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This toolkit was developed as a professional development resource to train teachers in the concepts of the Framework for K-12 Science Education and the Next Generation Science Standards. It was the product of the STEM Framework Course component of the MPRES Grant. It is not intended to be used as curriculum for classroom instruction.
July 2013

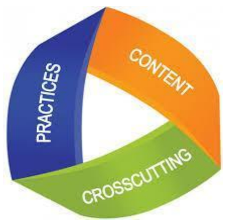
DRAFT

NOTE: This is a DRAFT version

	Asking Questions in Science & Defining Problems in Engineering	
Framework Rationale	**Science** Science begins with a question about a phenomenon, such as "Why is the sky blue?" or "What causes cancer?" and seeks to develop theories that can provide explanatory answers to such questions. A basic practice of the scientist is formulating empirically answerable questions about phenomena, establishing what is already known, and determining what questions have yet to be satisfactorily answered. **Engineering** Engineering begins with a problem, need, or desire that suggests an engineering problem that needs to be solved. A societal problem such as reducing the nation's dependence on fossil fuels may engender a variety of engineering problems, such as designing more efficient transportation systems, or alternative power generation devices such as improved solar cells. Engineers ask questions to define the engineering problems, determine criteria for a successful solution, and identify constraints. From the [A Framework for K-12 Science Education](), 2011, p. 50	 **Practices** • **Asking Questions & Defining Problems** • Obtaining, Evaluating and Communicating **Crosscutting Concepts** • Structure and Function (Defining Problems Activity) **Disciplinary Core Ideas** • 2-PS1-2; K-2-ETS1-1 • 3-5-ETS1-1

Background Information	Asking questions is essential to developing scientific habits of mind. Even for individuals who do not become scientists or engineers, the ability to ask well-defined questions is an important component of science literacy, helping to make them critical consumers of scientific knowledge. Scientific questions arise in a variety of ways. They can be driven by curiosity about the world. They can be inspired by a model's or theory's predications or attempts to extend or refine a model or theory. Or they can result from the need to provide better solutions to a problem. The experience of learning science and engineering should therefore develop students' ability to ask- and indeed, encourage them to ask-well formulated questions that can be investigated empirically. Students also need to recognize the distinction between questions that can be answered empirically and those that are answerable only in other domains of knowledge or human experience. Defining problems in engineering is essential for the creation of new products, making improvements to existing materials and working with systems. Engineers ask questions like what is the problem, who has the problem and why is it important to solve the problem? These become the who, what and why in the defining problems process. The who is the user, the what is the need and the why is the insight. As students work through defining problems, it is important for them to keep the who, what and why of the problem in mind.	
Activities	Asking Questions: Balloons and Skewer (scroll to access) Defining Problems: Pringles Mailing Challenge (scroll to access)	DCI: 2-PS1-2; K-2-ETS1-1 DCI: 3-5-ETS1-1

Asking Questions & Defining Problems Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
NGSS Website 	Planning and Carrying Out Investigations podcast Science Notebooks podcast Science Notebooks Prezi	Student Notebook Entry (scroll to access)	Placeholder

Placeholder	Placeholder	Placeholder	Placeholder
			

Balloons and Skewers

General Objective: To provide an opportunity for students to ask questions in science by observing a phenomenon and experiencing that phenomenon.

Learning Outcomes: At the end of the lesson, students can answer the following “I can” statements:
1. I can ask questions.
2. I can successfully put a skewer through a balloon.
3. I can provide 1-2 real-life examples of skewers in balloons.
4. I can explain why the balloon doesn’t pop when the skewer is put through it.
5. I can keep a record of my learning in a science notebook/journal.

Materials needed: balloons, skewers

Safety Issue: sharp objects and balloons (potential choking hazard)

Instructional Procedures:

1. Show balloon and skewer.
2. Blow up balloon.
3. Ask what happens when a sharp object and a balloon come into contact.
4. When people say that the balloon pops, then pop the balloon.
5. Blow up a 2nd balloon. Say something like, “wouldn’t it be interesting if I could push the skewer through the balloon without popping it?” Do it as you say it.
6. Let students observe the skewer in the balloon. Solicit questions from students and encourage them to record those questions in their notebooks.
7. You can help students differentiate between researchable questions and testable questions. Researchable questions are those that can be looked up in a resource such as a dictionary or a on a web search. Testable questions are those can that be tested to determine the answer.
8. Pass out balloons and skewers to everyone.
9. Assist students as needed.
10. Once everyone has been successful, have students revisit their questions and answer them
11. At some point, have students record diagrams, observations, questions, etc. in their science notebooks/journals. This is the Science

Practice of Obtaining, Evaluating & Communicating.
12. Ask for any final questions or comments.

Pringles Potato Chip Mailing Challenge

Modified from http://www.sciencespot.net/Media/chiprulesB.pdf

Description:

Students will design and test a container for shipping a single "Pringles" potato chip, via USPS. Upon arrival, the packages will be evaluated and scored using the format in the scoring section. The goal is to mail a Pringles chip in a #10 legal sized envelope that has the smallest volume/mass ratio and protects the chip that it arrives at its destination undamaged.

Rules and Regulations:

1. Students will use 1 (regular) Pringles potato chip and materials of their choosing to create a device that will protect the chip on its journey through the post system. The outer package will be a #10 legal sized envelope.

2. Students may choose a variety of items for packing materials; however, the materials cannot be wood, metal, glass, or hard plastic and must not leave a wet or greasy spot on a paper towel.

3. The chip must be a plain Pringles chip and may not be modified in any way.

4. The package must have a mass less than 300 grams in the "ready to mail" form, which means it is loaded with a chip and sealed with tape. Students should take into account the mass of the chip and tape as they prepare their chip containers to make sure they don't go over the limit.

5. The envelope will be opened by using a letter opener to cut the top of the envelope.

6. Once the package is completed and a single chip has been "loaded", the package must be mailed. In the envelope, include the names of the group member.

Mailing Procedure:
The envelopes must be mailed through the USPS.

Scoring Procedures:
Once all envelopes have been received, the teacher or other designated persons will open the envelope.

Final scores will be divided into two categories: Perfect Pringles and Pringles Pieces. All envelopes will be massed for calculating the final score. The lowest overall score will be the one used to determine the winner. In the case of a tie, the package with the smallest mass will be declared the winner.

Final Score = [Mass (g) x Volume (cm3)] ÷ Rating Scoring Examples:

Team 1:
Mass = 145 g
Volume = 240 cu. cm
Rating = 100 (perfect chip)
SCORE = (145 x 240) ÷ 100 = 348 points

Team 2:
Mass = 145 g
Volume = 240 cu. cm
Rating = 50 (cracked chip) Score: (145 x 240) ÷ 50 = 696 points

Final Checklist for Teachers
(1) Are all chips mailed in #10 envelope?

(2) Are the materials acceptable?
No wood, metal, glass, or hard plastic materials have been used. Materials do not leave a wet or greasy mark on a paper towel. The chip has not been modified in any way.

(3) Does each package contain only 1 Pringles potato chip?

(4) Are students identified?
Team members have included the basic information (team name, team number, members, school, & grades)

NOTE: No other information is allowed on the outside of the box, such as Fragile, Handle with Care or Hand Stamp, etc. (5) Students know where to mail the envelopes?

As a Defining Problems in Engineering activity, have students identify the WHO, WHAT and WHY engineering questions as a critical component of this exercise.

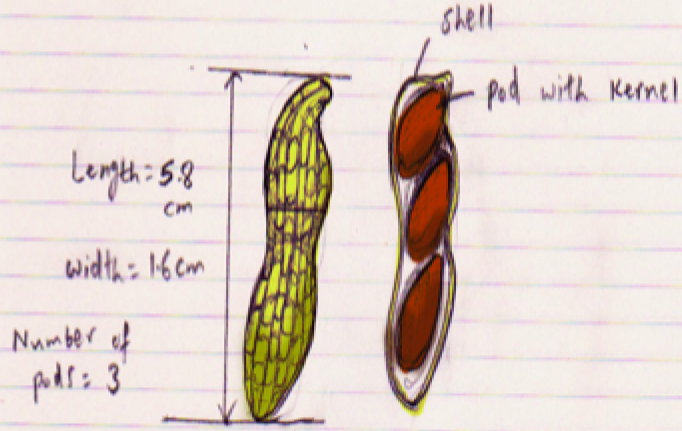
Student Notebook Entry Example

Description of a Legume

No.

Date 9.13.12

A diagram depicting a raw shelled peanut and its description:



Scientific name: Arachis hypogaea

Source: 'Kaki-pea' brand from Fuji Supermarket, Tokyo

1. Japanese peanuts are usually larger compared to other varieties.

	Developing and Using Models	
Framework Rationale	In A Framework for K-12 Science Education (2012) one of the goals is “to ensure that by the end of 12th grade, all students have some appreciation of the beauty and wonder of science.” One of the practices to achieve that goal is developing and using models. **Models** are used by both scientists and engineers. They can be as simple as a crayon drawing of a pattern of color and shapes, the frequency of a pendulum, or a computer simulation of particulate matter emission from a smoke stack. Models help the designer better understand their world and can even help solve problems of society. Students and engineers alike can ask questions, make predictions and comparisons, and test their models to better understand the task at hand. By evaluating the data produced by the model, students can argue the validity of their model using that evidence among their peers so that the best possible solutions emerge. From the A Framework for K-12 Science Education, 2011, p. 56	 **Practices** • **Developing and Using Models** • Arguing from Evidence • Obtaining, Evaluating & Communicating **Crosscutting Concepts** • Cause & Effect • Scale, Proportion & Quantity **Disciplinary Core Idea** • 5-PS1-1

Background Information	Scientists construct mental and conceptual models of phenomena. Mental models are internal, personal, idiosyncratic, incomplete, unstable, and essentially functional. They serve the purpose of being a tool for thinking with, making predictions, and making sense of experience. Conceptual models are, in contrast, explicit representations that are in some ways analogous to the phenomena they represent. Conceptual models allow scientists and engineers to better visualize and understand a phenomenon under investigation or develop a possible solution to a design problem. Engineering makes use of models to analyze existing systems; this allows engineers to see where or under what conditions flaws might develop or to test possible solutions to a new problem. Although they do not correspond exactly to the more complicated entity being modeled, they do bring certain features into focus while minimizing or obscuring others. Because all models contain approximations and assumptions that limit the range of validity of their application and the precision of their predictive power, it is important to recognize their limitations. Engineers also use models to visualize a design and take it to a higher level of refinement, to communicate a design's features to others, and as prototypes for testing design performance. Models, particularly modern computer simulations that encode relevant physical laws and properties of materials, can be especially helpful both in realizing and testing designs for structures, such as buildings, bridges, or aircraft, that are expensive to construct and that must survive extreme conditions that occur only on rare occasions. Other types of engineering problems also benefit from use of specialized computer-based simulations in their design and testing phases. From the A Framework for K-12 Science Education, 2011, p. 57-58	
Activities	Air Pressure Model (Scroll to access)	DCI: 5-PS1-1

Developing and Using Models

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
[NGSS Website] 	Developing and Using Model [podcast]	Student Notebook Entry (scroll to access)	Placeholder

Placeholder	Placeholder	Placeholder	Placeholder
			

Syringe and Plunger

The purpose of this activity is to make a model from the evidence based on observation.

