Unit Title: Tower of the Future	**Grade Level:** 2
Date Developed/Last Revised: 07.15.13	**Time Frame:** 22 class periods (45 min each)
Unit Author(s): L. Higashi, L. Lum, R. Saito, K. Umeda	**Primary Content Area:** Science, Engineering

UNIT DESCRIPTION:

Students will discover and investigate the nature of matter through hands-on engagement with solid Earth materials (i.e. soil, sand and rocks). More specifically, students will be able to identify solid Earth materials and their physical properties (i.e., size, shape, color, texture, magnetism and the ability to absorb water). They will then use their knowledge of these properties to classify a "mystery" material. Students will further understand that it is the properties of materials that determine how they are used and why, especially as it relates to engineering. They will then use the Engineering Design Process to design and build a model of a tall tower using man-made materials.

While the Scientific Inquiry Process helps us to answers questions about the world, the Engineering Design Process (EDP) enables us to solve problems, create, and redesign products and systems. Through engagement in this process, students will engage in creating prototypes of ideas while applying their knowledge in science, math, and technology. They will also practice the GLOs and the STEM Competencies as they apply the cooperative skills needed to work in engineering design teams and optimize their product. In this unit, students will work in teams and apply their scientific knowledge of natural and manmade materials towards engineering a "tower of the future" of their own design.

Big Ideas (Student Insights that Will Be Developed Over the Course of the Unit):

- Scientists conduct investigations by using a systematic process to test a prediction.
- Solid Earth materials such as sand, soil and rocks can be classified by their physical properties (i.e., size, weight, color, texture, and the ability to absorb water).
- Some Earth materials are used to construct buildings and other structures.

Essential Questions (Questions that Will Prompt Students to Connect to the Big Ideas):

- How do we conduct scientific investigations?
- What are solid Earth materials and how are they classified?
- What are some changes that have occurred in society as a result of new technologies?
- What is the Engineering Design Process?
- How does the Engineering Design Process help us to create and innovate?

	BENCHMARKS/STANDARDS/LEARNING GOALS
Science	*Note: The "L" codes at the end of each benchmark refer to the assigned level of the Marzano's Taxonomic Level of Understanding. For example, "L3" refers to Taxonomic Level 3: Analysis. Benchmarks being assessed are bolded.* • **SC.2.1.1 Develop predictions based on observations (L3)** • **SC.2.1.2 Conduct a simple investigation using a systematic process safely to test a prediction (L1)** • **SC.2.8.1 Identify different Earth materials and classify them by their physical properties (L3)**
Technology	• **SC.2.2.1 Describe changes that have occurred in society as a result of new technologies (L2)**
Engineering	• **CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems**
Mathematics	<u>Supporting CCSS Mathematical Standards</u> • CCSS.Math.Content.2.OA.A.1 Use addition and subtraction within 100 to solve word problems involving lengths that are given in the same units, e.g., by using drawings (such as drawings of rulers) and equations with a symbol for the unknown number to represent the problem. • CCSS.Math.Content.2.MD.D.9 Generate measurement data by measuring lengths of several objects to the nearest whole unit, or by making repeated measurements of the same object. Show the measurements by making a line plot, where the horizontal scale is marked off in whole-number units. <u>Supporting CCSS Mathematical Practices</u> 1. Make sense of problems and persevere in solving them. 2. Reason abstractly and quantitatively. 3. Construct viable arguments and critique the reasoning of others. 5. Use appropriate tools strategically. 6. Attend to precision.
English Language Arts and Literacy	<u>Supporting CCSS Language Arts Standards</u> • CCSS.ELA-Literacy.RI.2.1 Ask and answer such questions as who, what, where, when, why, and how to demonstrate understanding of key details in a text. • CCSS.ELA-Literacy.W.2.1 Write opinion pieces in which they introduce the topic or book they are writing about, state an opinion, supply reasons that support the opinion, use linking words (e.g., because, and, also) to connect opinion and reasons, and provide a concluding statement or section. • CCSS.ELA-Literacy.SL.2.4 Tell a story or recount an experience with appropriate facts and relevant, descriptive details, speaking audibly in coherent sentences.

