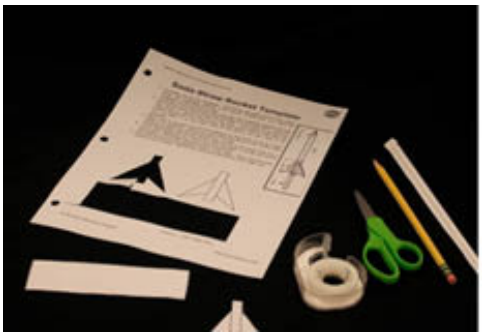
Soda Straw Rockets

3rd-5th Grade NGSS, Common Core, and 21st Century Skills Alignment Document



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 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 IS ENERGY TRANSFERRED AND CONSERVED?

NRC Core Question: PS3: Energy

HOW DO ENGINEERS SOLVE PROBLEMS?

NRC Core Question: ETS1: Engineering Design

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

NRC PS2.A: Forces and Motions

What underlying forces explain the variety of interactions observed?

NRC PS2.B: Types of Interactions

What is energy?

NRC PS3.A: Definitions of Energy

INSTRUCTIONAL OBJECTIVES

Students will be able

IO1: to plan and conduct an investigation into the effects of a force on the distance traveled and path it travels.

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?

NRC ETS1.B: Developing Possible Solutions

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

NRC ETS1.C: Optimizing the Design Solution

1.0 About This Activity

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.

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.

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 lesson).

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?

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

HOW IS ENERGY TRANSFERRED AND CONSERVED?

NRC Core Question: PS3: Energy

HOW DO ENGINEERS SOLVE PROBLEMS?

NRC Core Question: ETS1: Engineering Design

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

NRC PS2.A: Forces and Motions

What underlying forces explain the variety of interactions observed?

NRC PS2.B: Types of Interactions

What is energy?

NRC PS3.A: Definitions of Energy

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?

NRC ETS1.B: Developing Possible Solutions

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

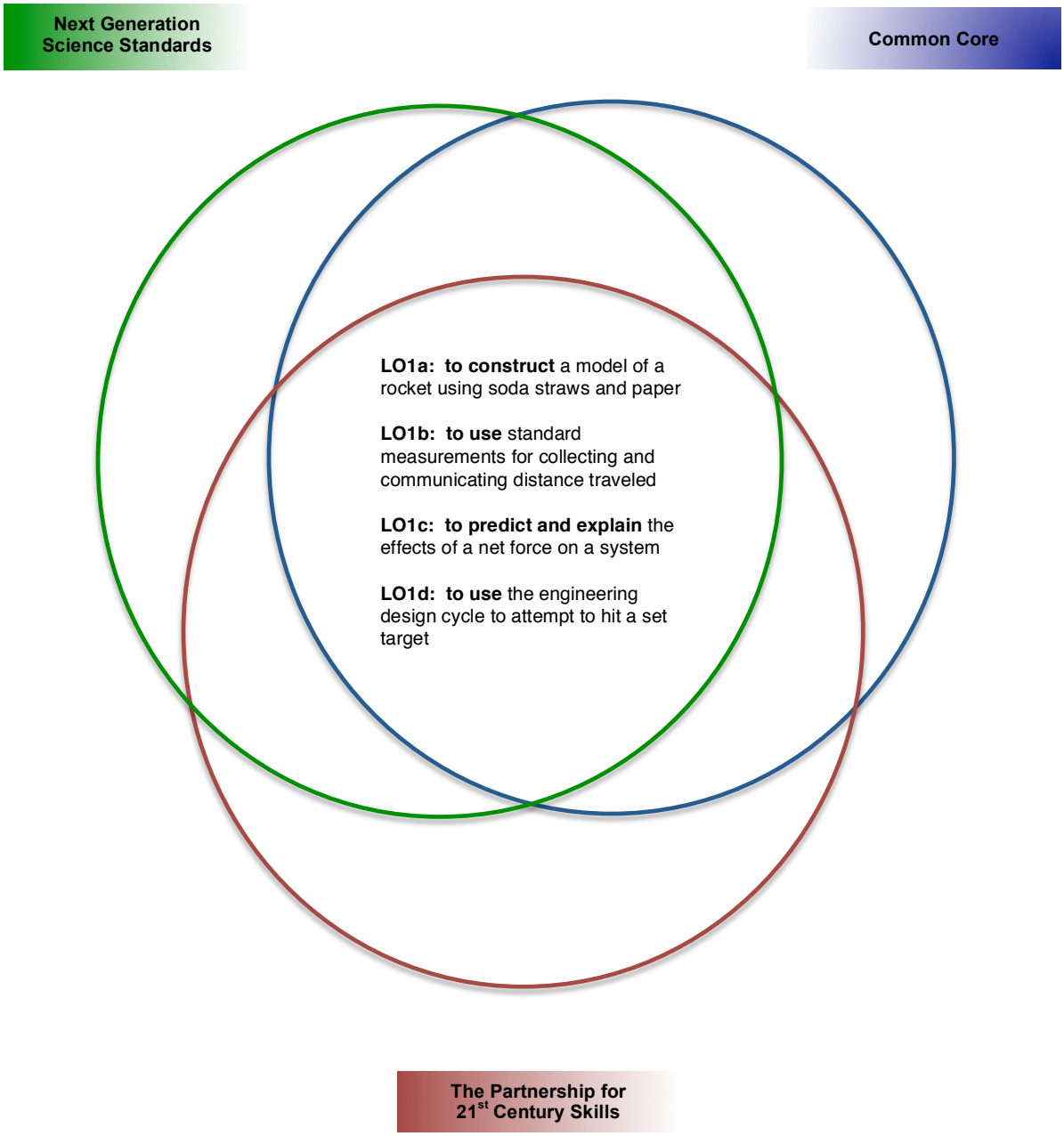
NRC ETS1.C: Optimizing the Design Solution