In this activity we will observe the phenomenon of a syringe and a plunger.

Materials:

large syringe

Each group of students is given a syringe and a plunger. Students are instructed to complete two tasks:

1. Fill the syringe with air and place your finger over the end and observe what happens when the syringe is pulled back.
2. With the end still sealed, push the plunger in as far as you can and observe what happens.

Students then create models (drawings in notebook) to show the phenomenon of what they think happens to one air particle. Students will draw three models, one showing a picture of a particle of air in the middle of the syringe when filled with air, one showing where and what the single particle looked like when the plunger was pulled back, and one with the plunger pushed in. In both instances the plunger returned to its original spot.

The students then share the models and describe their models. Students may struggle with this concept because it is difficult to picture one particle of air. It may be easier to show the relationship between particles, but looking at one particle might help students to understand the idea of compression and expansion.

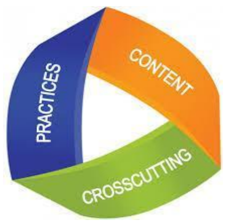
Extension: Have students explore further to see what might happen if water or bubbles were placed inside the plunger.

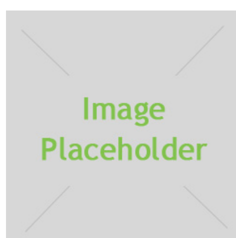
From Starr & Associates, Educational Consultants

	Planning & Carrying Out Investigations **Science and Engineering Practices**	
Framework Rationale	A major practice of Scientists is **Planning and Carrying Out a Systematic Investigation**, which requires the identification of what is to be recorded, and if applicable, what are to be treated as the dependent and independent variables (control of variables). Observations and data collected from such work are used to test existing theories and explanations or to revise and develop new ones. Engineers use investigations both to gain data essential for specifying design criteria or parameters and to test their designs. Like scientists, engineers must identify relevant variables, decide how they will be measured, and collect data for analysis. These investigations help them to identify how effective, efficient, and durable their designs may be under a range of conditions. From A Framework for K-12 Science Education, 2011, p. 50	 **Practices** **• Planning & Carrying Out Investigations** • Obtaining, Evaluating, and Communicating Information • Asking Questions and Defining Problems **Crosscutting Concepts** • Cause and Effect • Energy and Matter: Flows, cycles, and conservation **Disciplinary Core Ideas** • K-PS2-1

Background Information	Scientists and engineers investigate and observe the world with essentially two goals: 1) to systematically describe the world and 2) to develop and test theories and explanations of how the world works. In the first, careful observation and description often lead to identification of features that need to be explained or questions that need to be explored. The second goal requires investigations to test explanatory models of the world and their predictions and whether the inferences suggested by these models are supported by data. Key elements to consider: ● Plan for control variables. ● Decide on what measurements are needed, the level of accuracy required, and the kinds of instruments best suited. From A Framework for K-12 Science Education, 2011, p. 59	
Activities	Static Balloon (scroll to access)	DCI: K-PS2-1, 3-PS2-3

Planning & Carrying Out Investigations Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Supporting Resources
NGSS Website  	Planning & Carrying Out Investigations Podcast (Paul Anderson)	Student Notebook Entry	Steve Spangler Science Static Flyer Experiment Steve Spangler Science Static Flyer Video

Extensions			
Real-Life Application: Photocopy Machine	 	 	

Static Balloon Activity

Source: http://www.stevespanglerscience.com/lab/experiments/static-flyer-flying-bag

Materials
Cotton towel
Plastic produce bag
Scissors
Balloon

Experiment

Introduce activity with video or demonstration (engage)

1. Use a pair of scissors to cut a strip from the open end of the produce bag. Once the strip is cut, you should have a plastic band or ring.
2. Blow up a balloon to its full size and tie off the end.
3. Rub the cotton towel over the surface of the balloon for 30-45 seconds.
4. Flatten the plastic band on a hard surface and gently rub the towel on the band for 30-45 seconds.
5. Hold the plastic band about one foot over the balloon and release it. Holy guacamole... the plastic band is levitating!

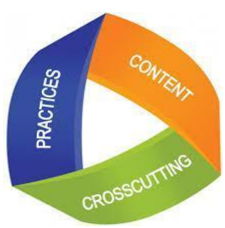
In science notebook, have document ideas as to what is "happening" in this activity. In groups of 2-3, design an investigation to prove/disprove hypothesis. Some questions to help drive the investigation are: What other objects can you use to levitate the plastic band utilizing this same principle? Are there other shapes, besides the plastic band, that you can levitate applying this same principle? In science notebook, have document results and refine hypothesis. (explore)

Have groups share results and supporting explanations. Help construct the vocabulary of attraction, and repulsion, as well as electrical energy concepts. Here is some basic information to help guide your understanding. Rubbing the towel against the balloon and the plastic band transfers a negative charge to both objects. The band floats above the balloon because the like charges repel one another. If you really want to impress someone, just tell them that it's a demonstration of "electrostatic propulsion and the repulsion of like charge." That should do it. When you rub a balloon on someone's hair the balloon picks up electrons, leaving it negatively charged and the hair positively charged. Because opposite charges attract, bringing the balloon near the hair causes the hair to stand up. When you bring a charged balloon near pieces of paper, the paper isn't charged so you might expect nothing to happen. But the paper is attracted to the balloon. Why? The negative charge on the balloon repels the electrons in the paper, making them (on average) farther from the balloon's charge than are the positive charges in the paper. Because electrical forces decrease in strength with distance, the attraction between the negatives and positives is stronger than the repulsion between the negatives and negatives. This leads to an overall attraction. The paper is said to have an induced charge. This explanation applies to a charged balloon sticking to a wall and a charged balloon attracting other uncharged objects. (explain)

	Analyzing & Interpreting Data	
Framework Rationale	**Science** Scientific investigations produce data that must be analyzed in order to derive meaning. Because data usually do not speak for themselves, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Sources of error are identified and the degree of certainty calculated. Modern technology makes the collection of large data sets much easier, thus providing many secondary sources for analysis. **Engineering** Engineers analyze data collected in the tests of their designs and investigations; this allows them to compare different solutions and determine how well each one meets specific design criteria—that is, which design best solves the problem within the given constraints. Like scientists, engineers require a range of tools to identify the major patterns and interpret the results. From the [A Framework for K-12 Science Education](), 2011, p. 51	 Practices • Analyzing & Interpreting Data • Using Mathematics & Computational Thinking • Obtaining, Evaluating & Communicating Crosscutting Concepts • Cause & Effect Disciplinary Core Ideas • K-PS2-2 • 3-PS2-2

Background Information	Once collected, data must be presented in a form that can reveal any patterns and relationship and that allows results to be communicated to others. Because raw data as such have little meaning, a major practice of scientists is to organize and interpret data through tabulating, graphing, or statistical analysis. Such analysis can bring out the meaning of data- and their relevance- so that they may be used as evidence. Students need opportunities to analyze large data sets and identify correlations. Increasingly, such data sets-involving temperature, pollution levels, and other scientific measurements- are available on the Internet. Moreover, information technology enables the capture of data beyond the classroom at all hours of the day. Such data sets extend the range of students' experience and help to illuminate this important practice or analyzing and interpreting data. From the A Framework for K-12 Science Education, 2011, p. 61-63	
Activities	Pendulum (scroll down to access)	DCI: K-PS2-2; 3-PS2-2

Analyzing & Interpreting Data Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Activity
NGSS Website  	Analyzing & Interpreting Data podcast Pendulum Simulation	To be added: Student Notebook Entry (scroll to access)	Pendulum Activity

Activity –Pendulums

Common Language:

Frequency (measured in cycles per second)

Hertz (also called frequency)

Period (seconds per cycle)

Cycle (from starting point and back to the start position)

Amplitude (how far back you held the pendulum in start position)

Introduction

Pendulums are an easy way to engage elementary students in inquiry about natural phenomena. The pendulum is easy to set up and manipulate for young students. The pendulum can be used to introduce students to a wide variety of scientific ideas including force, energy, friction, and gravity. The purpose of this activity is to analyze data that is recorded and decide how to represent it. How will students interpret the data collected?

Investigation

In this activity students find what variables affect the frequency of a pendulum: mass, string length, placement of structure, and amplitude.

Materials: washers, paperclips, string, masking tape, stand to hold pendulums, rulers, and stopwatch

Students are given the materials listed above and are to find the frequency of the pendulum at different string lengths and mass to determine what influences frequency.

First, tape the string to the stand. Have groups determine the number of washers and determine the degree angle to be released. First, test the variable mass keeping other variables constant. Record the amount of time it took the pendulum to cycle 10 times. With each trial, add or discard washers. With this data collection, find if mass affects the frequency.

Second, use 10 different string lengths. Complete 3 trials for each string length. Keep all other variables constant. Take the average time for each string length trial. Record this data in a line graph and determine if frequency is affected by string length. Use graphing and predicting to analyze data. Look for patterns in numbers and find relationships.