STEM Competencies	Supporting STEM Competencies • Indicator 2.2: Collaborates with, helps and encourages others in group situations (in science and engineering teams) • Indicator 2.5: Demonstrates responsible and ethical behavior in decision making (while making choices for the team's implementation plans) • Indicator 6.4: Uses the appropriate technologies for communication, collaboration, research, creativity, and problem solving (multi-meter/internet/apps)

Overview of Science, Technology, Engineering, and Math used in this lesson			
S: • Scientific Inquiry Process (SIP) • Earth materials and their properties • Manmade materials and their properties	**T:** • Meter stick, tape measure • Internet resources • Livebinder of Earth Material resources • iPad Apps • Discovery Education	**E:** • Engineering Design Process (EDP) • Engineering a Tower of the Future	**M: (application of prior knowledge)** • Mathematical Practices • Data Collection • Linear Measurement

LESSON SEQUENCE

	Lesson Title/ Description	Learning Goals (What Students Will Know and Be Able to Do)	Assessments	Time Frame 45 min/period
Part 1: SCIENTIFIC INQUIRY INVESTIGATION (SIP)				
1	Introductory Activity	*Students will:* • Make observations of the Earth as a biosphere that includes the hydrosphere, atmosphere, and lithosphere. • Know that Earth materials include air, water, soil, sand, and rocks/minerals.	**Formative:** • Teacher observations and conversations	1 class period
2	Structured Inquiry: Identifying Properties of Earth Materials	*Students will:* • Work in groups to engage in an inquiry investigation. • Make predictions about the properties of the Earth materials as they are introduced. • Compare and contrast the data for the different Earth materials. • Identify the solid Earth materials: soil, sand, and rocks. • Identify their physical properties: size, weight, color, texture, and the ability to absorb water.	**Formative:** • Teacher observations and conversations • Properties of Earth Materials Data Recording Sheet	2-3 class periods, depending how the stations are structured
3	Research of Background Information	*Students will:* • Use a variety of Internet resources to learn more about soil, sand, and rocks. • Connect what was learned from the structured inquiry investigation to what they learned from their research.	**Formative:** • Teacher observations and conversations • KWL Chart	1 class period
4	Guided Inquiry: Mystery Material Investigation	*Students will:* • Work in groups to engage in an inquiry investigation. • Make predictions about an anomalous "mystery" sample based on observations. • Conduct a simple investigation using a systematic process to test a prediction (Mystery Material Investigation). • Classify the mystery sample based on its properties. • Draw a conclusion based on data collected during the investigation. • Make applications of what they have learned to the real world. (i.e., Which Earth material would be most appropriate to construct a building and why?)	**Formative:** • Discussions (conversations) of concepts (Teacher facilitated, using Evidence/Criteria as a guide) • Observations conducted as participants conduct their inquiry investigations • "Mystery" Material Data Recording Sheet	1-2 class periods

5	Connecting Earth Materials to Man-Made Materials	*Students will:* • Know that natural materials are found naturally occurring all around us and that many natural materials are used to create man-made materials. • Be able to identify an object in the classroom that is man-made and explain their reasoning for selecting that object.	**Formative:** • Teacher observations and conversations	1 class period
6	Summative Assessment	*Students will:* • Identify solid Earth materials and their properties • Explain why it is important to know the properties of materials.	**Summative:** Earth Materials Assessment	1 class period
Part 2: ENGINEERING DESIGN PROCESS (EDP)				
7	Building Student Understanding Through Discovery Learning	*Students will:* • Work in groups to engage in discovery learning including data collection, recording and analysis. • Share their findings and participate in a class discussion to understand how the effects of gravity and types of structural features affect a "tower's" ability to remain upright.	**Formative:** • Teacher observations and conversations • Tower of the Future Stations Recording Sheet	2 class periods
8	Engagement Activity Introduction to the Performance Task EDP Step 1: Ask EDP Step 2: Imagine	*Students will:* • Identify the problem of the performance task and what they are creating. • Ask and record questions they have about constructing a tall tower. • Individually brainstorm ideas for constructing this tower and drawing and/or writing their ideas in their EDP Journal. • Share their ideas with their engineering team and be able to defend their reasons for their specific prototype.	**Formative:** • Teacher observations and conversations • EDP Journal	1 class period
9	EDP Step 3: Plan	*Students will:* • Work with their engineering team to create a design for their tall tower. • Record their team's prototype with precision in their EDP Journal.	**Formative:** • Teacher observations and conversations • EDP Journal	1 class period

