: Defining and Delimiting an Engineering Problem

What is the process for developing potential design solutions?

NGSS ETS1.B: Developing Possible Solutions

How can the various proposed design solutions be compared and improved?

NGSS ETS1.C: Optimizing the Design Solution

Instructional Objective (IO) *Students will be able to:*	**Learning Outcomes (LO)** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*
IO1: **Plan and conduct an investigation through construction of a model rocket using soda straws and paper to test the effects of a push and of design changes of a rocket on the distance of travel**	**LO1a: to use standard (1st – 2nd) or non-standard (K) measurements for collecting and communicating distance traveled** **LO1b: to predict the effects of a push (breath) on a system and design a test to gather evidence to understand the cause and effect relationship** **LO1c: to use the engineering design cycle to record observations and construct an argument that events have causes that generate observable patterns**	**DISCIPLINARY CORE IDEAS:** **PS2.A: Forces and Motion** **ETS1.A: Defining and Delimiting Engineering Problems** **ETS1.B: Developing Possible Solutions** **ETS1.C: Optimizing the Design Solution** **PRACTICES:** **1. Asking Questions and Defining Problems** **2. Developing and Using Models** **3. Planning and Carrying out Investigations** **4. Analyzing and Interpreting Data** **5. Using Mathematics and Computational Thinking** **6. Engaging in Argument from Evidence** **7. Obtaining, Evaluating, and Communicating Information** **Scientific Knowledge is Based on Empirical Evidence** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** **CROSSCUTTING CONCEPTS:** **1. Cause and Effect** **2. Scale, Proportion and Quantity** **INTERDEPENDENCE OF SCIENCE, ENGINEERING, AND TECHNOLOGY**

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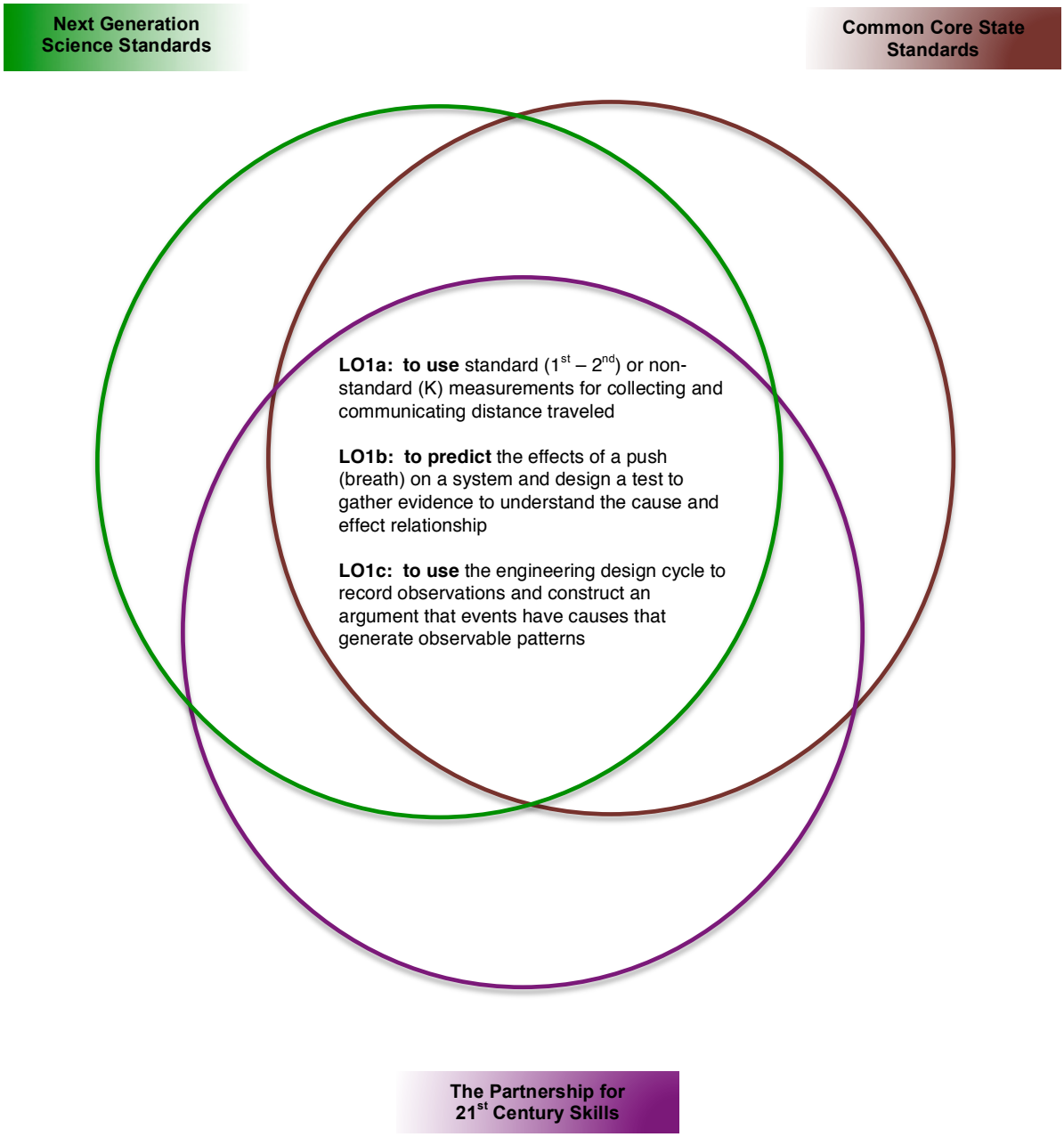
3.0 Learning Outcomes, NGSS, Common Core, & 21st Century Skills Connections