	Using Mathematics & Computational Thinking	
Framework Rationale	**Science –** Mathematics provides powerful models for describing and predicting such events as gravitational forces, atomic structures, and quantum mechanics. Mathematics is also used to collect and analyze large data sets, and to search for relationships and significant features that were otherwise impossible before. Mathematics also allows for ideas to be expressed in precise form and enables the identification of new ideas about the physical world, as well as the ability to do calculations that cannot be carried out analytically. (i.e. computer simulations with the mouse traps and ping pong ball.) **Engineering**- Mathematical and computational skills allow for engineers to create models of bridge and building designs from which they can test their performance, probe for structural limits, and assess whether or not they can be completed within the acceptable budgets. From the A Framework for K-12 Science Education, 2011, p. 64-66	 **Practices** **• Using Mathematics & Computational Thinking** • Developing & Using Models • Engaging in Argument from Evidence **Crosscutting concepts** • Scale, proportion, and quantity **Disciplinary core Ideas:** • 5-ESS2-2

Background Information	Mathematics and computational tools are central to science and engineering. Mathematics enables scientists to have the numerical representation of variables and the prediction of outcomes, whereas engineering uses math to test models for different outcomes. Both fields use mathematics and computational thinking to accomplish investigations and analyses and build complex models that would otherwise be out of the question. In discussion amongst colleagues, science and math seem to logically flow together, and should be used as such as much as possible. With an emphasis being put mainly on reading and math in our schools, it is sometimes hard to fit in things such as science and social studies. Good news! You can do science and math at the same time, and if we want future engineers, we should be using the two together on a regular basis when we can. From the K-12 Framework, 2011, p. 64-66 and discussion groups	
Activities	Scale Drawing of Playground: Man vs. Computer (scroll to access)	DCI 5-ESS2-2

Using Mathematics & Computational Thinking Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
NGSS Website 	Using Mathematics & Computational Thinking podcast	Student Notebook Entry (scroll to access)	Placeholder

Placeholder	Placeholder	Placeholder	Placeholder
			

Activity: Scale Drawing of Playground: Man vs. Computer

(You could do a building, a track, your perimeter, etc)
Background: You would have wanted to already have taught some measurement skills and how a map scale works. A quick lesson with graph paper using each square to equal a foot would be fun to do inside your classroom as a warm-up.

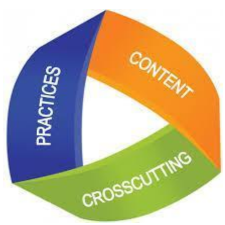
Materials to put in bags ahead of time (I use the reusable cloth grocery bags). You will need one of everything, plus a few extras of your own in case they need it. We have broken a few measuring tapes due to over extending---have them be cautious and stop before the end!
1 large, wind-up measuring tape (I use 50 m. tapes)
Clipboard
Graph paper
pencils for each group
ruler
Calculator
Materials for later:
Computers with Google Earth

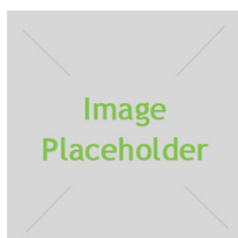
Procedure:
-Discuss with students the idea of models and why they are used. Brainstorm possibilities as to why engineers might want to use models to construct something before they actually build it. Review scale and how it will work. Explain that they will need to come up with a reasonable scale for their drawings today.
-Have the students work in groups of 3 (2 for measuring and 1 to record data) to measure and draw the playground (or track, or sidewalk around the school, etc.---keep in mind you would want to be able to see it on Google Earth, so inside things will have to wait for follow-up activities.) They will want to be as precise as they can, as their goal is precision against Google Earth's measurements.
-Have students draw their playground to scale on their graph paper. The scale of their map must be included.
-Now have students measure a selected, smaller area of the playground that will represent water.
-After maps are completed and group members agree that they are good, have students log on to Google Earth and type in the School's address. -Using the ruler tool on the program, have them measure their playground and smaller area on Google earth and see if their measurements are reasonable. If they are different, have the come up with arguments as to why.
-Students then calculate the percentage of the "water" area of the playground. This can be contrasted to the amount of fresh water on a global scale.

	Constructing Explanations & Designing Solutions	
Framework Rationale	**In Science:** Engaging students and helping them gain an understanding of the major ideas that science has developed is a central part of science education. Scientists achieve their own understanding by building theories and theory-based explanations with the aid of models and representations and by drawing on data and evidence. **In Engineering:** In engineering, the goal is a design rather than an explanation. Engineering activities have different elements than those of scientists in that they include such elements as constraints, desired qualities of the solution, developing a design plan, producing models or prototypes, optimize achievement of design criteria, or refining design based on performance. Scientists have the, “oh, so that’s why that happens” thought process, and engineers have the, “oh, so that’s what happens, but what happens if we tweak it like this…, or what will this make it better?” thought process. From the [A Framework for K-12 Science Education](), 2011, p. 52	 **Practices** • **Constructing Explanations & Designing Solutions** • Engaging in Argument from evidence **Crosscutting Concepts** • Structure and Function **Disciplinary Core Ideas** • 3-PS2-2; 3-5 ETS1-3
Background Information	Scientific theories are developed to provide explanations aimed at illuminating the nature of particular phenomena, predicting future events, or making inferences about past events. These theories are not mere guesses, and they can provide explanations for multiple instances. In addition, the term “hypothesis” is also used as an explanation for an observed phenomenon that can predict what will happen in a given situation. It, too, is made based on existing theoretical understanding relevant to the situation. From the [A Framework for K-12 Science Education](), 2011, p. 67-69	

Activities	Walk the Plank (Scroll down to access)	3-PS2-2; 3-5 ETS1-3

Constructing Explanations & Designing Solutions Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
NGSS Website 	Constructing Explanations & Designing Solutions podcast Webinar on Constructing Explanations	To be added: Student Notebook Entry (scroll to access)	Placeholder

Placeholder	Placeholder	Placeholder	Placeholder
			

Walk the Plank!! Or Half a Bridge is Better than None

Intro: When your small wooden sailboat shipwrecked on the deserted island, you were happy to find there was only a narrow channel of deep water between you and safety. That was the good news. But the bad news is that you still have a couple of problems: an alligator and a shark live in the channel. Swimming in that water could be a little nippy. Always ready to sink your teeth into any problem, you gather up the wood and ropes from your wrecked boat. Then you build a bridge high enough and long enough to get you across the water to safety.

Challenge: Design and construct a cantilever that can reach a distance of 35 cm from its base. A cantilever is a beam supported at only one end. One example is a diving board. The arm of the cantilever may not touch the table that the base rests on. (Extension…who can make the longest cantilever?)

Materials and Supplies: You can only use – 20 popsicle sticks, 50 cm of masking tape, a #2 pencil, a metric ruler

Rules and Regulations:

1. Get the materials and supplies listed above from your teacher. Do not break any of the popsicle sticks because they will be used again by other students.
2. Using a pencil, lightly draw a 15cm square on your desk/table. You must build the base of your cantilever inside this square. It can be smaller, but not bigger. Fasten the base to the table with tape.
3. Pretend that the plane of the table represents the surface of the water. The free end of the cantilever may not touch or cross the plane of the table.
4. The length of the cantilever will be measured horizontally in a straight line from the point of the base nearest to the free end. Remember, the distance must be at least 35 cm.
5. You can always start over. All you have to do is gather together all of your used masking tape and ask your teacher to trade it in for a new 50cm piece.

Science Concepts:

Here are some definitions that may help you understand the scientific principles important to this activity.

CANTIVLEVER – is a projecting beam supported at one end by a pier or base.

PLANE – is a flat or level surface that extends infinitely in two dimensions. It has no thickness.

HORIZONTAL – means flat and straight across, parallel to the horizon, going in a sideways direction.

VERTICAL – means straight up and down, perpendicular to the horizon.

Things to Think About:

1. One example of a cantilever is a diving board. Another is a limb growing out from a tree trunk. You might be interested to know that sometimes two cantilevers are put together to form a bridge.

2. The easiest way to solve this problem successfully is to think of it in two parts: first, build a stable base; and second, build the extending arm or beam.

3. Experiment with the building materials provided by your teacher. Discover the best possible design for a cantilever. Remember; there

is no one “right way” to make it.

Discussion Ideas: Facts you can bring out post-activity

1. A tripod usually makes the strongest, most stable base, and it uses the least material.
2. Photographers and surveyors use tripods to hold their tools.
3. Triangle shapes (one side of a tripod) are often used in the construction of bridges, trusses, geodesic domes, pyramids…

	Engaging in Argument	
Framework Rationale	In **Science**, reasoning and argument are essential for identifying the strengths and weaknesses of a line of reasoning and for finding the best explanation for a natural phenomenon. Scientists must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated. In **Engineering**, reasoning and argument are essential for finding the best possible solution to a problem. Engineers collaborate with their peers throughout the design process, with a critical stage being the selection of the most promising solution among a field of competing ideas. Engineers use systematic methods to compare alternatives, formulate evidence based on test data, make arguments from evidence to defend their conclusion, evaluate critically the ideas of others, and revise their designs in order to achieve the best solution to the problem at hand. From the A Framework for K-12 Science Education, 2011, p. 52	 **Practices** **• Engaging in argument from evidence** • Asking questions & defining problems • Developing & using models **Crosscutting concepts** • Cause & effect • Energy & matter **Core Discipline Ideas** • Applies to all

Background Information	In **Science**, the production of knowledge is dependent on a process of reasoning that requires a scientist to make a justified claim about the world. In response, other scientists attempt to identify the claim's weaknesses and limitations. Their arguments can be based on deductions from premises, on inductive generalizations of existing patterns, or on inferences about the best possible explanation. Argumentation is also needed to resolve questions involving, for example, the best experimental design, the most appropriate techniques of data analysis, or the best interpretation of a given data set. Science is replete with arguments that take place both informally in lab meetings and symposia, and formally, in peer review. Development of a scientific idea shows how a new idea is often difficult to accept and has to be argued for. From the A Framework for K-12 Science Education, 2011, p. 71-74	
Activities	Any of your choosing	

Engaging in Argument Resource Set

NGSS	Podcasts	Student Artifacts	Placeholder
NGSS Website 	Analyzing & Interpreting Data podcast Prezi MPRES	Student Notebook Entry (scroll to access)	

Placeholder	Placeholder	Placeholder	Placeholder
			

To model Arguing from Evidence, students must be afforded the opportunity to present an argument by identifying the strengths and weaknesses of a line of reasoning and for finding the best explanation for a natural phenomenon. They must defend their explanations, formulate evidence based on a solid foundation of data, examine their own understanding in light of the evidence and comments offered by others, and collaborate with peers in searching for the best explanation for the phenomenon being investigated. This can be done individually or in collaboration with their peers. The audience should be encourage to ask questions, challenge information given and engage in an academic discussion of the topic. Argument should not be viewed as a confrontational activity, but instead as a collaborative opportunity to share ideas based on evidence. The burden of credibility needs to be placed on evidence, not the forcefulness of the argument.