Instructional Objective *Students will be able*	**Learning Outcomes** *Students will demonstrate the measurable abilities*	**Standards** *Students will address*
IO1: **to plan and conduct** an investigation into the effects of a force on the distance traveled and path it travels.	**LO1a: to construct** a model of a rocket using soda straws and paper **LO1b: to use** standard measurements for collecting and communicating distance traveled **LO1c: to predict and explain** the effects of a net force on a system **LO1d**: **to use** the engineering design cycle to attempt to hit a set target	**NSES: UNIFYING CONCEPTS & PROCESSES:** **K-12: Evidence, models, and explanations** **NSES (A): SCIENCE AS INQUIRY** **Abilities necessary to do scientific inquiry** **Grades 5-8:** A3 **NSES (E): SCIENCE & TECHNOLOGY** **Evaluate Completed Technological Design or Products** **Grades 5-8:** E1d **NGSS Disciplinary Core Idea:** **PS2.A: Forces and Motion** **PS2.B: Types of Interactions** **PS3.A: Definitions of Energy** **ETS1.A: Defining and Delimiting Engineering Problems** **ETS1.B: Developing Possible Solutions** **ETS1.C: Optimizing the Design Solution** **NGSS Practices:** **Asking Questions and Defining Problems**

		Developing and Using Models **Planning and Carrying out Investigations** **Analyzing and Interpreting Data** **Using Mathematics and Computational Thinking** **Constructing Explanations and Designing Solutions** **Engaging in Argument from Evidence** **Scientific Investigations use a Variety of Methods** **Scientific Knowledge is Based on Empirical Evidence** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** **NGSS Cross-Cutting Concept:** **Patterns** **Cause and Effect** **Scale, Proportion and Quantity** **Systems and System Models** **Energy and Matter** **Structure and Function** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** **Interdependence of Science, Engineering, and Technology**	

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

Rubric: A rubric has been provided to assess student understanding of the simulation and to assess metacognition. A copy has been provided in the Student Guide for students to reference prior to the simulation. This rubric will allow them to understand the expectations set before them.