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, ELA Common Core Standards, and the 21st Century Skills and visually determine where there are overlaps in these documents.



4.0 Evaluation/Assessment

Use the *(L) Soda Straw Rockets 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, Common Core State Standards, and 21st Century Skills.

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.

Anderson, L.W., & Krathwohl (Eds.). (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives.* New York: Longman.

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.

National Academies Press. (1996, January 1). *National science education standards*. Retrieved February 7, 2011 from http://www.nap.edu/catalog.php?record_id=4962

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards*. Washington, DC: Authors.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

The Partnership for 21st Century Skills (2011). *A framework for 21st century learning.* Retrieved March 15, 2012 from http://www.p21.org

(I) Teacher Resource. Soda Straw Rockets 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:
(K-PS2-1), (K-PS2-2), (K-2-ETS1-1), (K-2-ETS1-2), (K-2-ETS1-3)

Next Generation Science Standards Alignment (NGSS)

Instructional Objective *Students will be able to*	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
IO1: **Plan and conduct an investigation through construction of a model rocket using soda straws and paper to test the effects of a push and of design changes of a rocket on the distance of travel**	**Asking Questions and Defining Problems:** Define a simple problem that can be solved through the development of a new or improved object or tool. **Developing and Using Models:** Distinguish between a model and the actual object, process, and/or events the model represents. Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). **Planning and Carrying Out Investigations:** With guidance, plan and conduct an investigation in collaboration with peers (for K). Plan and conduct an investigation	**PS2.A: Forces and Motion** Pushes and pulls can have different strengths and directions. (K-PS2-1),(K-PS2-2) Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1),(K-PS2-2) **ETS1.A: Defining and Delimiting: Engineering Problems** Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1) **ETS1.B: Developing Possible Solutions:** Designs can be conveyed through sketches,	**Cause and Effect:** Events have causes that generate observable patterns. Simple tests can be designed to gather evidence to support or refute student ideas about causes. **Scale, Proportion, and Quantity:** Standard units are used to measure length. **Interdependence of Science, Engineering, and Technology:** Science and engineering involve the use of tools to observe and measure things

	Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal. Make predictions based on prior experiences. **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena:** Scientists use drawings, sketches, and models as a way to communicate ideas. Scientists search for cause and effect relationships to explain natural events.	(K-2-ETS1-2) **ETS1.C: Optimizing the Design Solution:** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)	

(I) Teacher Resource. Soda Straw Rockets NGSS Alignment (2 of 3)

Next Generation Science Standards Alignment (NGSS)

Learning Outcomes *Students will demonstrate the measurable abilities*	Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
LO1a: **to use standard (1st – 2nd) or non-standard (K) measurements for collecting and communicating distance traveled**	**Planning and Carrying Out Investigations:** With guidance, plan and conduct an investigation in collaboration with peers (for K). Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal. **Analyzing and Interpreting Data:** Record information (observations, thoughts, and ideas). Analyze data from tests of an object or tool to determine if it works as intended. **Using Mathematics and Computational Thinking:** Use counting and numbers to identify and describe patterns in the natural and designed world(s). Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs. Use quantitative data to compare two alternative solutions to a problem.	**PS2.A: Forces and Motion** Pushes and pulls can have different strengths and directions. (K-PS2-1),(K-PS2-2) Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1),(K-PS2-2) **ETS1.A: Defining and Delimiting: Engineering Problems** Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1) **ETS1.B: Developing Possible Solutions:** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2) **ETS1.C: Optimizing the Design Solution:** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)	**Cause and Effect** Simple tests can be designed to gather evidence to support or refute student ideas about causes. **Scale, Proportion, and Quantity:** Standard units are used to measure length. **Interdependence of Science, Engineering, and Technology:** Science and engineering involve the use of tools to observe and measure things.