	Obtaining, Evaluating & Communicating	
Framework Rationale	**Science** cannot advance if scientists areunable to communicate their findings clearly and persuasively or to learn about the findings of others. A major practice of science is thusthe communication of ideas and the results of inquiry—orally, in writing, with the use of tables, diagrams, graphs, and equations, and by engaging in extended discussions with scientific peers. Science requires the ability to derive meaning from scientific texts (such as papers, the Internet, symposia, and lectures), to evaluate the scientific validity of the information thus acquired, and to integrate that information. **Engineers** cannot produce new or improved technologies if the advantages of their designs are not communicated clearly and persuasively. Engineers need to be able to express their ideas, orally and in writing, with the use of tables, graphs, drawings, or models and by engaging in extended discussions with peers. Moreover, as with scientists, they need to be able to derive meaning from colleagues' texts, evaluate the information, and apply it usefully. In engineering and science alike, new technologies are now routinely available that extend the possibilities for collaboration and communication. From the A Framework for K-12 Science Education, 2011, p. 53	 **Practices** • **Obtaining, Evaluating & Communicating** **Crosscutting Concepts** **Disciplinary Core Ideas** • Can be applied to all all Disciplinary Core Ideas

Background Information	Reading for content, interpreting data, and understanding results can be a very daunting task for anyone, especially our youth. Trying to locate, evaluate, interpreting and then sharing that information to others can be even harder. Writing and communicating in of themselves, is a hill to climb. Add to that the information to be shared is based on science content makes most grow weary. We as science teachers sometimes find it insurmountable trying to get our students to observe like a scientist let alone write and communicate like one. Modeling baby steps is the first step one can take to assist their students. Modeling a science notebook and then having students make use of their own in the classroom is a great first step. The first week of school is a great time to initiate this process. Classroom observations or school yard observations can help students to start looking at their world from the eyes of a scientist. Just ask a question, then another and then another. Notebooks are not just used for observations they can be used for that tough vocabulary that stumps us all at one time or another. How about drawing what you are observing and labeling the different parts? This is a basic strategy that you can do to get your student to think, observe, record, graph, evaluate information and yes that dreaded step even research an idea. The use of other strategies will assist our students into content reading of science articles, interpreting scientific data, communicating results of testing, and validating their outcomes to their peers. From the A Framework for K-12 Science Education, 2011, p. 74	
Activities	Find an Object (scroll to access)	DCI: Should be applied to all

Obtaining, Evaluating & Communicating Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
[NGSS Website] 	Obtaining, Evaluating & Communicating podcast Science Notebooks podcast Science Notebooks Prezi	Student Notebook Entry (scroll to access)	Placeholder

Placeholder	Placeholder	Placeholder	Placeholder
			

Find an Object

A scientist needs to obtain, evaluate and communicate their findings effectively. One of the most meaningful ways to do this is through science notebooking. It is critical that this skill be taught early on to students. Specifically, students need to understand how to create drawings and use expository text features (bold, color, labels, captions, heading, diagrams, charts, tables,etc.) to communicate their thinking through written words and illustrations. Additionally, this is a great place for them to practice the skill of asking questions. Once taught, science notebooking should be applied consistently through all lessons. A great activity for introducing science notebooking is "Find an Object."

Find an Object involves having the students find an object to observe and draw. This might involve the teacher bringing in an object for the whole class to observe, the class going outside to make an observation, the class bringing an object from home, or the class going outside to obtain and bring back an object from outside. Once the object is obtained, the student is required to make observations and draw what they see. They should include the text features listed above to clarify their drawing. They should be encouraged to write additional comment with regard to what they are observing with their other senses, such as smell, sound, etc.

Please note that as students develop their skills they should be encouraged to include drawings from many different perspectives. Additionally, as the need for data tables and graphs arises these organizational tools need to be explicitly taught.
This activity addresses the COMMUNICATING concept of the practice. Be sure to tie in both the OBTAINING and EVALUATING components. These include the use of tables, diagrams, graphs, and equations. Meaning needs to be able to be derived from scientific texts including papers, the Internet, symposia, and lectures.

*Great opportunity for Language Arts Common Core in the Content Area Tie-in.

	Patterns Crosscutting Concept	
Framework Rationale	**Patterns** exist everywhere-in regular occurring shapes or structures and repeating events and relationships. One major use of pattern recognition is in classification, which depends on careful observation of similarities and differences; objects can be classified into groups on the basis of similarities of visible or microscopic features or on the basis of similarities of function. Such classification is useful in codifying relationships and organizing a multitude of objects or processes into a limited number of groups. Patterns of similarity and difference and the resulting classifications may change, depending on the scale at which phenomenon is observed. Once patterns and variations have been noted, they lead to questions; scientists seek explanations for observed patterns and for the similarity and diversity within them. Engineers often look for and analyze patterns, too. For example, they may diagnose patterns of failure of a designed system under test in order to improve the design, or they may analyze patterns of daily and seasonal use of power to design a system that can meet the fluctuating needs. From the K-12 Framework, 2011, p. 85	 **Crosscutting Concepts:** • **Patterns** • Structure and Function **Practices** • Analyzing and Interpreting Data • Constructing explanations • Obtaining, evaluating and communicating information • Arguing from evidence **Disciplinary Core Idea** • 2-PS1-1

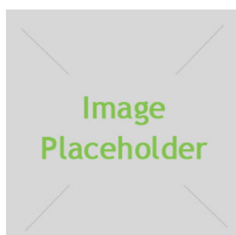
Progression	Human beings are good at recognizing patterns. Young children begin to recognize patterns in their own lives well before coming to school. They observe, for example, that the sun and the moon follow different patterns of appearance in the sky. Once they are students, it is important for them to develop ways to recognize, classify, and record patterns in the phenomena they observe. Elementary students- can describe and predict the patterns in the seasons of the year, they can observe and record patterns in the similarities and differences between parents and their offspring. They can investigate the characteristics that allow classification of animal types such as mammals, fish, and insects. They can investigate the characteristics of plants such as trees, shrubs, and grasses or they can investigate the characteristics of materials such as wood, metal and plastics. These classifications will become more detailed and closer to scientific classifications in the upper elementary grades, when students should also begin to analyze patterns in rate of change as in the growth rate of plants under different conditions. From the K-12 Framework, 2011, p. 85-87 **K-2** In the K-2 grade band, students can use observations of patterns in the natural and human designed world to describe phenomena and provide evidence. Examples from Life science include using data to describe the patterns of what plants and animals need to survive (K-LS1-a). Examples from Physical Science include using information from observations to support the explanation that different individual plants and animals of the same type have similarities and differences. Examples from Earth and Space Science include using observations to describe patterns of objects in the sky that are cyclic and can be predicted. **3-5** In the 3-5 grade band, students can observe similarities and differences in patterns to sort and classify natural and human designed phenomena. Simple	

	rates of change and cyclic patterns of change for these phenomena can be analyzed and used in to make predictions. Examples from Life Science include using evidence to support the idea that patterns of traits pass from parents to offspring and are influenced by environmental patterns (3-LS3-a). Examples from Physical Science include developing a model to describe patterns produced by waves in terms of amplitude and wavelength (4-PS4-a). Examples from Earth and Space Science include using standard units to record local weather data to identify day-to-day and long-term patterns of weather. Middle school students- can begin to relate patterns to the nature of microscopic and atomic-level structure-for example, they may note that chemical molecules contain particular ratios of different atoms. From the K-12 Framework, 2011, p. 85-87 **6-8** In the 6-8 grade band, macroscopic patterns are related to the nature of microscopic and atomic level structure. Students can observe patterns in rates of change and other numerical relationships to provide information about natural and human designed systems, as well as identify cause and effect relationships. These patterns and relationships can often be identified in data using graphs and charts.Examples from Life Science include constructing explanations for the anatomical similarities and differences between fossils of once living organisms and organisms living today, then relating these explanations to the assumption that events in natural systems occur in consistent patterns (MS-LS4-c). Examples from Physical Science include developing models of a variety of substances, from those having simple patterns of molecules to those with extended structures (MS-PS1-a). Examples from Earth and Space Science include developing and using models of tectonic plate motions to explain patterns in the fossil record, rock record, continental shapes, and seafloor structures. High School- students should recognize that different patterns may be observed at each of the scales at which a system is studied. Thus classifications used at one scale may fail or need revision when information from smaller or larger scales is	

	introduced (e.g., classification based on DNA comparisons versus those based on visible characteristics). From the K-12 Framework, 2011, p. 85-87 **9-12** In the 9-12 grade band, students may observe patterns at multiple scales of systems. Some of these patterns are identified using mathematical representations. Information about these patterns is used to provide evidence for causal explanations of phenomena, but students learn that classifications or explanations used at one scale may fail or need revision at a smaller or larger scale and therefore require improved investigations and experiments. Patterns of the performance of designed systems can be analyzed and interpreted to reengineer and improve the systems. Examples from Life Science include using a model to explain how mitotic cell division results in daughter cells with identical patterns of genetic material essential for producing and maintaining a complex organism (HS-LS1-e). Examples from Physical Science include constructing an explanation using the structure of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties to support predictions about the outcome of simple chemical reactions (HS-PS1-i). Examples from Earth and Space Science include constructing explanations, using the theory of plate tectonics, for patterns in the general trends of the ages of both the continental and oceanic crust	
Activities	Jelly Bean Classification (scroll to access)	DCI: 2-PS1-1

Patterns Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
NGSS Website 	Patterns podcast		Placeholder

Placeholder	Placeholder	Placeholder	Placeholder
			

Jellybean Classification

Adapted from "Harry Potter and the Dichotomous Key" by David T. Crowther from Science and Children, 2003

Objective: This activity is used to teach children scientists classify plants, animals and other organisms based on patterns.

Materials: Enough assorted flavored (the more the merrier!) jellybeans for the class so that each has a wide variety of flavors, colors and spots. Jelly Belly jelly beans or Kirkland jelly beans are good beans to use.

Set of rubber gloves for each student for handling jelly beans

Science notebooks

Activity:
Explain to the class how scientists use patterns to classify specimens in nature. Lead a class discussion on how you could group specimens by common patterns: color, size, shape, number of features, and features versus no features.

Explain to the class that they are a group of scientists who have come across an unusual group of specimens and they need to classify them and make a dichotomous key for their specimens. The students will need to record their process in their science notebooks. Then hand out the jellybeans and let the fun begin! If the jelly beans survive, allow the students to eat them! You may also hand out a small amount for the kids to eat as they are doing the activity. Don't forget to save some for yourself! You may also find there are a few students who have braces on their teeth, so provide an alternative candy for them to eat!

Once all of the groups are finished, allow each group to share their key with the class.

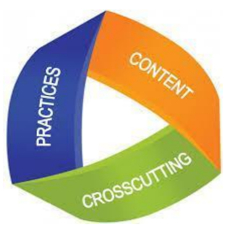
Key Concepts: Students must be able to identify patterns that they used to classify (group) their jellybeans.