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

(L) Teacher Resource. Soda Straw Rockets Rubric (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.

Instructional Objective 1: to plan and conduct an investigation into the effects of a force on the distance traveled and path it travels.

Related Standard(s)

National Science Education Standards (NSES)
UNIFYING CONCEPTS & PROCESSES

Grades K-12 (A2) Evidence, models, and explanations
Evidence consists of observations and data on which to base scientific explanations. Using evidence to understand interactions allows individuals to predict changes in natural and designed systems. Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. Models help scientists and engineers understand how things work. Models take many forms, including physical objects, plans, mental constructs, mathematical equations, and computer simulations.

Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements. Different terms, such as "hypothesis," "model," "law," "principle," "theory," and "paradigm" are used to describe various types of scientific explanations.

As students develop and as they understand more science concepts and processes, their explanations should become more sophisticated. That is, their scientific explanations should more frequently include a rich scientific knowledge base, evidence of logic, higher levels of analysis, greater tolerance of criticism and uncertainty, and a clearer demonstration of the relationship between logic, evidence, and current knowledge.

National Science Education Standards (NSES)
(A) Science as Inquiry: Abilities necessary to do scientific inquiry

Grades 5-8: (A3)
Design & Conduct a Scientific Investigation. Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.

(A5) Develop descriptions, explanations, predictions, and models using evidence.

Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description—providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge.

National Science Education Standards (NSES)
(E) Science and Technology: Abilities of Technological Design
Evaluate a Product or Design. Students should use criteria relevant to the original purpose or need, consider a variety of factors that might affect acceptability and suitability for intended users or beneficiaries, and develop measures of quality with respect to such criteria and factors; they should also suggest improvements and, for their own products, try proposed modifications. (Grades 5-8: E1d)

This lesson supports the preparation of students toward achieving Performance Expectations using the Practices, Cross-Cutting Concepts and Disciplinary Core Ideas defined below:

(3-PS2-1); (3-PS2-2)
(4-PS2-1)
(5-PS2-1)
(3-5-ETS1-1); (3-5-ETS1-2); (3-5-ETS1-3)

Next Generation Science Standards (NGSS)
Disciplinary Core Idea: PS2.A: Forces and Motion
(Learning Outcomes Addressed: LO1c, LO1d)

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it.

Next Generation Science Standards (NGSS)
Disciplinary Core Idea: PS3.B: Definitions of Energy
(Learning Outcomes Addressed: LO1b, LO1d)

- The faster a given object is moving, the more energy it possesses.

Next Generation Science Standards (NGSS)
Disciplinary Core Idea: PS2.B: Types of Interactions
(Learning Outcomes Addressed: LO1c, LO1d)

- The gravitational force of Earth acting on an object near Earth's surface pulls that object toward the planet's center.

Next Generation Science Standards (NGSS)
Disciplinary Core Idea: ETS1.A Defining and Delimiting Engineering Problems
(Learning Outcomes Addressed: LO1a, LO1d)

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

Next Generation Science Standards (NGSS)
Disciplinary Core Idea: ETS1.B Developing Possible Solutions
(Learning Outcomes Addressed: LO1a, LO1d)

- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

Next Generation Science Standards (NGSS)
Disciplinary Core Idea: ETS1.C Optimizing the Design Solution
(Learning Outcomes Addressed: LO1a, LO1d)

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.

Next Generation Science Standards (NGSS)
Practices: Asking Questions and Defining Problems
(Learning Outcomes Addressed: LO1a, LO1d)

- Ask questions about what would happen if a variable is changed.
- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

Next Generation Science Standards (NGSS)
Practices: Developing and Using Models
(Learning Outcomes Addressed: LO1a, LO1d)

- Develop and/or use models to describe and/or predict phenomena.
- Use a model to test cause and effect relationships or interactions concerning the functioning of a natural or designed system.