	Obtaining, Evaluating, and Communicating Information: Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas.		
LO1b: **to predict the effects of a push (breath) on a system and design a test to gather evidence to understand the cause and effect relationship**	**Developing and Using Models:** Distinguish between a model and the actual object, process, and/or events the model represents. Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). **Planning and Carrying Out Investigations:** With guidance, plan and conduct an investigation in collaboration with peers (for K). Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal. Make predictions based on prior experiences. **Obtaining, Evaluating, and Communicating Information:** Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas.	**PS2.A: Forces and Motion** Pushes and pulls can have different strengths and directions. (K-PS2-1),(K-PS2-2) Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1),(K-PS2-2) **ETS1.A: Defining and Delimiting: Engineering Problems** Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1) **ETS1.B: Developing Possible Solutions:** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2) **ETS1.C: Optimizing the Design Solution:** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)	**Cause and Effect** Simple tests can be designed to gather evidence to support or refute student ideas about causes.
LO1c: **to use the**	**Asking Questions and Defining Problems:** Define a simple problem that can be solved	**PS2.A: Forces and Motion** Pushes and pulls can have different strengths	**Cause and Effect:** Events have causes that generate observable patterns.

engineering design cycle to record observations and construct an argument that events have causes that generate observable patterns	through the development of a new or improved object or tool. **Developing and Using Models:** Distinguish between a model and the actual object, process, and/or events the model represents. Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). **Planning and Carrying Out Investigations:** With guidance, plan and conduct an investigation in collaboration with peers (for K). Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal. Make predictions based on prior experiences. **Analyzing and Interpreting Data:** Record information (observations, thoughts, and ideas). Use and share pictures, drawings, and/or writings of observations. Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. Compare predictions (based on prior experiences) to what occurred (observable events). Analyze data from tests of an object or tool to determine if it works as intended.	and directions. (K-PS2-1),(K-PS2-2) Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1),(K-PS2-2) **ETS1.A: Defining and Delimiting: Engineering Problems** Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1) **ETS1.B: Developing Possible Solutions:** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2) **ETS1.C: Optimizing the Design Solution:** Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)	Simple tests can be designed to gather evidence to support or refute student ideas about causes. **Scale, Proportion, and Quantity:** Standard units are used to measure length. **Interdependence of Science, Engineering, and Technology:** Science and engineering involve the use of tools to observe and measure things

	Using Mathematics and Computational Thinking: Use counting and numbers to identify and describe patterns in the natural and designed world(s). Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs. Use quantitative data to compare two alternative solutions to a problem. **Engaging in Argument from Evidence:** Construct an argument with evidence to support a claim. Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence. **Obtaining, Evaluating, and Communicating Information:** Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas. **Scientific Knowledge is Based on Empirical Evidence:** Scientists look for patterns and order when making observations about the world. **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena:** Scientists use drawings, sketches, and models as a way to communicate ideas. Scientists search for cause and effect relationships to explain natural events.		

(I) Teacher Resource. Soda Straw Rockets NGSS 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
Research Common Rocket Features	**Engage**	**Planning and Carrying Out Investigations:** Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons.	**PS2.A: Forces and Motion:** Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. An object sliding on a surface or sitting on a slope experiences a pull due to friction on the object due to the surface that opposes the object's motion.	**Cause and Effect: Mechanism and Prediction** Events have causes that generate observable patterns.
(A) Soda-Straw Rocket Template	**Explore**	**Planning and Carrying Out Investigations:** With guidance, plan and conduct an investigation in collaboration with peers (for K). Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. **Developing and Using Models:** Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).	**ETS1.B: Developing Possible Solutions:** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. To design something complicated, one may need to break the problem into parts and attend to each part separately but must then bring the parts together to test the overall plan.	**Systems and System Models:** Objects and organisms can be described in terms of their parts. Systems in the natural and designed world have parts that work together.

(B) Soda-Straw Rocket Data Log	**Explore**	**Planning and Carrying Out Investigations:** With guidance, plan and conduct an investigation in collaboration with peers (for K). Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. **Using Mathematics and Computational Thinking:** Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs. **Scientific Knowledge is Based on Empirical Evidence:** Scientists look for patterns and order when making observations about the world.	**PS2.A: Forces and Motion:** Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. An object sliding on a surface or sitting on a slope experiences a pull due to friction on the object due to the surface that opposes the object's motion.	**Cause and Effect: Mechanism and Prediction** Events have causes that generate observable patterns. Simple tests can be designed to gather evidence to support or refute student ideas about causes. **Scale, Proportion, and Quantity:** Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). **Interdependence of Science, Engineering, and Technology:** Science and engineering involve the use of tools to observe and measure things.
(C) Safety Procedure	**Explore**			
(D) Soda-Straw Rocket Results	**Explain**	**Developing and Using Models:** Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). **Analyzing and Interpreting Data:** Use and share pictures, drawings, and/or writings of observations. Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. **Constructing Explanations and Designing Solutions:** Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena.	**PS2.A: Forces and Motion:** Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. An object sliding on a surface or sitting on a slope experiences a pull due to friction on the object due to the surface that opposes the object's motion.	**Cause and Effect: Mechanism and Prediction** Events have causes that generate observable patterns. **Scale, Proportion, and Quantity:** Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). **Systems and System Models:** A system can be described in terms of its components and their interactions. **Interdependence of Science, Engineering, and Technology:** Science and engineering involve the use of tools to observe and measure things.

		Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena: Scientists search for cause and effect relationships to explain natural events. Scientists use drawings, sketches, and models as a way to communicate ideas. Scientists search for cause and effect relationships to explain natural events.		
(E) Apply to New Ideas	**Elaborate**	**Asking Questions and Defining Problems:** Ask and/or identify questions that can be answered by an investigation. **Developing and Using Models:** Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s). **Analyzing and Interpreting Data:** Use and share pictures, drawings, and/or writings of observations. Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems. **Using Mathematics and Computational Thinking:** Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems. **Constructing Explanations and Designing Solutions:** Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena. **Science Models, Laws, Mechanisms, and**	**PS2.A: Forces and Motion:** Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. An object sliding on a surface or sitting on a slope experiences a pull due to friction on the object due to the surface that opposes the object's motion.	**Cause and Effect: Mechanism and Prediction** Events have causes that generate observable patterns. **Scale, Proportion, and Quantity:** Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). **Systems and System Models:** A system can be described in terms of its components and their interactions.

		Theories Explain Natural Phenomena: Scientists search for cause and effect relationships to explain natural events.		
(F) Engineering Design Cycle	**Evaluate**	**Engaging in Argument from Evidence:** Construct an argument with evidence to support a claim. **Analyzing and Interpreting Data:** Analyze data from tests of an object or tool to determine if it works as intended. **Obtaining, Evaluating, and communicating Information:** Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas. **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena:** Scientists search for cause and effect relationships to explain natural events. Scientists use drawings, sketches, and models as a way to communicate ideas. Scientists search for cause and effect relationships to explain natural events.	**ETS1.A: Defining and Delimiting an Engineering Problem:** A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. Asking questions, making observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem. **ETS1.B: Developing Possible Solutions:** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. To design something complicated, one may need to break the problem into parts and attend to each part separately but must then bring the parts together to test the overall plan. **ETS1.C: Optimizing the Design Solution:** Because there is always more than one possible solution to a problem, it is useful to compare designs, test them, and discuss their strengths and weaknesses.	**Cause and Effect: Mechanism and Prediction:** Events have causes that generate observable patterns. Simple tests can be designed to gather evidence to support or refute student ideas about causes. **Scale, Proportion, and Quantity:** Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower). **Systems and System Models:** A system can be described in terms of its components and their interactions.

(J) Teacher Resource. Soda Straw Rockets CCSS Alignment (1 of 2)

Common Core State Standards			
Instructional Objective *Students will be able to*	**Reading Standards for Informational Text (K-2)**	**Writing Standards (K-2)**	**Speaking and Listening Standards (K-2)**
IO1: **Plan and conduct an investigation through construction of a model rocket using soda straws and paper to test the effects of a push and of design changes of a rocket on the distance of travel**	**Key Ideas and Details:** **Kindergarten:** With prompting and support, ask and answer questions about key details in a text. With prompting and support, describe the connection between two individuals, events, ideas, or pieces of information in a text. **Grade 1:** Ask and answer questions about key details in a text. Describe the connection between two individuals, events, ideas, or pieces of information in a text. **Grade 2:** Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.	**Text Types and Purposes:** **Kindergarten:** Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic. **Grade 1:** Write informative/explanatory texts in which they name a topic, supply some facts about the topic, and provide some sense of closure.	**Comprehension and Collaboration:** **Kindergarten:** Participate in collaborative conversations with diverse partners about kindergarten topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., listening to others and taking turns speaking about the topics and texts under discussion). b. Continue a conversation through multiple exchanges. Confirm understanding of a text read aloud or information presented orally or through other media by asking and answering questions about key details and requesting clarification if something is not understood. Ask and answer questions in order to seek help, get information, or clarify something that is not understood. **Grade 1:** Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., listening to others with care, speaking one at a time about the topics and texts under discussion). b. Build on others' talk in conversations by responding to the comments of others through multiple exchanges.

			c. Ask questions to clear up any confusion about the topics and texts under discussion. Ask and answer questions about key details in a text read aloud or information presented orally or through other media. Ask and answer questions about what a speaker says in order to gather additional information or clarify something that is not understood. **Grade 2:** Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion). b. Build on others' talk in conversations by linking their comments to the remarks of others. c. Ask for clarification and further explanation as needed about the topics and texts under discussion. Recount or describe key ideas or details from a text read aloud or information presented orally or through other media. Ask and answer questions about what a speaker says in order to clarify comprehension, gather additional information, or deepen understanding of a topic or issue.