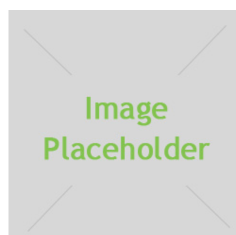
	Cause & Effect **Crosscutting Concept**	
Framework Rationale	**Science:** Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts. For example: Understanding the cause of infectious diseases, will enable predictions and design of preventive measures, treatments, and cures. **Engineering:** The goal is to design a system to cause a desired effect. The process of design is a good place to help students begin to think in terms of cause and effect, because they must understand the underlying causal relationships in order to devise and explain a design that can achieve a specified objective. From the [K-12 Framework](), 2011, p. 87-89	 **Practices** • **Cause and Effect** • Constructing explanations (for science) & designing solutions (for engineering) **Crosscutting Concepts** Patterns, System & System Models, Energy and Matter Disciplinary Core Ideas • 2-PS1-2; 3-PS2-2; 4-PS3-3

Progression	**K-2** Concept Application In the earliest grades, as students begin to look for and analyze patterns—whether in their observations of the world or in the relationships between different quantities in data—they can also begin to consider what might be causing these patterns and relationships and design tests that gather more evidence to support or refute their ideas. **3-5** Concept Application: By the upper elementary grades, students should have developed the habit of routinely asking about cause-and effect relationships in the systems they are studying, particularly when something occurs that is, for them, unexpected. The questions “How did that happen?” or “Why did that happen?” should move toward “What mechanisms caused that to happen?” and “What conditions were critical for that to happen?” **Middle School/High School** Concept Application: In middle and high school, argumentation starting from students’ own explanations of cause and effect can help them appreciate standard scientific theories that explain the causal mechanisms in the systems under study. Strategies for this type of instruction include asking students to argue from evidence when attributing an observed phenomenon to a specific cause. For example, students exploring why the population of a given species is shrinking will look for evidence in the ecosystem of factors that lead to food shortages, over predation, or other factors in the habitat related to survival; they will provide an argument for how these and other observed changes affect the species of interest. From the K-12 Framework, 2011, p. 88, 89	

Activities	Cause & Effect: Water Volume and Sound (scroll to access)	DCI: 2-PS1-2; 3-PS2-2; 4-PS3-3

Cause & Effect Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
NGSS Website 	Cause & Effect podcast Notebooks: podcast	To be added: Student Notebook Example	Placeholder

	Placeholder	Placeholder	Placeholder
			

Water Volume and Sound Cause and Effect

Materials:

Water, about 10 containers of the same size, measuring device with milliliters labeled, dropper, and spoon

Purpose: To determine how the amount of water in a container affects the sound produced when the container is tapped.

- The change in sound (effect) is caused by a change in the volume of water.
- The cause (independent variable) is a variable that you purposely change. The variable that responds to this change is the effect (dependent variable).
- The problem for the investigation identifies the cause (independent variable) and effect (dependent variable).
- For example: How does the volume of water (cause) in a container affect the sound produced (effect) when the container is tapped?
- Controlled variables include the type of container, the type of water, and the type of tapper used.

Investigation: Students will investigate the relationship between water volume in a container and the sound produced when the container is tapped.

Students should be encouraged to record questions, answers, observations, etc. in their science notebooks.

	Scale, Proportion & Quantity **Crosscutting Concept**	
Framework Rationale	In thinking scientifically about systems and processes, it is essential to recognize that they vary in size (e.g., cells, whales, galaxies), in time span (e.g., nanoseconds, hours, millennia), in the amount of energy flowing through them (e.g., lightbulbs, power grids, the sun), and in the relationship between the scales of these different quantities. The understanding of relative magnitude is only a starting point. The large idea is that the way in which things work may change with scale. Different aspects of nature change at different rates with changes in scale, and so the relationship among them change, too. Appropriate understanding of scale relationships is critical as well to engineering- no structure could be conceived, much less constructed, without the engineer's precise sense of scale. From a human perspective, one can separate three major scales at which to study science: (1) macroscopic scales that are directly observable; (2) scales that are too small or fast to observe directly; and (3) those that are too large or too slow. From the [K-12 Framework](), 2011, p. 89	 **Crosscutting Concepts** • **Scale, Proportion & Quantity** **Systems** and system models, Structure and function **Practices** • Asking Questions & Defining Problems • Planning & Carrying Out Investigations • Using Mathematics & Computational Thinking • Obtaining, Evaluating, & Communicating **Disciplinary Core Ideas** K-PS3-1

Progression	**Elementary students** - Young children can begin understanding scale with objects, space, and time related to their world and with explicit scale models and maps. They may discuss relative scales-the biggest and smallest, hottest and coldest, fastest and slowest-without reference to particular units of measurement. Units of measurement are the first to be introduced in the contest of length, in which students can recognize the need for a common unit of measure-even develop their own before being introduced to standards units-through appropriately constructed experiences. Once students become familiar with measurements of length, expand their understanding of scale and of the need for units that express quantities of weight, time, temperature, and other variables. They can also develop an understanding of estimation across scales and contexts, which is important for making sense of data. As students become more sophisticated, the use of estimation can help them not only to develop a sense of the size and time scales relevant to various objects, systems, and processes but also to consider whether a numerical result sounds reasonable. Students acquire the ability as well to move back and forth between models at various scales, depending on the question being considered. They should develop a sense of the powers-of-10 scales and what phenomena correspond to what scale, from the size of the nucleus of an atom to the size of the galaxy and beyond. Well-designed instruction is needed if students are to assign meaning to the types of ratios and proportional relationships they encounter in science. Thus the ability to recognize mathematical relationships between quantities should begin developing in the early grades with students' representations of counting (e.g., leaves on a branch), comparisons of amounts (e.g., of flowers on different plants), measurements (e.g., the height of a plant), and the ordering of quantities such as number, length, and weight. **Middle school students** - Students can then explore more sophisticated mathematical representations, such as the use of graphs to represent data collected. The interpretation of these graphs may be, for example, that a plant	

	gets bigger as time passes or that the hours of daylight decrease and increase across the months. As students deepen their understanding of algebraic thinking, they should be able to apply it to examine their scientific data to predict the effect of a change in one variable on another, for example, or to appreciate the difference between linear growth and exponential growth. **High School** - As their thinking advances, so too should their ability to recognize and apply more complex mathematical and statistical relationships in science. A sense of numerical quantity is an important part of the general "numeracy" (mathematics literacy) that is needed to interpret such relationships. From the K-12 Framework, 2011, p.90-91	
Activities	**Scale:** Candy Wrappers (scroll to access) **Proportion:** Solar System (scroll to access) **Quantity:** Talk It Over (scroll to access)	DCI: K-PS3-1

Scale, Proportion & Quantity Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
[NGSS Website](#) 	Scale, Proportion & Quantity [podcast](#)		Placeholder

Placeholder	Placeholder	Placeholder	Placeholder
			

Candy Wrappers

To Teach students about the concept of drawing objects to scale.

Materials List:

- Graphing paper
- Any kind of candy wrapper

Three dimensions of the Framework:

Scientific and Engineering Practices: Asking Questions, Developing and using models, Planning and carrying out investigations, Using mathematics and computational thinking

Crosscutting Concepts: Scale, proportion, and quantity, Systems and system models

Disciplinary Core Ideas: Engineering, Technology, and Applications of Science: Engineering design

Description: To teach about the concept of drawing objects to scale, start off with two-dimensional drawings of simple objects. Try having students enlarge a candy wrapper. Cut it into 1/4-inch grids, then give each student a 1-inch square numbered on the back. Have the students recreate their piece of wrapper onto their square, multiplying every dimension by four. Then take all of the completed squares and arrange them based on the numbers on the back. If everything goes correctly, you should have a perfect replica of the candy wrapper at four times the size of the original. Award points based on accuracy. For fun, give the student with the best drawing an actual bar of the candy you enlarged.

Solar System

Materials List:

- Science Journal
- drawing compass
- colored pencils
- ruler
- string
- index cards
- tape

Description: This activity models proportion. When we view the solar system our perception of the distance between the planets is skewed. Making a model will allow the student to see a scale sized model of something that is too large to be observed directly. Scientists use astronomical units (AU) when measuring distances in the solar system simply because distances measured in kilometers can get large. Look at the following table to get an idea of the vast size of our solar system. One astronomical unit is interpreted as the distance of the Earth from the Sun. Making a scale model of the solar system is easy if you remember to use each planet's distance from the sun, measured in Au, and convert it by moving the decimal place one space to the right and measure the distance in centimeters.

Procedure: (you will need a large area to run the length of the ropes depending on the scale the students use)
Step 1 Have students draw a picture in of what they think the solar system looks like.
Step 2 Review the order of the planets and write them on the index cards
Step 3 Place the sun at the start of the string.
Step 4 Using the scale distance from the sun column, tape the Mercury card on the string.
Step 5 Do the same for the rest of the planets.
Step 6 Next have students draw another picture of what the model really looked like.

Planet	Distance from Sun (AU)	Distance to Planet (Km)	Scale distance From sun (cm)	Actual Diameter (km)	Model diameter (mm)	Material For Planet Models
Sun (a star)	0			1,391,980	139	6 inch diameter ball(grapefruit size)
Mercury	0.39	58,000,000	3.9	4,880	0.5	Small pinhead
Venus	0.72	108,000,000	7.9	12,100	1.2	Large pinhead
Earth	1.00	150,000,000	10	12,800	1.3	Large pinhead
Mars	1.52	228,000,000	15.2	6,800	0.7	Small pinhead
Jupiter	5.20	778,000,000	52.0	142,000	14.3	Standard marble
Saturn	9.54	1,430,000,000	95.4	120,000	12.0	Standard marble

Uranus	19.2	2,870,000,000	192	51,800	5.2	Ball bearing
Neptune	30.1	4,500,000,000	301	49,500	4.8	Ball bearing
Pluto	39.4	5,900,000,000	394	2,300	0.2	Small Pinhead

Talk It Over: How does the sun's direction affect temperature? (Quantity of sunlight and temperature)

This activity models quantity.

Source: [John Wiley & Sons, Inc.]

Where does the sun appear to be in the sky at different times of the day?

Does the sun feel hotter or cooler when you face in different directions?

How can you find out?

Materials List:

- Half-gallon milk carton
- Sand or stones
- 4 indoor-outdoor tube thermometers*
- Tape
- Plastic wrap
- Compass
- Sunny spot outdoors

Three dimensions of the Framework:

Scientific and Engineering Practices: Asking Questions, Developing and using models, Planning and carrying out investigations, Using mathematics and computational thinking, Constructing explanations, Engaging in argument from evidence, Obtaining, evaluating, and communicating information.