Next Generation Science Standards (NGSS)
Practices: Planning and Carrying out Investigations
(Learning Outcomes Addressed: LO1a, LO1b, LO1c, LO1d)

- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials

considered.
- Evaluate appropriate methods and/or tools for collecting data.
- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.
- Make predictions about what would happen if a variable changes.
- Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.

Next Generation Science Standards (NGSS)
Practices: Analyzing and Interpreting Data
(Learning Outcomes Addressed: LO1b, LO1c, LO1d)

- Analyze and interpret data to make sense of phenomena, using logical reasoning, mathematics, and/or computation.
- Compare and contrast data collected by different groups in order to discuss similarities and differences in their findings.
- Use data to evaluate and refine design solutions.

Next Generation Science Standards (NGSS)
Practices: Using Mathematics and Computational Thinking
(Learning Outcomes Addressed: LO1b, LO1c, LO1d)

- Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.
- Organize simple data sets to reveal patterns that suggest relationships.
- Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.

Next Generation Science Standards (NGSS)
Practices: Constructing Explanations and Designing Solutions
(Learning Outcomes Addressed: LO1a, LO1b, LO1c, LO1d)

- Construct an explanation of observed relationships (e.g., the distribution of plants in the back yard).
- Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
- Identify the evidence that supports particular points in an explanation.
- Apply scientific ideas to solve design problems.
- Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

Next Generation Science Standards (NGSS)
Practices: Engaging in Argument from Evidence
(Learning Outcomes Addressed: LO1a, LO1b, LO1c, LO1d)

- Compare and refine arguments based on an evaluation of the evidence presented.

- Respectfully provide and receive critiques from peers about a proposed procedure, explanation, or model by citing relevant evidence and posing specific questions.
- Construct and/or support an argument with evidence, data, and/or a model.
- Use data to evaluate claims about cause and effect.
- Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

Next Generation Science Standards (NGSS)
Practices: Scientific Investigations use a Variety of Methods
(Learning Outcomes Addressed: LO1b, LO1d)

- Science methods are determined by questions.
- Science investigations use a variety of methods, tools, and techniques.

Next Generation Science Standards (NGSS)
Practices: Scientific Knowledge is Based on Empirical Evidence
(Learning Outcomes Addressed: LO1b, LO1c)

- Science findings are based on recognizing patterns.
- Scientists use tools and technologies to make accurate measurements and observations.

Next Generation Science Standards (NGSS)
Practices: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
(Learning Outcomes Addressed: LO1c, LO1d)

- Science explanations describe the mechanisms for natural events.

Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Patterns
(Learning Outcomes Addressed: LO1c, LO1d)

- Students identify similarities and differences in order to sort and classify natural objects and designed products. They identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions.

Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Cause and Effect
(Learning Outcomes Addressed: LO1a, LO1c, LO1d)

- Students routinely identify and test causal relationships and use these relationships to explain change. They understand events that occur together with regularity might or might not signify a cause and effect relationship.

Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Scale, Proportion and Quantity
(Learning Outcomes Addressed: LO1b, LO1c, LO1d)

- Students recognize natural objects and observable phenomena exist from the very small to the immensely large. They use standard units to measure and describe physical quantities such as weight, time, temperature, and volume.

Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Systems and System Models
(Learning Outcomes Addressed: LO1a, LO1c, LO1d)

- Students understand that a system is a group of related parts that make up a whole and can carry out functions its individual parts cannot. They can also describe a system in terms of its components and their interactions.

Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Energy and Matter
(Learning Outcomes Addressed: LO1c, LO1d)

- Students learn matter is made of particles and energy can be transferred in various ways and between objects. Students observe the conservation of matter by tracking matter flows and cycles before and after processes and recognizing the total weight of substances does not change.

Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Structure and Function
(Learning Outcomes Addressed: LO1a, LO1c, LO1d)

- Students learn different materials have different substructures, which can sometimes be observed; and substructures have shapes and parts that serve functions.