(J) Teacher Resource. Soda Straw Rockets CCSS Alignment (2 of 2)

Common Core State Standards			
Learning Outcome *Students will be able*	**Mathematics (K-2)**		**Speaking and Listening Standards (K-2)**
LO1a: to use standard (1st – 2nd) or non-standard (K) measurements for collecting and communicating distance traveled	**Counting and Cardinality:** **Kindergarten:** Write numbers from 0 to 20. Represent a number of objects with a written numeral 0-20 (with 0 representing a count of no objects). Count to answer "how many?" questions about as many as 20 things arranged in a line, a rectangular array, or a circle, or as many as 10 things in a scattered configuration; given a number from 1–20, count out that many objects. Identify whether the number of objects in one group is greater than, less than, or equal to the number of objects in another group, e.g., by using matching and counting strategies. **Measurement and Data:** **Kindergarten:** Describe measurable attributes of objects, such as length or weight. Describe several measurable attributes of a single object. Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. For example, directly compare the heights of two children and describe one child as taller/shorter. **Geometry:** **Kindergarten:** Describe objects in the environment using names of shapes, and describe the relative positions of		**Comprehension and Collaboration:** **Kindergarten:** Participate in collaborative conversations with diverse partners about kindergarten topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., listening to others and taking turns speaking about the topics and texts under discussion). b. Continue a conversation through multiple exchanges. Confirm understanding of a text read aloud or information presented orally or through other media by asking and answering questions about key details and requesting clarification if something is not understood. Ask and answer questions in order to seek help, get information, or clarify something that is not understood. **Grade 1:** Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., listening to others with care, speaking one at a time about the topics and texts under discussion). b. Build on others' talk in conversations by responding to the comments of others through multiple exchanges.

	these objects using terms such as above, below, beside, in front of, behind, and next to. Correctly name shapes regardless of their orientations or overall size. Model shapes in the world by building shapes from components (e.g., sticks and clay balls) and drawing shapes.		c. Ask questions to clear up any confusion about the topics and texts under discussion. Ask and answer questions about key details in a text read aloud or information presented orally or through other media. Ask and answer questions about what a speaker says in order to gather additional information or clarify something that is not understood. **Grade 2:** Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion). b. Build on others' talk in conversations by linking their comments to the remarks of others. c. Ask for clarification and further explanation as needed about the topics and texts under discussion. Recount or describe key ideas or details from a text read aloud or information presented orally or through other media. Ask and answer questions about what a speaker says in order to clarify comprehension, gather additional information, or deepen understanding of a topic or issue.

Learning Outcome *Students will be able*	Reading Standards for Informational Text (K-2)	Writing Standards (K-2)	Speaking and Listening Standards (K-2)
LO1b: **to predict the effects of a push (breath) on a system and design a test to gather evidence to understand the cause and effect relationship** **LO1c:** **to use the engineering design cycle to record observations and construct an argument that events have causes that generate observable patterns**	**Key Ideas and Details:** **Kindergarten:** With prompting and support, ask and answer questions about key details in a text. With prompting and support, describe the connection between two individuals, events, ideas, or pieces of information in a text. **Grade 1:** Ask and answer questions about key details in a text. Describe the connection between two individuals, events, ideas, or pieces of information in a text. **Grade 2:** Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.	**Text Types and Purposes:** **Kindergarten:** Use a combination of drawing, dictating, and writing to compose informative/explanatory texts in which they name what they are writing about and supply some information about the topic. **Grade 1:** Write informative/explanatory texts in which they name a topic, supply some facts about the topic, and provide some sense of closure.	**Comprehension and Collaboration:** **Kindergarten:** Participate in collaborative conversations with diverse partners about kindergarten topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., listening to others and taking turns speaking about the topics and texts under discussion). b. Continue a conversation through multiple exchanges. Confirm understanding of a text read aloud or information presented orally or through other media by asking and answering questions about key details and requesting clarification if something is not understood. Ask and answer questions in order to seek help, get information, or clarify something that is not understood. **Grade 1:** Participate in collaborative conversations with diverse partners about grade 1 topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., listening to others with care, speaking one at a time about the topics and texts under discussion). b. Build on others' talk in conversations by responding to the comments of others through multiple exchanges. c. Ask questions to clear up any confusion about the topics and texts under discussion. Ask and answer questions about key details in a text read aloud or information presented orally or through other media. Ask and answer questions about what a speaker

			says in order to gather additional information or clarify something that is not understood. **Grade 2:** Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups. a. Follow agreed-upon rules for discussions (e.g., gaining the floor in respectful ways, listening to others with care, speaking one at a time about the topics and texts under discussion). b. Build on others' talk in conversations by linking their comments to the remarks of others. c. Ask for clarification and further explanation as needed about the topics and texts under discussion. Recount or describe key ideas or details from a text read aloud or information presented orally or through other media. Ask and answer questions about what a speaker says in order to clarify comprehension, gather additional information, or deepen understanding of a topic or issue.

(J) Teacher Resource. Soda Straw Rockets 21st Century Skills Alignment

21st Century Skills		
Learning Outcomes *Students will demonstrate the measurable abilities*	**21st Century Skill**	**Grade 4 Benchmark**
LO1a: to use standard (1st – 2nd) or non-standard (K) measurements for collecting and communicating distance traveled	**Collaboration**	Students work collaboratively with others, both in small and large groups, in their science classroom.
LO1b: to predict the effects of a push (breath) on a system and design a test to gather evidence to understand the cause and effect relationship	**Critical Thinking and Problem Solving**	Students construct their own scientific understanding and develop their scientific process skills by asking scientific questions, designing and conducting investigations, constructing explanations from their observations, and discussing their explanations with others.
	Communication	Students understand that models are simplified representations of real objects and processes, and that models serve as a means to communicate ideas and knowledge about how things work.
	Collaboration	Students work collaboratively with others, both in small and large groups, in their science classroom.
	Initiative and Self-Direction	Students are able to design an investigation based on a question they have generated from their own curiosity.
LO1c: to use the engineering design cycle to record observations and construct an argument that events have causes that generate observable patterns	**Critical Thinking and Problem Solving**	Students construct their own scientific understanding and develop their scientific process skills by asking scientific questions, designing and conducting investigations, constructing explanations from their observations, and discussing their explanations with others.
	Communication	Students understand that models are simplified representations of real objects and processes, and that models serve as a means to communicate ideas and knowledge about how things work.