Crosscutting Concepts: Scale, proportion, and quantity, Systems and system models, Structure and function, Cause and effect

Disciplinary Core Ideas: Earth and Space Science: ESS1 Earth's place in the universe, ESS2 Earth's systems

Description: Start this experiment in the morning on a sunny day. Put sand or stones in the milk carton to keep it from blowing over in a breeze. Tape 4 thermometers to the milk carton, one on each side, like this:

Wrap the carton and thermometers in plastic wrap. Find a sunny spot outside that will not be in the shade at any time during the day.

Using the compass, find which direction is north. Note where south, east, and west are.

Set the milk cartons so that the thermometers face the four directions exactly, like this:

Look at the milk carton's shadow. It tells you that the sun is in the opposite direction in the sky. (For example, if the shadow is falling toward the west, the sun is in the eastern sky.) Record this direction. Wait about 20 minutes. Then take your first temperature readings, one from each thermometer (direction). Record. Every hour throughout the day, read and record the four temperatures again.

Stay Safe: Never look into the sun. It can blind you. Infer where the sun is in the sky from the shadow the milk carton casts.

Show Your Results:

Record temperatures and the sun's direction in a table like this, using only three time columns for "Go Easy":

Direction	Temperature						
	9:00 a.m.	10:00 a.m.	11:00 a.m.	12:00 noon	1:00 p.m.	2:00 p.m.... and so on	
North							
East							
South							
West							
Sun's direction							

Tips and Tricks:

- Make sure to wrap your experiment in plastic wrap. You'll get bigger temperature differences. Can you explain why?
- Look carefully at your compass and the shadow cast by the milk carton. Read the opposite compass direction as accurately as you can. For example, if the shadow lies to the NNE (north northeast), the sun's direction is SSW (south southwest).

	Systems & System Models **Crosscutting Concept**	
Framework Rationale	**Systems and System Models** Defining the system under study- specifying its boundaries and making explicit a model of that system-provides tools for understanding and testing ideas that are applicable throughout science and engineering. "The natural world is complex; it is too large and complicated to investigate all at once. Scientists, engineers, and students alike have learned to define smaller portions of investigation which are referred to as 'systems'. Systems can be organized into a related group of objects or components that form a whole. There are forces acting on systems or flows of matter and energy across it and often the parts of a system are interdependent. Things viewed as subsystems at one scale may themselves be viewed as a whole system on a smaller scale. Models can be useful tools in predicting behaviors or diagnosing problems or failure in functions. Good system models must specify not only the parts, or subsystems of the system, they must also show interaction between one another and specify the boundary of the system being modeled delineating what is included in the model and what is to be treated as external. Models have assumptions and approximations but user beware on how they affect the reliability and precision. Both depend on the use of the model. From the K-12 Framework, 2011, pgs.92-93	 **Crosscutting Concepts** **• Systems & System Models** **Practices** • Developing and Using Models • Obtaining, Evaluating & Communicating Information **Discipline Core Ideas** • 4-LS1-1; MS-LS-3

Progression	Use of system models allows the user to better understand smaller segments of our complex world. **Elementary students:** Students can learn to use the concept of system models through drawings, diagrams, and descriptions of the interacting parts of models. They should be able to represent their ideas and explanations of all of the working parts of their systems to their peers. Examples: food webs, planets, classification Skills: Classify, labeling, recognizing **Middle School students:** The movement of energy, though invisible, should be represented by the models as well the use of mathematical interpretation of variables present within the system. Examples: Newton's first, second, and third laws of motion Skills: calculations, predictions, measuring **High School:** Students should now be able to take assumptions and approximations and represent their limitations within the model. Validity of the model should be discussed and defended among peers. Examples: modeling interactions between matter and energy Skills: design, construction, argument from evidence Across the progression of grades, models help students to take a complicated idea and break it into smaller more comprehensive pieces of information. Through the use of models students can represent their ideas, thoughts and understandings to their peers. By the processes of discussion, review, critique, and sharing of information generated by the system model the understanding of their system becomes a learning tool for both the designer and learner. From the K-12 Framework, 2011, p.	

Activities	Systems & System Models: Digestive System Model (Scroll to Access)	• 4-LS1:A • MS-LS1:A • HS-LS1:B

Systems & System Models Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
NGSS Website  	Systems & System Models podcast The Digestive System Prezi		Placeholder

Placeholder	Placeholder	Placeholder	Placeholder
 	 	 	

Digestive System Model

Your digestive system is a group of organs that work together to digest food so that it can be used by the body. Look at a picture of a digestive system. This system contains many parts and many of the parts are folded up inside your body. If you were to take your digestive system out of your body and lay it out flat, it would surprise you how long it is. In this lab, you will make models of your own digestive system by measuring and cutting yarn to represent the lengths of different parts of the system, and knotting the pieces of yarn together to form one long string.

Materials needed: meter sticks, 5 different colors of yarn—I used blue, red, green, yellow, and purple, but you could change it to any colors you have on hand, labels or masking tape, scissors, a digestive system diagram.
Procedure: ****note: you may want to add a few centimeters to each length to account for length lost when tying knots. I also hang these across the room when finished.
Challenge students to design their own proportionally correct model representing a human digestive system with materials given: these are teacher notes to help guide students.

1. Digestion begins in the mouth, so measure and cut a piece of red yard from the front to the back of the mouth. (You can do this by stretching the yarn from the front of your lips to the back of your jaw along your neck).

1. Record this length in centimeters (cm) in the data table on the next page.

1. The esophagus is a tube that connects the mouth and stomach. Measure and cut a piece of blue yarn the length of the esophagus. (Measure from your mouth to just below your rib cage). Tie the blue esophagus to the red mouth.

1. Record the length of this blue string in centimeters (cm) in the data table on the next page.

1. In the stomach, gastric juices break down solid food into a liquid. Find the length of the stomach by spreading the fingers of your hand and measuring the span from the thumb to the little finger. Measure and cut a piece of green yarn to match this length. Tie the green stomach to the blue esophagus.

1. Record the length of this green string in centimeters (cm) in the data table on the next page.
2. The small intestine is the longest part of the digestive system. It is folded up inside of you so it fits. Food is further digested and

absorbed here. Measure you heights and multiply it by four. Use yellow yarn to represent the length of the small intestine. Tie the yellow small intestine to the green stomach.

1. Record the length of this yellow string in centimeters (cm) in the data table on the next page.

1. Last is the large intestine. It is much wider than the small intestine, but is much shorter. It is about as tall as you are. Undigested material from the small intestine moves to the large intestine before it leaves your body. Use purple yarn to represent the length of your large intestine. Then tie the purple large intestine to the yellow small intestine.

1. Record the length of this purple string in centimeters (cm) in the data table.

1. Label each segment of your digestive system model with labels or masking tape like your teacher showed you.

DIGESTIVE ORGAN	LENGTH (CM)
Mouth	
Esophagus	
Stomach	
Small Intestine	
Large Intestine	

1) What is the TOTAL LENGTH of your digestive system? ______________________ cm

DIGESTIVE ORGAN	FUNCTION (JOB)
Mouth	
Esophagus	
Stomach	
Small Intestine	
Large Intestine	

	Energy & Matter: Flows, Cycles & Conservation **Crosscutting Concept**	
Framework Rationale	**Matter and energy conservation** has important implications for the disciplines of science. The cycle of input and output is necessary for many systems throughout our environment. Without inputs of energy, such as sunlight, and matter, such as carbon dioxide and water, a plant would not grow. Similarly, without the input and outputs of energy, the water cycle would not occur. In engineering, a major goal in design is to maximize certain types of energy output while minimizing others. Think about how car designers try to minimize fuel used and maximize energy output. The ability to examine, characterize, and model the transfers and cycles of matter and energy is a tool that students can use across virtually all areas of science and engineering. And studying the interactions between matter and energy supports students in developing increasingly sophisticated conceptions of their role in any system. However, for this development to occur, there needs to be a common use of language about energy and matter across the disciplines in science instruction. From the K-12 Framework, 2011, p. 94-95	 **Crosscutting Concepts** **• Energy & Matter: Flows, Cycles & Conservation** • Cause and Effect • Structure and Function **Practices** • Developing & Using Models • Planning & Carrying out Investigations • Analyzing & Interpreting Data **Disciplinary Core Ideas** 1-LS1-1;2-PS1-1;2-PS1-2;K-2-ETS 1-1;K-2-ETS1-3;4-PS3-1;3-5-ETS1-2;3-5-ETS1-3; MS-PS2-1

Progression	**K-2** students are likely to have difficulty studying the concept of energy in depth—everyday language surrounding energy contains many shortcuts that lead to misunderstandings—for example the perception that food or fuel is a type of energy. For this reason, the concept is not developed at all in K-2 and only very generally in grades 3-5. By **middle school**, a more precise idea of energy—for example, the understanding that food or fuel undergoes a chemical reaction with oxygen that releases stored energy—can emerge. Also, the idea of atoms and their conservation is taught in grades 6-8. By **high school** (grades 9-12), nuclear substructure and the related conservation laws for nuclear processes are introduced. From the K-12 Framework, 2011, p. 95-96	
Activities	Egg Drop (scroll down to access)	1-LS1-1;2-PS1-1;2-PS1-2;K-2-ETS 1-1;K-2-ETS1-3;4-PS3-1;3-5-ETS1-2;3-5-ETS1-3; MS-PS2-1

Energy & Matter: Flows, Cycles & Conservation Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
NGSS Website 	Energy & Matter: Flows, Cycles & Conservation podcast	To be included: Student Notebook Entry (scroll to access)	For more ideas: http://learningcenter.nsta.org/search.aspx?action=browse&subject=42

http://www.stevespanglerscience.com for experiments. If you sign up with Steve Spangler, you will receive weekly experiments.	IDEA: Could be used as a performance assessment	Montana Indian Ed. For All website http://opi.mt.gov/PDF/IndianEd/Search/Science/G_K-8_All_Units.pdf	POETRY Writing Rubric On Toolkit Resource Page
			

Science Egg Drop Contest Rules
(from Melrose School, Melrose, Montana)
Grades K-8

Ideas for Curriculum placement: This activity could be used at the end of an elementary grade unit on eggs of different species (i.e. looking at the difference between chicken, frog and reptile eggs and how they survive in that state. For middle school, this activity could be used at the end of a unit on biomimicry.