Next Generation Science Standards (NGSS)
Cross-Cutting Concepts: Scientific Knowledge Assumes an Order and Consistency in Natural Systems
(Learning Outcomes Addressed: LO1a, LO1c, LO1d)

- Science assumes consistent patterns in natural systems.
- Basic laws of nature are the same everywhere in the universe.

Next Generation Science Standards (NGSS)
Interdependence of Science, Engineering, and Technology
(Learning Outcomes Addressed: LO1b, LO1d)

- Science and technology support each other.
- Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies.

Common Core State Standards
Writing Standards: Research to Build and Present Knowledge
(Learning Outcomes Addressed: LO1a, LO1d)

- Conduct short research projects that build knowledge about a topic. (Grade 3)
- Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (Grade 3)

- Conduct short research projects that build knowledge through investigation of different aspects of a topic. (Grade 4)
- Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (Grade 4)

- Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (Grade 5)
- Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (Grade 5)

Common Core State Standards
Speaking and Listening Standards: Comprehension and Collaboration
(Learning Outcomes Addressed: LO1a, LO1b LO1c, LO1d)

- Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 3 topics and texts, building on others' ideas and expressing their own clearly. (Grade 3)
    - Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
    - 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).
    - Ask questions to check understanding of information presented, stay on topic, and link their comments to the remarks of others.
    - Explain their own ideas and understanding in light of the discussion.

- Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 4 topics and texts, building on others' ideas and expressing their own clearly. (Grade 4)
    - Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
    - Follow agreed-upon rules for discussions and carry out assigned roles.
    - Pose and respond to specific questions to clarify or follow up on information, and make comments that contribute to the discussion and link to the remarks of others.
    - Review the key ideas expressed and explain their own ideas and understanding in light of the discussion.

- Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly. (Grade 5)
    - Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.
    - Follow agreed-upon rules for discussions and carry out assigned roles.
    - Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
    - Review the key ideas expressed and draw

Common Core State Standards
Speaking and Listening Standards: Presentation of Knowledge and Ideas
(Learning Outcomes Addressed: LO1c, LO1d)

- Speak in complete sentences when appropriate to task and situation in order to provide requested detail or clarification. (See grade 3 Language standards 1 and 3 on pages 28 and 29 for specific expectations.) (Grade 3)

- Differentiate between contexts that call for formal English (e.g., presenting ideas) and situations where informal discourse is appropriate (e.g., small-group discussion); use formal English when appropriate to task and situation. (See grade 4 Language standards 1 on pages 28 and 29 for specific expectations.) (Grade 4)

- Adapt speech to a variety of contexts and tasks, using formal English when appropriate to task and situation. (See grade 5 Language standards 1 and 3 on pages 28 and 29 for specific expectations.) (Grade 5)

Common Core State Standards
Mathematics - Measurement and Data
(Learning Outcomes Addressed: LO1b)

- 3.MD.4 Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units—whole numbers, halves, or quarters.

- 4.MD.1 Know relative sizes of measurement units within one system of units including km, m, cm; kg, g; lb, oz.; l, ml; hr, min, sec. Within a single system of measurement, express measurements in a larger unit in terms of a smaller unit. Record measurement equivalents in a two-column table. For example, know that 1 ft is 12 times as long as 1 in. Express the length of a 4 ft snake as 48 in. Generate a conversion table for feet and inches listing the number pairs (1, 12), (2, 24), (3, 36).

- 5.MD.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.

Common Core State Standards
Mathematics – Number and Operation in Base Ten
(Learning Outcomes Addressed: LO1b)

- 5.NBT.1 Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.
- 5.NBT.2 Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10.
- 5.NBT.3 Read, write, and compare decimals to thousandths.
    - Read and write decimals to thousandths using base-ten numerals, number names, and expanded form, e.g., 347.392 = 3 × 100 + 4 × 10 + 7 × 1 + 3 × (1/10) + 9 × (1/100) + 2 × (1/1000).
    - Compare two decimals to thousandths based on meanings of the digits in each place, using >, =, and < symbols to record the results of comparisons.
- 5.NBT.4 Use place value understanding to round decimals to any place.