	Collaboration	Students work collaboratively with others, both in small and large groups, in their science classroom.
	Initiative and Self-Direction	Students are able to design an investigation based on a question they have generated from their own curiosity.

(L) Teacher Resource. Soda Straw Rockets NGSS Rubric (1 of 3)

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. to use standard (1st – 2nd) or non-standard (K) measurements for collecting and communicating distance traveled	Uses standard units (e.g. inches/feet or centimeters/meters) or non-standard units (e.g. number of floor tiles) consistently and accurately measures, records and communicates results.	Uses standard units (e.g. inches/feet or centimeters/meters) or non-standard units (e.g. number of floor tiles) consistently and measures, records and communicates results with minimal error.	Uses quantitative units, but is not consistent in the usage of units or does not accurately record and communicate results.	Uses comparative language such as further or less far. Does not use quantitative measurements.
LO1b: to predict the effects of a push (breath) on a system and design a test to gather evidence to understand the cause and effect relationship				
LO1c: to use the engineering design cycle to record observations and construct an argument that events have causes that generate observable patterns				

(L) Teacher Resource. Soda Straw Rockets CCSS Rubric (2 of 3)

Common Core – ELA and Math

	Expert	Proficient	Intermediate	Beginner
Key Ideas and Details	Uses specific evidence from text to support ideas. Develops an accurate and in depth summary, extending prior understanding and opinions.	Uses specific evidence from text to support ideas. Develops an in depth summary, extending prior understanding and opinions.	Uses information from text to support ideas. Develops a summary, extending prior understanding and opinions.	Supports ideas with details, relying on prior understanding and opinions.
Text Type and Purposes	Uses a combination of drawing, dictating, and writing to describe the results of the experiment, supported with facts about the experiments, and a closing statement about the experiment.	Uses drawing, dictating, or writing to describe the results of the experiment, supported with facts about the experiments, and a closing statement about the experiment.	Uses drawing, dictating, or writing to describe the results of the experiment and is supported with facts about the experiments.	Uses drawing, dictating, or writing to provide the results of the experiment.
Comprehension and Collaboration	Clearly articulates ideas in collaborative discussion while following agreed upon class rules for discussion. Extremely prepared drawing from experiences. Asks clarifying questions to ensure full understanding of content. Articulates own ideas related to the discussion and connects others ideas to own.	Articulates ideas in collaborative discussion while following agreed upon class rules for discussion. Prepared for discussion by drawing from experiences. Asks questions. Articulates own ideas related to the discussion.	Interested in collaborative discussion. Asks questions. Articulates own ideas related to the discussion.	Interested in collaboration with peers.
Counting and Cardinality	Accurately counts to a number no greater than 20 to answer how many tiles the rocket flew and correctly identifies which rocket flight is greatest and which is least.	Counts to a number no greater than 20 with no more than once miscount to answer how many tiles the rocket flew and correctly identifies which rocket flight is greatest and which is least.	Counts to a number no greater than 20 with at least 1 miscount to answer how many tiles the rocket flew or incorrectly identifies which rocket flight is greatest and which is least.	Counts to a number no greater than 20 with at least 1 miscount to answer how many tiles the rocket flew and incorrectly identifies which rocket flight is greatest and which is least.

Measurement and Data	Accurately identifies and compares distance measurements that are greater than and less than to describe their meaning	Identifies and compares distance measurements that are greater than and less than	Identifies greater than and less than, but unable to compare the measurements to describe their meaning	Unable to identify greater than and less than, therefore is unable to describe and/or compare results or allows the group to decide the result with little to no input
Geometry	Uses correct shape names to describe rocket parts, whether paper models or in video/image, such as the nose cone or cylinder for the body. Correctly describes the relative position of the rocket parts and rocket to the target and launch pad.	Uses correct shape names to describe rocket parts, whether paper models or in video/image, such as the nose cone or cylinder for the body. Correctly describes the relative position of the rocket parts or rocket to the target and launch pad.	Uses correct shape names to describe paper rocket parts, such as the nose cone or cylinder for the body. Correctly describes the relative position of the rocket parts or rocket to the target and launch pad.	Uses simplified names to refer to the parts of a paper rocket, such as top or bottom. May struggle with describing the relative position of the rocket parts and between the rocket to target/launch pad.