How the Competition Works
Student or teachers (yes teachers can participate to show their skills) are to build an egg holder that will protect a raw, uncooked egg as it falls from the top of the large slide (approximately 4 meters) on the playground. For the upper grades, a second story window or roof top would work, but be safe and always remember the safety of your students. If you are successful, you will win a prize or a really good grade; learn about energy, motion and design and watch other people splatter their eggs.

Creation of Container
All containers may be made at home prior to the event or you may have the children bring in various materials to be shared while constructing the containers at school. Materials should follow the guidelines below and you may want to remind your students that organic materials may be used too. You may want them to focus on recycleable materials, as well. Brainstorming a supply list with the class would aide in making sure the rules are followed and materials are readily available.

Rules
Container must hold a large egg.

Weight and Size and Design Restrictions: 2 lbs, 10 inch maximum package in all directions

No wings or parachutes, No Styrofoam, No pre-made plastic bubble wrap or other store bought packing material or foam.

No gases other than air may be used.

No splatterables such as peanut butter, Jell-O, liquids, fruit or vegetables (popcorn is OK).

No flammable substances.

No glass.

Containers may be made with minimal adult help but must be made by the child.

(Research by the child to assist in choosing the general design of the container is acceptable when the research provides the benefit of teaching the child more
about energy, motion, and construction design or this could be used as a final project at the end of a unit on matter and energy.)

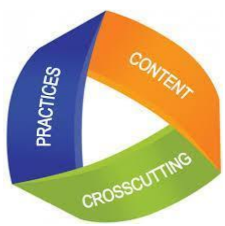
Containers must be able to withstand three droppings at the direction of the Scientists in charge of the demonstration. No alterations, repairs or repackaging can be made after first drop.

Container must be constructed with a hatch or door so that the egg can be inserted before each drop and inspected after each drop.
Tape can be used for this purpose. We will have tape on hand. Failure to follow design guidelines above could result in disqualification. It is up to the judges' discretion as to whether or not the guidelines are being followed. Prior to the drop, the contestants may inspect eggs for cracks. All eggs will be of similar size, age and grade. Prior to the drop, at the site, the contestant must insert the egg into the container. Adult volunteers or teachers will drop all competing egg containers. Children will not get to drop the containers. A cracked egg is defined as one that is visibly leaking its contents. Hairline fractures are not considered cracks. After each drop the contestant will be required to remove the egg from their container to show the judges that it did not break. Students must document in their science notebooks using the rubrics for P.O.E.T.R.Y. The science notebook entries and outcome of contest could be used as a performance assessment.

	Structure & Function **Crosscutting Concept**	
Framework Rationale	As expressed by the National Research Council in 1996 and reiterated by the College Board in 2009, "Form and function are complementary aspects of objects, organisms, and systems in the natural and designed world…Understanding of form and function applies to different levels of organization. Function can be explained in terms of form and form can be explained in terms of function" (2,3). The functioning of natural and built systems alike depends on the shapes and relationships of certain key parts as well as on the properties of the materials of which they are made. From the [K-12 Framework](), 2011, p. 96	 **Crosscutting Concepts** **• Structure & Function** **Practices** • Obtaining, Evaluating & Communicating **Core Ideas** K-2-ETS1-2; 4-LS1-1
Progression	Exploration of the relationship between structure and function can begin in the early grades through investigations of accessible and visible systems in the natural and human-built world. **Elementary students** - For example, children explore how shape and stability are related for a variety of structure (e.g., a bridge's diagonal brace) or purposes (e.g., different animals get their food using different parts of their bodies). As children move through the elementary grades, they progress to understanding the relationships of structure and mechanical function (e.g., wheels and axles, gears). For **upper-elementary students**, the concept of matter having a substructure at a scale too small to see is related to properties of materials; for	

	example, a model of a gas as a collection of moving particles (not further defined) may be related to observed properties of gases. Upper-elementary students can also examine more complex structures, such as subsystems of the human body, and consider the relationship of the shapes of the parts to their functions. **Middle school students** - By the middle grades, students begin to visualize, model, and apply their understanding of structure and function to more complex or less easily observable systems and processes (e.g., the structure of water and salt molecules and solubility, Earth's plate tectonics). For students in the middle grades, the concept of matter having a submicroscopic structure is related to properties of materials; for example, a model based on atoms and/or molecules and their motions may be used to explain the properties of solids, liquids, and gases or the evaporation and condensation of water. **High School** - As students develop their understanding of the relationships between structure and function, they should begin to apply this knowledge when investigating phenomena that are unfamiliar to them. They recognize that often the first step in deciphering how a system works is to examine in detail what it is made of and the shapes of its parts. From the K-12 Framework, 2011, p. 97-98	
Activities	Mouth Structures of Animals (scroll to access)	CDI: K-2-ETS1-2; 4-LS1-1

Structure & Function Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
NGSS Website 	Structure & Function podcast		Placeholder

Placeholder	Placeholder	Placeholder	Placeholder
			

MOUTH STRUCTURES OF ANIMALS (Montana PBS Learning Media)

Overview: In this lesson, students gather evidence to understand features that enable them to meet their needs. In particular, they examine the mouth structures of different animals to help them understand how animals are adapted to obtain food in their environment.
Objectives:

- Understand that living things have features that enable them to meet their needs
- Understand that specialized mouth structures enable animals to eat certain types of foods

Materials: Computers for pairs of students, science notebooks
Multimedia Resources:

Bird Food - http://montana.pbslearningmedia.org/resource/tdc02.sci.life.colt.birdfood/
Bird Beak Gallery http://montana.pbslearningmedia.org/resource/tdc02.sci.life.stru.beakgallery/
Unhinged! http://montana.pbslearningmedia.org/resource/tdc02.sci.life.stru.eatingvid/
Animal Mouthshttp://montana.pbslearningmedia.org/resource/tdc02.sci.life.colt.mounths/

Procedure:
1. Animals have specialized mouth structures that help them capture, handle, and eat the food available to them in their environment. Have students examine the Bird Food, stills, which show different types of birds eating different types of food. Ask:
How do different beak shapes help birds eat different kinds of food?

2. In pairs, have students look at the Bird Beak Gallery stills and guess what type of food each bird eats. Have them draw each bird beak and record their predictions on a piece of paper, then share them with the class.

3. Show students the Unhinged! video, which compares the mouth structures of humans and snakes. Discuss how the mouths of these organisms are specialized for eating certain types of food.

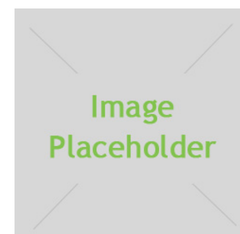
4. Have students look at the Animal Mouths stills and consider how the mouths of these animals are specialized to catch, chew, and swallow particular foods. As students look at each picture, have them imagine what kind of food that animal eats. Tell them to look at the shape, for example, of the mouth, tongue, jaw, and teeth for clues.

	Stability & Change **Crosscutting Concept**	
Framework Rationale	**Stability** denotes a condition in which some aspects of a system are unchanging, at least at the scale of observation. Stability means that a small disturbance will fade away—that is, the system will stay in, or return to, the stable condition. Such stability can take different forms, with the simplest being a static equilibrium, such as a ladder leaning on a wall. A repeating pattern of cyclic **change**—such as the moon orbiting Earth—can also be seen as a stable situation, even though it is clearly not static. Such a system has constant aspects, however, such as the distance from Earth to the moon, the period of its orbit, and the pattern of phases seen over time. When studying a system's patterns of change over time, it is also important to examine what is unchanging. Understanding the feedback mechanisms that regulate the system's stability or that drive its instability provides insight into how the system may operate under various conditions. These mechanisms are important to evaluate when comparing different design options that address a particular problem. From the K-12 Framework, 2011, p. 98-99	 **Crosscutting Concepts** **• Stability & Change** **Practices** • Obtaining, Evaluting & Communicating **Core Ideas** • 2-ESS1-1; MS-ESS3-1

Progression	Even very young children begin to explore stability (as they build objects with blocks or climb on a wall) and change (as they note their own growth or that of a plant). The role of instruction in the **early grades** is to help students to develop some language for these concepts and apply it appropriately across multiple examples, so that they can ask such questions as "What could I change to make this balance better?" or "How fast did the plants grow?" One of the goals of discussion of stability and change in the elementary grades should be the recognition that it can be as important to ask why something does not change as why it does. Likewise, students should come to recognize that both the regularities of a pattern over time and its variability are issues for which explanations can be sought. Examining these questions in different contexts (e.g., a model ecosystem such as a terrarium, the local weather, a design for a bridge) broadens students' understanding that stability and change are related and that a good model for a system must be able to offer explanations for both. **In middle school**, as student's understanding of matter progresses to the atomic scale, so too should their models and their explanations of stability and change. Furthermore, they can begin to appreciate more subtle or conditional situations and the need for feedback to maintain stability. At the high school level, students can model more complex systems and comprehend more subtle issues of stability or of sudden or gradual change over time. Students at this level should also recognize that much of science deals with constructing historical explanations of how things evolved to be the way they are today, which involves modeling rates of change and conditions under which the system is stable or changes gradually, as well as explanations of any sudden change. From the K-12 Framework, 2011, p. 100-101	
Activities	The Stability of Land (scroll to access)	DCI: 2-ESS1-1; MS-ESS3-1

Stability & Change Resource Set

NGSS	Podcasts	Student Artifacts or Examples	Placeholder
NGSS Website  	Stability & Change podcast		Placeholder

Placeholder	Placeholder	Placeholder	Placeholder
 	 	 	

Analyzing the Stability of Land

Summary: In this section, we will look at one activity examining stability and change and its progression throughout the grade levels. The purpose is to provide a concrete example of how an activity changes in complexity throughout a student's progression through grade levels.

Primary (Students recognize stability and change in their own lives and develop language to describe it. Students design concrete, stable and unstable structures.)

Student Background Information/Objectives: There are things around me that are stable and unstable. I can build a stable mud mountain and wash it away with water. Asking questions about the mud mountain helps me redesign for stability.

Materials:

- Stream Table or Dirt/Water
- Science Journal

Upper Elementary (Students recognize stability and change and develop questions in regards to why something changes AND why it does not. Students strive to design concrete and abstract stable and unstable systems with the understanding that good explanations include both change and stability.)

Student Background Information/Objectives: I can relate an investigation of a stream table to my local, surrounding landforms. I recognize that plant material prevents erosion of river banks and surfaces. I can predict what will happen to surrounding landforms over time due to the process of erosion. I will present a PowerPoint to my classmates about the future of a local landform and argue my point of view with evidence from the stream table model and other examples.