21st Century Skills
Creativity and Innovation
(Learning Outcomes Addressed: LO1a, LO1b, LO1c, LO1d)

- Students provide concrete examples of science as a way of thinking that involves both systematic and creative processes that anyone can apply as they ask questions, solve problems, invent things, and develop ideas about the world around them. (Grade 4 Benchmark)

- Students are able to describe how science and engineering involve creative processes that include generating and testing ideas, making observations, and formulating explanations; and can apply these processes in their own investigations. (Grade 8 Benchmark)

21st Century Skills
Critical Thinking and Problem Solving
(Learning Outcomes Addressed: LO1a, LO1b, LO1c, LO1d)

- 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. (Grade 4 Benchmark)

- Students plan and conduct scientific investigations and write detailed explanations based on their evidence. Students compare their explanations to those made by scientists and relate them to their own understandings of the natural and designed worlds. (Grade 8 Benchmark)

21st Century Skills
Communication
(Learning Outcomes Addressed: LO1a, LO1b, LO1c, LO1d)

- 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. (Grade 4 Benchmark)

- Students can identify conventions for writing and speaking scientifically that distinguish scientific communication from other types of expression, and describe reasons behind those differences such as the need in science for precision, detail, and evidence over opinion. (Grade 8 Benchmark)

21st Century Skills
Collaboration
(Learning Outcomes Addressed: LO1a, LO1b, LO1c, LO1d)

- Students work collaboratively with others, both in small and large groups, in their science classroom. (Grade 4 Benchmark)

- Students work collaboratively with others, either virtually or face-to-face, while participating in scientific discussions and appropriately using claims, evidence, and reasoning. (Grade 8 Benchmark)

21st Century Skills
Initiative and Self-Direction
(Learning Outcomes Addressed: LO1d)

- Students are able to design an investigation based on a question they have generated from their own curiosity. (Grade 4 Benchmark)

21st Century Skills
Collaboration
(Learning Outcomes Addressed: LO1a, LO1b, LO1c, LO1d)

- Students are able to structure scientific discussions to allow for differing opinions, observations, experiences, and perspectives. (Grade 8 Benchmark)

21st Century Skills
Leadership and Responsibility
(Learning Outcomes Addressed: LO1d)

- Students can describe how doing science carries responsibilities for assuring the safety and rights of others and can provide examples of their own responsibilities while doing science activities at school. (Grade 4 Benchmark)

(D) Teacher Resource. Soda Straw Rockets Rubric (2 of 2)

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

Learning Outcome	Expert	Proficient	Intermediate	Beginner
LO1a: to construct a model of a rocket using soda straws and paper	Model is correctly constructed to test the use of a push (blown air) for distances traveled.	Model constructed with a minimal amount of support from the facilitator.	Model is constructed with a fair amount of support from the facilitator.	Model is constructed by the facilitator.
LO1b: to use standard measurements for communicating distance traveled	Measurements are accurate and appropriate tools are used.	Measurements are relatively accurate and appropriate tools are used.	Measurements are relatively accurate and most tools are appropriate to the task.	Measurements are made with a variety of tools.
LO1c: to predict and explain the effects of a net force on a system	Prediction is logical and based on evidence from prior examinations of the soda straw model. Predictions show insightful interpretation of the data.	Prediction is logical and based on evidence from prior examinations of the soda straw model.	Prediction is logical and uses some evidence from prior examinations of soda straw model.	Prediction is written and based on personal preferences.
LO1d: to use the engineering design cycle to attempt to hit a set target	Uses the model as a predictive *and* explanatory tool to test and communicate scientific phenomena.	Uses the model as a predictive *or* explanatory tool that to test or communicate scientific phenomena.	Uses the model as an explanatory tool to communicate scientific phenomena.	Discusses use of models by scientists.