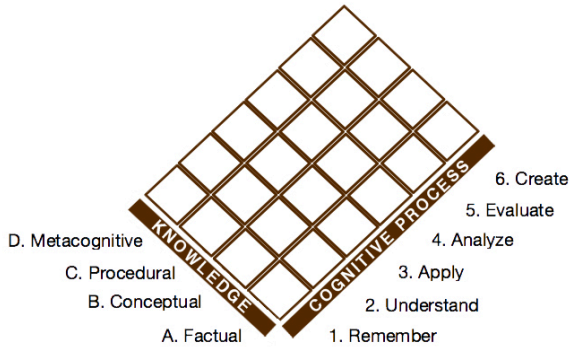
(L) Teacher Resource. Soda Straw Rockets 21st Century Skills Rubric (3 of 3)

Partnership for 21st Century Skills

	Expert	Proficient	Intermediate	Beginner
Effectiveness of collaboration with team members and class.	Extremely interested in collaborating in the group. Actively provides solutions to problems, listens to suggestions from others, and attempts to ensure everyone has a contribution.	Extremely Interested in collaborating in the group. Actively provides suggestions and occasionally listens to suggestions from others.	Interested in collaborating in the group. Listens to suggestions from peers and attempts to use them. Occasionally provides suggestions in group discussion.	Interested in collaborating in the group.
Effectiveness of Critical Thinking and Problem Solving	Develops detailed verbal explanations based on experimental evidence. Compares explanations to those made by peers and relates them to their new understandings.	Develops detailed verbal explanations based on experimental evidence. Relates them to their new understandings.	Develops verbal explanations. Relates explanation to their new understandings.	Attempts to explain the design based on own preconceived understanding or generally agree with the explanations provided by the group.
Effectiveness in Communication	Demonstrates the understanding that the paper rocket is a simple model of a real rocket, not all components of the rocket are represented, and communication is rooted in reality, not make-believe.	Demonstrates the understanding that the paper rocket is a simple model of a real rocket, not all components of the rocket are represented, and may pretend the rocket is real, but majority of the experiment is rooted in reality.	Demonstrates the understanding that the paper rocket is a simple model of a real rocket and may pretend the rocket is real, but majority of the experiment is rooted in reality.	Plays with the rocket regardless of the goals of the task
Effectiveness of Initiative and Self-Direction	Designs an investigation based on a question they have generated as a result of their experiment with push vs. distance.	Designs an investigation based on a question generated by another group and is the result of the experiment with push vs. distance.	Designs an investigation based on a question generated by the teacher and is the result of the experiment with push vs. distance.	Plays with the rocket regardless of the goals of the task

(M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (1 of 3)

This lesson adapts Anderson and Krathwohl's (2001) taxonomy, which has two domains: Knowledge and Cognitive Process, each with types and subtypes (listed below). Verbs for objectives and outcomes in this lesson align with the suggested knowledge and cognitive process area and are mapped on the next page(s). Activity procedures and assessments are designed to support the target knowledge/cognitive process.