10	EDP Step 4: Create	*Students will work with their team members to:* • Follow their plan and build their prototype. • Agree upon and record any modifications that need to be made to make their prototype work. • Share their prototype tall towers with the whole class.	**Formative:** • Teacher observations and conversations • EDP Journal	2 class periods
11	EDP Step 5: Experiment	*Students will work with their team members to:* • Test the ability of their tall tower to bear the weight of the golf ball and stand upright for 2 minutes. • Log the data into their journals.	**Formative:** • Teacher observations and conversations • EDP Journal	1 class period
12	EDP Step 6: Improve	*Students will work with their team members to:* • Review the results of their data. • Repeat the Engineering Design Process to improve their tall tower. • Conduct a data analysis comparing the first set of results with the second set of data. • Explain the conclusions made based on the data analysis.	**Formative:** • Teacher observations and conversations • EDP Journal	4 class periods
13	Tall Towers in the Real World	*Students will:* • Compare the tallest building in 1950 with the tallest building in 2013. • Know why we build taller buildings. • Apply what they have learned from their investigations to understand what enables us (society) to build taller buildings.	**Formative:** • Teacher observations and conversations	1 class period
14	Summative Assessments	*Students will:* • Identify the steps of the Engineering Design Process. • Describe what they did in this project for each step of the process. • Explain why we engage in the Engineering Design Process.	**Summative:** • EDP Assessment • EDP Reflections	1 class period

Unit Title: Tower of the Future Lesson Title: Scientific Inquiry Investigation Date Developed/Last Revised: 07.15.13 Unit Author(s): L. Higashi, L. Lum, R. Saito, K. Umeda	Lesson #: 1-6 Grade Level: 2 Primary Content Area: Science Time Frame: Six 60-minutes sessions+

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

Note: The "L" codes at the end of each benchmark refer to the assigned level of the Marzano's Taxonomic Level of Understanding. For example, "L3" refers to Taxonomic Level 3: Analysis.

Science

- SC.2.1.1 Develop predictions based on observations (L3)
- SC.2.1.2 Conduct a simple investigation using a systematic process safely to test a prediction (L1)
- SC.2.8.1 Identify different Earth materials and classify them by their physical properties (L3)

2A. Criteria- What Students Should Know and Be Able to Do:

*Students will **know**:*

- That Earth materials include air, water, soil, sand, and rocks/minerals.
- That natural materials are found naturally occurring all around us and that many natural materials are used to create man-made materials.

*Students will be **able** to:*

- Identify the solid Earth materials: sand, soil and rocks.
- Identify their physical properties (i.e., size, mass, color, texture, and the ability to absorb water).
- Make predictions about an anomalous "mystery" material based on observations.
- Conduct a simple investigation using a systematic process to test a prediction (Mystery Sample Investigation).
- Classify the "mystery" material based on its properties.
- Draw a conclusion based on data collected during the investigation.
- Make applications of what they have learned to the real world. (i.e., Which Earth material would be most appropriate to construct a building and why?)

2B. Assessment Tools/Evidence:

Formative:

- Discussions (conversations) of concepts (Teacher facilitated, using Evidence/Criteria as a guide)
- Observations conducted as participants conduct their inquiry investigations
- Properties of Earth Materials Data Recording Sheet

Summative:

- "Mystery" Material Investigation
- Earth Materials Assessment (See attached assessment document and key of possible answers)

Task Specific Rubric to Assess Science Process Skills for Benchmarks SC.2.1.1 and SC.2.1.2

	1	2	3
Develops predictions based on observations	Student needs assistance in developing a prediction that is based on observations and prior knowledge.	Student's prediction is a statement of what they think will happen but may not be able to provide a rationale for their prediction.	Student's prediction is a statement of what they think will happen based on observations and prior knowledge.
Conducts a simple investigation to test a prediction	Student needs assistance to follow a systematic process in order to test a prediction.	Student follows a systematic process to safely test a prediction.	Student independently uses a systematic process to safely test a prediction.