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

Partnership for 21st Century Skills

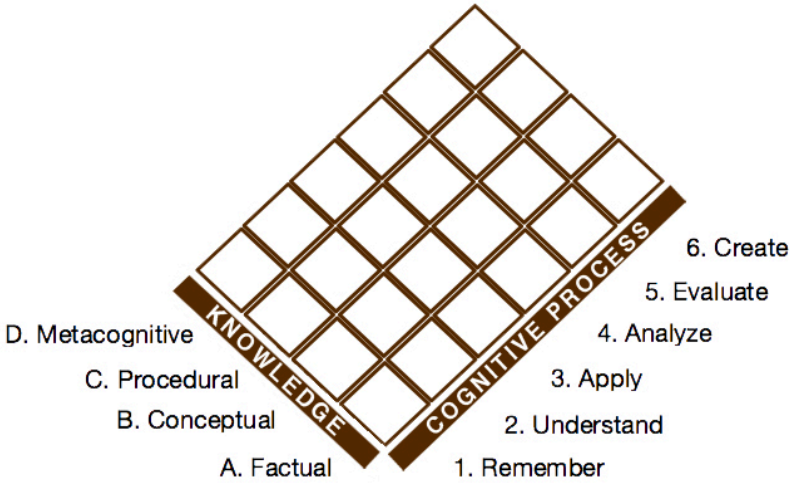
	Expert	Proficient	Intermediate	Beginner
Effectiveness of social and cross-cultural collaboration with team members and class.	Extremely Interested in collaborating in the simulation. Actively provides solutions to problems, listens to suggestions from others, attempts to refine them, monitors group progress, and attempts to ensure everyone has a contribution.	Extremely Interested in collaborating in the simulation. Actively provides suggestions and occasionally listens to suggestions from others. Refines suggestions from others.	Interested in collaborating in the simulation. Listens to suggestions from peers and attempts to use them. Occasionally provides suggestions in group discussion.	Interested in collaborating in the simulation.
Effectiveness in communication	Communicates ideas in a clearly organized and logical manner using a model that is consistently maintained.	Communicates ideas in an organized manner using a model that is consistently maintained.	Communications of ideas are organized, but not consistently maintained.	Communicates ideas as they come to mind.
Effectiveness of critical thinking and Initiative	Develops detailed investigations and explanations based on credible evidence. Compares explanations to those made by peers and relates them to their new understandings.	Develops detailed investigations and explanations based on credible evidence. Relates them to their new understandings.	Develops investigation and explanations. Relates explanation to their new understandings.	Attempts to explain the design based on own preconceived understanding.
Effectiveness in Leadership and Responsibility	Demonstrates and discusses appropriate lab safety skills toward peers and others when using the soda straw rocket.	Demonstrates appropriate lab safety skills toward peers and others when using the soda straw rocket.	Discusses appropriate lab safety skills toward peers and others when using the soda straw rocket.	Uses soda straw rockets at will.

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

Common Core – ELA

	Expert	Proficient	Intermediate	Beginner
Research to Build and Present Knowledge	Recalls relevant information from experience; summarizes information in finished work; draws evidence from informational texts to support analysis, reflection, and research.	Recalls relevant information from experience; draws evidence from informational texts to support analysis, reflection, and research.	Recalls information from experience; draws evidence from informational texts to support analysis, reflection, and research.	Recalls information from experience.
Effective Demonstration of 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.
Effective Presentation of Knowledge and Ideas	Includes accurate drawings of concepts, speaks audibly, clearly and in complete sentences, and writes ideas in complete sentences.	Includes accurate drawings of concepts, speaks audibly, and in complete sentences, writes most ideas in complete sentences.	Includes drawings of concepts, speaks audibly, writes most ideas in complete sentences.	Includes drawings of concepts and speaks when spoken to.