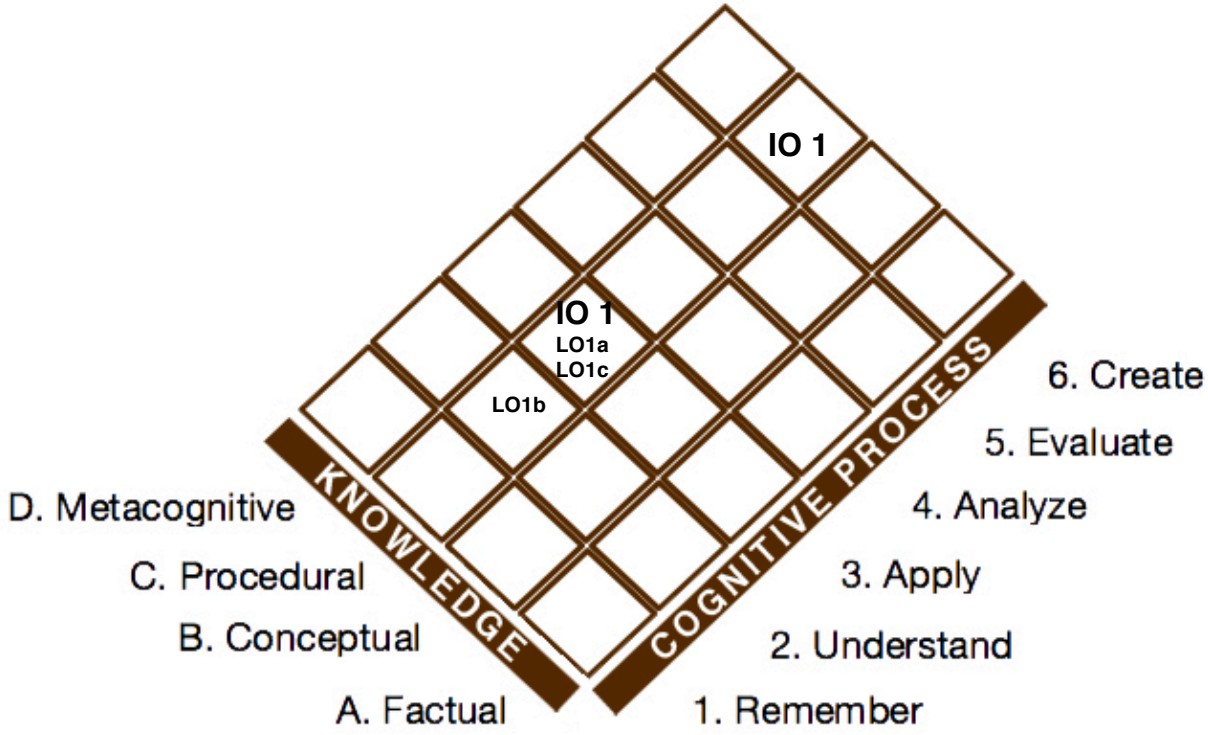


Knowledge	Cognitive Process
A. Factual **Aa:** Knowledge of Terminology **Ab:** Knowledge of Specific Details & Elements **B. Conceptual** **Ba:** Knowledge of classifications and categories **Bb:** Knowledge of principles and generalizations **Bc:** Knowledge of theories, models, and structures **C. Procedural** **Ca:** Knowledge of subject-specific skills and algorithms **Cb:** Knowledge of subject-specific techniques and methods **Cc:** Knowledge of criteria for determining when to use appropriate procedures **D. Metacognitive** **Da:** Strategic Knowledge **Db:** Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge **Dc:** Self-knowledge	**1. Remember** **1.1** Recognizing (Identifying) **1.2** Recalling (Retrieving) **2. Understand** **2.1** Interpreting (Clarifying, Paraphrasing, Representing, Translating) **2.2** Exemplifying (Illustrating, Instantiating) **2.3** Classifying (Categorizing, Subsuming) **2.4** Summarizing (Abstracting, Generalizing) **2.5** Inferring (Concluding, Extrapolating, Interpolating, Predicting) **2.6** Comparing (Contrasting, Mapping, Matching **2.7** Explaining (Constructing models) **3. Apply** **3.1** Executing (Carrying out) **3.2** Implementing (Using) **4. Analyze** **4.1** Differentiating (Discriminating, distinguishing, focusing, selecting) **4.2** Organizing (Finding coherence, integrating, outlining, parsing, structuring) **4.3** Attributing (Deconstructing) **5. Evaluate** **5.1** Checking (Coordinating, Detecting, Monitoring, Testing) **5.2** Critiquing (Judging) **6. Create** **6.1** Generating (Hypothesizing) **6.2** Planning (Designing) **6.3** Producing (Constructing)

(M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (2 of 3)

IO1: Plan and conduct an investigation through construction of a model rocket using soda straws and paper to test the effects of a push and of design changes of a rocket on the distance of travel (6.2, 3.1; Cb)

LO1a. **to use** standard (1st – 2nd) or non-standard (K) measurements for collecting and communicating distance traveled (3.2; Ca)
LO1b. **to predict** the effects of a push (breath) on a system and design a test to gather evidence to understand the cause and effect relationship (2.5; Bb)
LO1c. **to use** the engineering design cycle to record observations and construct an argument that events have causes that generate observable patterns (3.2; Cb)



(M) Teacher Resource. Placement of Instructional Objective and Learning Outcomes in Taxonomy (3 of 3)

The design of this activity leverages Anderson & Krathwohl's (2001) taxonomy as a framework. Below are the knowledge and cognitive process types students are intended to acquire per the instructional objective(s) and learning outcomes written for this lesson. The specific, scaffolded 5E steps in this lesson (see 5.0 Procedures) and the formative assessments (worksheets in the Student Guide and rubrics in the Teacher Guide) are written to support those objective(s) and learning outcomes. Refer to (M, 1 of 3) for the full list of categories in the taxonomy from which the following were selected. The prior page (M, 2 of 3) provides a visual description of the placement of learning outcomes that enable the overall instructional objective(s) to be met.

At the end of the lesson, students will be able

IO1: **Plan and conduct** an investigation through construction of a model rocket using soda straws and paper to test the effects of a push and of design changes of a rocket on the distance of travel
- **6.2:** to plan
- **3.1:** to conduct
- **Cb:** Knowledge of subject-specific techniques and methods

To meet that instructional objective, students will demonstrate the abilities:

LO1a: **to use** standard (1st – 2nd) or non-standard (K) measurements for collecting and communicating distance traveled
- 3.2: to use
- Ca: knowledge of subject-specific skills and algorithms

LO1b: **to predict** the effects of a push (breath) on a system and design a test to gather evidence to understand the cause and effect relationship
- 2.5: to predict
- Bb: knowledge of principles and generalizations

LO1c: **to use** the engineering design cycle to record observations and construct an argument that events have causes that generate observable patterns
- 3.2: to use
- Cb: Knowledge of subject-specific techniques and methods