3. Learning Experiences (Lesson Plan)

SCIENTIFIC INQUIRY INVESTIGATION

Teacher Background Information:

- Earth materials consist of rocks, sand, soil, water, and gases in the Earth's atmosphere.
- Natural materials are the basis for many of the manmade materials we use today.

Lesson Summary:

Students will:

- Engage and explore through a structured inquiry activity, which compares and contrasts the different Earth materials. This will provide students with a common base of experiences to learn the properties of different solid Earth materials.
- Deepen their understanding by having these concepts explained and clarified by their teacher through a series of non-fiction reading and science media.
- Elaborate or extend their understanding of these concepts and processes by engaging in a guided inquiry, which enables them to apply their knowledge about the properties of earth materials to classify a "mystery" material.
- Evaluate their learning based on results of their inquiry investigation. Assessment evidence includes the reasonableness of both their prediction and conclusions made based on their data.
- Extend their understanding of materials and their properties to man-made materials.

Lesson 1: Introductory Activity

Teacher Preparation:

- Post Driving Question Banner: What are Earth materials and how can we classify them by their properties?
- Post or project Earth's Composition diagram http://library.thinkquest.org/09jan-oracle-n-001/02242/page_490783175.html

Procedure:

- Draw student's attention to the Earth's Composition diagram.
    - Ask students to make observations. Record student observations and elicit their wonderings.
    - Introduce that the Earth is a biosphere that includes the hydrosphere, atmosphere, and lithosphere. Together, these 3 spheres are the source of Earth materials. Make connections to where they might see these spheres in the real world.
    - Ask: What Earth material does the hydrosphere provide? What does the atmosphere provide?
    - Ask: What Earth materials make up the lithosphere? Record student responses.
    - Explain that the biosphere is anywhere living organisms exist, (which include the hydrosphere, atmosphere and lithosphere), and that air, water, rocks, soil, sand and/or minerals are what we consider Earth materials.
    - Direct student's attention to the responses recorded earlier. Circle rocks, soil and sand, and explain that because they are most readily available, we will be focusing on these Earth materials in our next investigation.

<u>Lesson 2: Structured Inquiry: Identifying Properties of Earth Materials</u>

Materials for each station:

- 250 ml of soil, sand or rock
- 1 beaker
- 1 sieve
- 1 coffee filter
- 1 measuring cup with 100 ml of water
- 1 balance scale
- 1 set of weights
- 1 tray
- 1 hand lens
- 1 magnet (optional)
- Properties of Earth Materials Data Recording Sheet

Teacher Preparation:

- Post Essential Question: What are solid Earth materials and how are they classified?
- Post targeted benchmarks
- Post the Steps in a Scientific Investigation
- Station Set Up:
    - Each station should have 250 ml of Earth material: 100 ml in a coffee filter that is in placed in a sieve over a beaker; 100 ml placed in a balance scale, and 50 ml placed in a tray to make sensory observations.
    - The measuring cup with the 100 ml of water should be set near the material in the beaker.
    - The weights should be placed next to the balance scale.
    - The tray containing the 50 ml of material should be placed closest to where the

students will be standing to conduct their investigations. The hand lens should be placed adjacent to the tray.

- Group students into teams of 3.

Notes to the Teacher:

- The number of stations should be determined by class size with 3 students per group. How the stations are set up will be based on the prior knowledge of the class. For classes with little prior knowledge, there should be multiple stations investigating just one type of earth material per day. For classes with a better knowledge base you can create stations that have the variety of earth materials to investigate (e.g. Station 1 and 2: Rocks, Station 3 and 4: Sand, Stations 5 and 6: Soil), and have the student groups move from station to station. As students are working at the stations, you should assist the students in building their understanding of conducting simple investigations (SC 2.1.2).
- Students will need prior experiences with measuring liquid volume and mass using a balance scale.