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



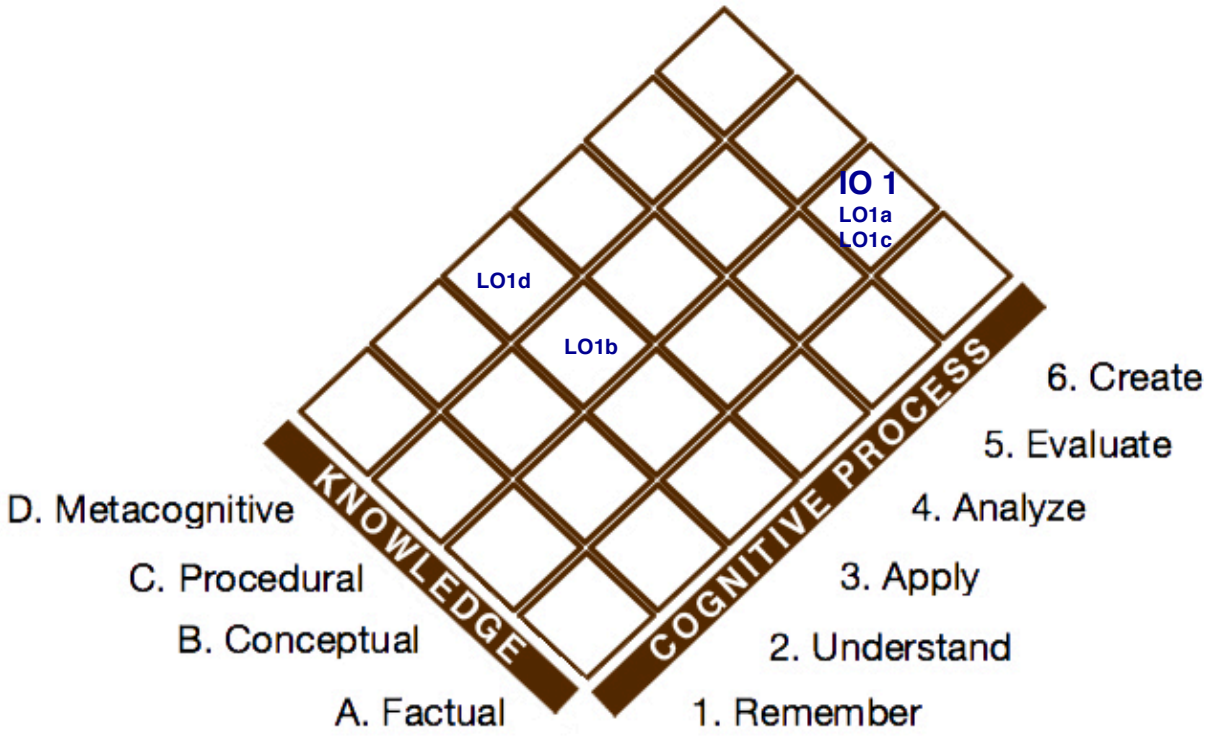
This lesson adapts Anderson and Krathwohl's (2001) taxonomy, which has two domains: Knowledge and Cognitive Process, each with types and subtypes (listed below). Verbs for objectives and outcomes in this lesson align with the suggested knowledge and cognitive process area and are mapped on the next page(s). 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: to plan and conduct an investigation into the effects of a puff of air on soda straw rocket. (6.2, 6.3; Bc)

- **LO1a. to construct** a model of a rocket using soda straws and paper (6.3; Bc)
- **LO1b. to use** standard measurements for communicating relative size and distance (3.1; Ca)
- **LO1c. to predict and explain** the effects of a net force on a system (6.1; Bb)
- **LO1d to use** the engineering design cycle to attempt to hit a set target (3.2; Da)



(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: to plan and conduct an investigation into the effects of a puff of air on soda straw rocket.

6.2: to plan
6.3: to construct
Bc: knowledge of theories, models, and structures

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

LO1a: to construct a model of a rocket using soda straws and paper
6.3: to construct
Bc: knowledge of theories, models, and structures

LO1b: to use standard measurements
3.1: to use
Ca: knowledge of subject-specific skills and algorithms

LO1c: to predict and explain the effects of a net force on a system
6.1: to predict
Bb: knowledge of principles and generalizations

LO1d: to use the engineering design cycle to attempt to hit a set target
3.2: to use
Da: strategic knowledge