Materials:

- Stream Table or Dirt/Water
- Local Landform List
- PowerPoint Accessibility
- Projector/Computer
- Internet Access
- Science Journals
- Colored Pencils

Middle School (On an atomic scale, students recognize stability and change and develop questions in regards to why something changes AND why it does not. Students strive to design stable systems with the understanding that good explanations include both change and stability.)

Student Background Information/Objectives: I can relate an investigation of a stream table to my local, surrounding landforms. I recognize that plant material prevents erosion of river banks and surfaces. I can predict what will happen to surrounding landforms over time due to the process of erosion I can identify mud in the erosion process as a mixture or a solution. I can compare and contrast the mineral composition of rocks and soil to determine resistance of erosion. I can identify areas of high erosion and areas of low erosion.

Materials:
Rock Samples
Water
Internet Access
Computer Simulation Software
To Be Determined by Design

High School (Students recognize stability and change and develop questions in regards to why something changes AND why it does not. Students strive to design stable systems with the understanding that good explanations include both change and stability. Students are able to recognize and represent gradual change over time and express it mathematically.)

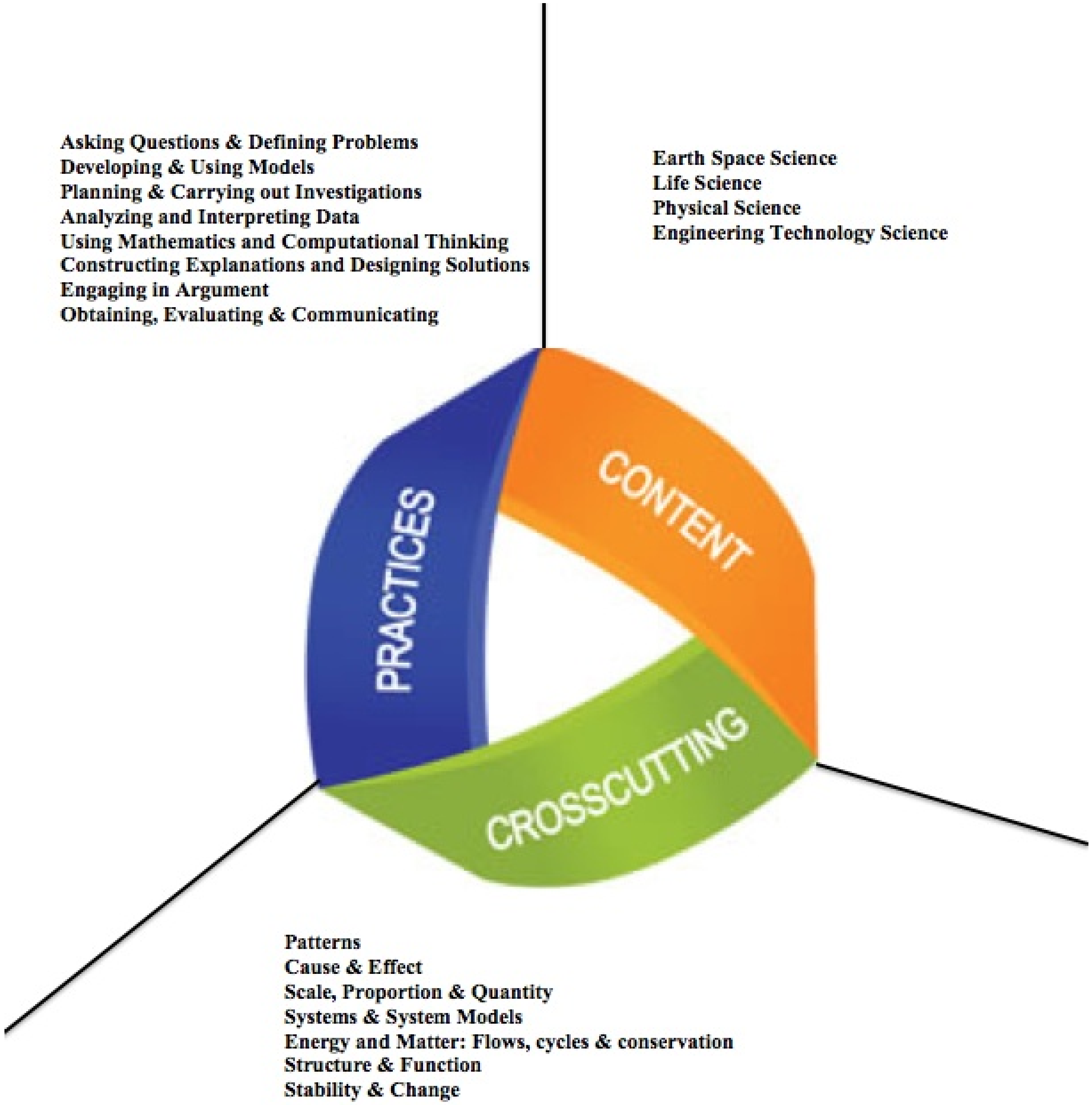
Student Background Information/Objectives: I can identify erosion areas of concern in my local landscape. I can express the rate of erosion mathematically and predict the effects of erosion on the land. I can use computer simulation, plants, and other materials to design a solution regarding erosion of a local riverbank or agricultural site.

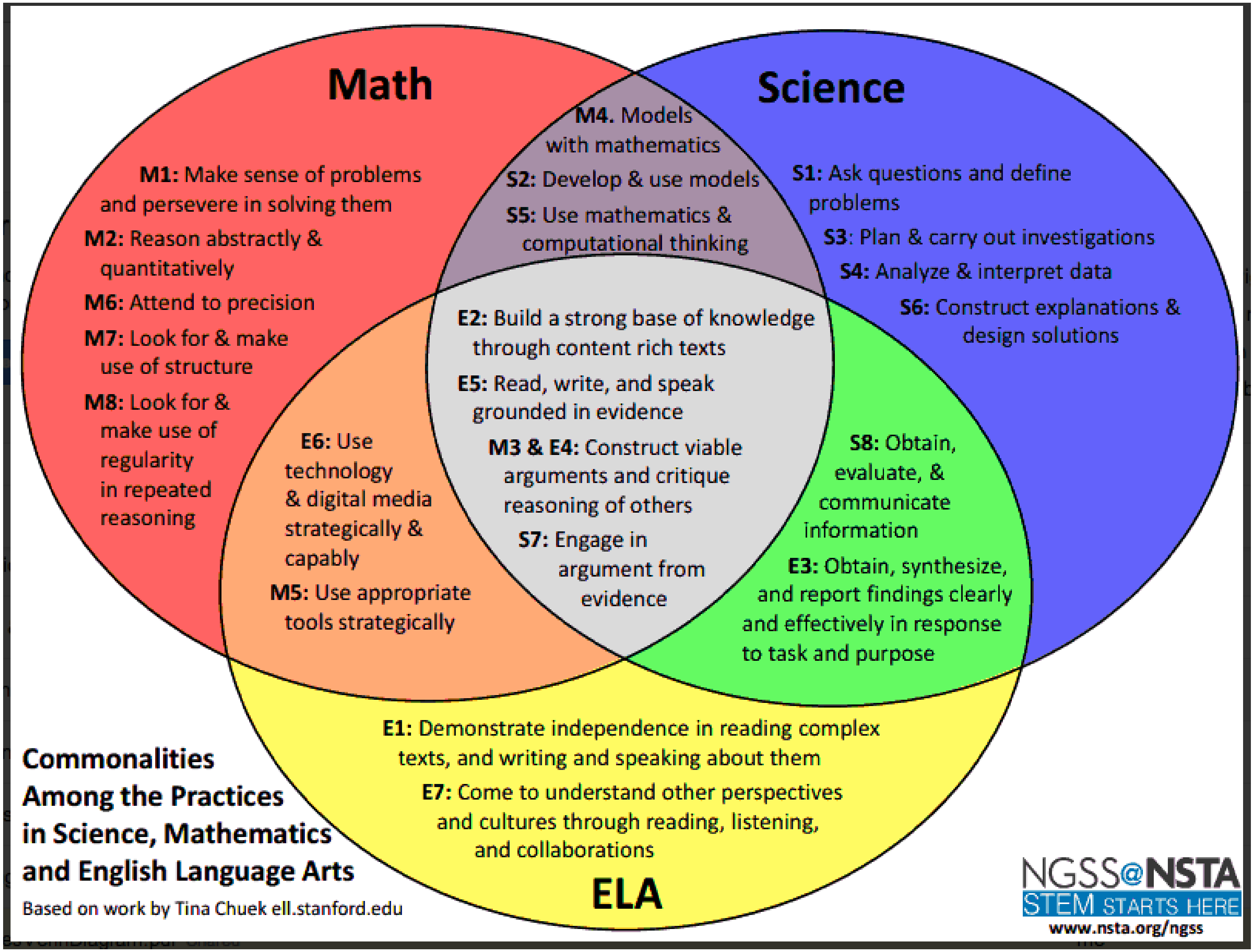
Materials:
Land/Site
Tools for Data Collection
Computer Simulation Software
To Be Determined by Design

Toolkit Resources

Dimensions Diagram (scroll to access)
NGSS/CCSS Venn Diagram (scroll to access)
P.O.E.T.R.Y. Writing Rubric (scroll to access)

Dimensions Diagram





Commonalities Among the Practices in Science, Mathematics and English Language Arts

Based on work by Tina Chuek ell.stanford.edu

Practices in Mathematics, Science, and English Language Arts*

Math	Science	English Language Arts
M1. Make sense of problems and persevere in solving them.	**S1.** Asking questions (for science) and defining problems (for engineering).	**E1.** They demonstrate independence.
M2. Reason abstractly and quantitatively.	**S2.** Developing and using models.	**E2.** They build strong content knowledge.
M3. Construct viable arguments and critique the reasoning of others.	**S3.** Planning and carrying out investigations.	**E3.** They respond to the varying demands of audience, task, purpose, and discipline.
M4. Model with mathematics.	**S4.** Analyzing and interpreting data.	**E4.** They comprehend as well as critique.
M5. Use appropriate tools strategically.	**S5.** Using mathematics, information and computer technology, and computational thinking.	**E5.** They value evidence.
M6. Attend to precision.	**S6.** Constructing explanations (for science) and designing solutions (for engineering).	**E6.** They use technology and digital media strategically and capably.
M7. Look for and make use of structure.	**S7.** Engaging in argument from evidence.	**E7.** They come to understanding other perspectives and cultures.
M8. Look for and express regularity in repeated reasoning.	**S8.** Obtaining, evaluating, and communicating information.	

* The Common Core English Language Arts uses the term "student capacities" rather than the term "practices" used in Common Core Mathematics and the Next Generation Science Standards.

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