Procedure:

- Engage prior knowledge by asking students:
    - What do we know about _____(soil, sand, rocks)?
    - Where is _____ usually found?
    - Are all _____ the same? How might they be the same/different?
    - What do you wonder about Earth materials?
- Introduce the word "Investigation" and explain that an investigation is a search for an answer to a question, such as some of the wonderings they have about Earth materials (ScienceSaurus, 2005).
- Introduce this activity by stating that today we are going to explore and learn or "Investigate" more about _____(soil, sand, rocks).
- Divide students into groups of three or four and assign each group to a station.
- Pass out Properties of Earth Materials Data Recording Sheet and pencils to each student.
- Explain that at each station, students will:
    - Observe and record the material's color and size.
    - Touch it to determine its texture.
    - Measure its mass using a scale.
    - Measure its capacity to hold water using the following procedure:
        - Place the Earth material (along with the coffee filter) on a sieve.
        - Place the sieve over a beaker.
        - Slowly pour 100 ml of water over the Earth material and allow time for the water to drain through.
        - Measure the water captured in the beaker and subtract this amount from the total amount of water poured into the Earth material.
            - The difference represents the amount of water absorbed.
    - Record each of their data points on their worksheet.

- At the end of each day's investigation:
  - Have teams share their data with the whole class.
  - Discuss any discrepancies in their data and reach consensus to create a class data chart comparing and contrasting each of the earth materials. An example of a chart is as follows:

	Soil	Sand	Rocks
Color			
Size			
Texture			
Mass			
Absorbency			

- At the beginning of lab activities for Day 2 and 3, have students make observations of the new material and initial comparisons with the previous days' material. Introduce the word "prediction" as an idea about what will happen next in an investigation. Have students make predictions about the new material (i.e., Will it heavier/lighter? What about texture? Will it absorb more/less water?)
- Culminate this investigation by having students:
  - Compare and contrast data for the different Earth materials.
  - Identify primary properties for each Earth material.

Lesson 3: Research of Background Information

Materials:

- Computers with Internet access
- Chart paper
- Note paper for students to record their information

Teacher Preparation:

Have the following sites open on the computers for easy access by the students:

- Discovery Education video
  - In the search box, type in soil
    - > "Rocks: The Solid Earth Materials" full video. View the first 7 minutes, 30 seconds
    - > "Sid the Science Kid: The Dirt on Dirt" full video. View first 5 minutes
    - > eBooks in Media Type > Read pull down window
      - "What is Soil Made of?", "What is Soil?" and/or "What is in That Soil, Anyway?"
  - In the search box, type in sand > on eBooks in the media pull down window > "What is Sand?"
- BBC Bitesize: Rocks and Soils: http://www.bbc.co.uk/bitesize/ks2/science/materials/rocks_soils/read/1/

- BBC Science Clips: Rocks and Soils: http://www.bbc.co.uk/schools/scienceclips/ages/7_8/rocks_soils.shtml
- The Dirt on Soil-Learning Adventures: http://school.discoveryeducation.com/schooladventures/soil/
- Dig Deeper: http://www.soils4kids.org/about
- "What is Soil?" http://library.thinkquest.org/J003195F/definiti.htm
- "What is Soil?" http://soils.usda.gov/education/facts/soil.html
- "Soiled Again: What is Soil?" http://urbanext.illinois.edu/gpe/case2/c2m1.html
- "Where Does Hawaii Beach Sand Come From?" http://www.soest.hawaii.edu/coasts/presentations/BeachSand.pdf

Procedure:
Note: Consider having the student teams jigsaw and share their research for purposes of time.

- Create a KWL chart with the students.
    - Review what was learned from the structured inquiry and record that information in the "Know" section of the chart.
    - Ask students what we would like to know now and record that in the "What" section.
    - Introduce the various resources and have students conduct their research.
    - Discuss what was learned from the research and record it in the "Learned" section of the chart.
    - Make connections between what was learned from their investigation and what was learned from their research.
- Introduce that the lab activities they engaged in are also called "investigations" and that part of conducting an investigation is to research background information.

Lesson 4: Guided Inquiry: Mystery Materials Investigation
Materials:
- "Mystery" Earth Material (Possible mystery materials include black or green sand, sand from the east side of the Big Island, and soil from the slopes of Mauna Kea.)
- "Mystery" Material Data Recording Sheet

Teacher Preparation:
- Set up 5 exploration stations (similar to the Structured Inquiry)

Procedure:
- Have students on the floor sitting with their teammates.
- Pass out student worksheets and pencils.
- Discuss and record any wonderings they have now about Earth materials.
- Introduce the "mystery" material.
    - Ask students to make initial observations.
    - Review that part of the investigative process is making predictions.
    - Have students develop a prediction they have about the "mystery" material and record

it on their student worksheet.
- Have teams test the "mystery" sample at their exploration station.
- Have teams share their findings with the class.
    - Discuss any discrepancies in their data and reach consensus as to what the material might be.
- Reveal the identity the "mystery" material.
    - Discuss whether their predictions were validated.
    - Ask what conclusions can be made from this phase of the investigation.

Conclusion
- Ask students what they learned from this investigation.
- Address any wonderings they might still have.
- Explain that the properties of Earth materials determine how they are used.
    - Have students make connections between the Earth materials they have learned and how they are used in the real world.
    - Utilize the following Fossweb interactive to reinforce this concept: http://www.fossweb.com/modulesK-2/PebblesSandandSilt/index.html

Lesson 5: Connecting Earth Materials to Man-Made Materials

Consider the following sources to enhance teacher understanding:
- eHow.com: Differences Between Natural and Manmade Materials: http://www.ehow.com/info_8667607_differences-between-natural-manmade-materials.html
- http://www.kids-science-experiments.com/facts-materials.html

Materials:
- "Earth and Man-Made Materials" PowerPoint
- Computer
- LCD Projector

Procedure:
- Have students view the attached PowerPoint titled, "Earth and Man-Made Materials", which will guide the discussion in preparing students to engage in their engineering project using manmade materials.
- Formatively assess students by having them go on a scavenger hunt and find an object they think is made from a man-made material or man-made (engineered) from an earth or natural material. Have students their objects and explain their reasoning for selecting them.
- Inform students that they will be using man-made materials to build a "Tower of the Future".

Lesson 6: Summative Assessment
- Have students complete the Earth Materials Assessment.

TEACHING & ASSESSMENT (Steps 4, 5, 6, &7)
Completed by teacher after instruction has taken place

4. Teaching and Collecting of Evidence of Student Learning: Teacher Notes:
5. Analysis of Student Products/Performances - Formative: Teacher Notes:
6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson): Teacher Notes:
7. Teacher Reflection: Replanning, Reteaching, Next Steps: Teacher Notes:

Unit Title: Tower of the Future Lesson Title: Engineering Design Process Date Developed/Last Revised: 07.15.13 Unit Author(s): L. Higashi, L. Lum, R. Saito, K. Umeda	Lesson #: 7-14 Grade Level: 2 Primary Content Area: Engineering Time Frame: Eight 60-minute sessions +

PLANNING (Steps 1, 2, & 3)

1. Standards/Benchmarks and Process Skills Assessed in this Lesson:

Note: The "L" codes at the end of each benchmark refer to the assigned level of the Marzano's Taxonomic Level of Understanding. For example, "L3" refers to Taxonomic Level 3: Analysis.

- CTE Standard 1: TECHNOLOGICAL DESIGN: Design, modify, and apply technology to effectively and efficiently solve problems
- SC.2.2.1 Describe changes that have occurred in society as a result of new technologies (L2)

2A. Criteria- What Students Should Know and Be Able to Do:

*Students will **know**:*

- The Engineering Design Process as a systematic process used to design and redesign tools/products.

*Students will be **able** to:*

- Apply their understanding of Earth material properties to understand properties of manmade materials.
- Design a "Tower of the Future" using the Engineering Design Process.

2B. Assessment Tools/Evidence:

Formative:

- Discussions (conversations) of concepts (Teacher facilitated, using Evidence/Criteria as a guide)
- Observations conducted as participants design their tower of the future
- EDP Journal (see attached rubric)

Summative:

- Engineering Design Process Assessment
- Engineering Design Process Reflections

3. Learning Experiences (Lesson Plan)

Handouts/Other Resources:

- Discovery Learning Stations Instructions
- Station Cards
- Tower of the Future Stations Recording Sheet
- Tower of the Future EDP Journal
- EDP Assessment
- EDP Rubric
- Teacher Observation Sheet

Teacher Background Information:
Read article: *How Buildings Work: The Simple Science of Structures*
http://www.explainthatstuff.com/howbuildingswork.html

- Know that objects have a center of gravity (a place where an objects' mass seems to be concentrated).
- The center of gravity of an object needs to be above the support base in order for it to be balanced and stable.
- The center of gravity of objects can shift.
- The taller the building, the greater the mass above the foundation (support base). Hence the need for a strong and wide foundation.
- Load-bearing pillars are needed to support the weight of floors and walls inside of the building.
- Different shapes affect the distribution of weight and space.

Lesson 7: Building Student Understanding Through Discovery Learning
Materials

- See Discovery Learning Stations Instructions

Procedure

- Establish learning stations to provide students the opportunity to explore the some of the content understandings identified above. Discovery Learning Stations Instructions, Station Cards, and Tower of the Future Stations Recording Sheets are attached. As with the previous inquiry investigation stations, how the students will engage in the stations will depend on the size and prior knowledge of your class.

Lessons 8-12: ENGINEERING DESIGN PROCESS
Teacher Understandings Before Implementing the Process
We have just studied the properties of Earth materials. We use Earth materials for everything we do in life. We use soil to grow our food. We mine minerals to get metals to build man-made bridges, structures, etc. We grow plants and raise animals to get food, wool, wood, paper, cotton and leather. People use the natural resources around them to help them to survive and make life easier. We have also learned how to combine these different natural materials to create stronger, flexible, and more durable man-made materials, which we use to make the things we need in our lives. We will be using manmade materials to build "Towers of the Future".

In this unit, students will be engineering a model of a tall tower using man-made materials. As a prerequisite to building this tower, it would be beneficial for students to know a little about structure and how buildings work.

Materials

- 1 golf ball for each student engineering team, which has been marked with a line at the bottom indicating the 20% of the ball that can go below the top of the structure.
- 1 set of 50 straws, 50 pipe cleaners, and 25 paper clips for each engineering team.

Lesson 8: Engagement Activity: Introduction to the Performance Task, EDP Step 1: Ask, EDP Step 2: Imagine

Preparation

- Establish a testing station adjacent to a wall. Attach a tape rule to the wall, which will ensure consistent measurement of each team's tower.
- Pass out Tower of the Future EDP Journals to each student.
- Explain that the class will go through each step of the process together. Stop after each step to discuss what the students did and the criteria needed. Teacher may refer to "Engineering Design Process Rubric" to help guide discussions. Do the amount of steps you feel your students can handle in the time allotted. It may take 1 day or many days to go through and understand these steps. Don't worry… it's the process that's important.
- Show sub-standard examples of the Tower of the Future.
- Just as they would in the real world, assign students to work in teams.
- Note and clarify with students that although they are part of a team, each student is responsible for completing each part of their own Engineering Design Process Journal. The team is there to help brainstorm, share ideas, and create 1 product, but each student must participate and contribute their individual ideas to help the group.

Engagement Activity

- Show students a pencil. Ask students…
    - What is an engineer? (A person who solves problems by creating technological tools/products by applying their scientific knowledge.)
    - How is this pencil an example of engineering?
- Show students a mechanical pencil. Ask students…
    - How did an engineer come up with this new design?
    - What process did the engineer go through to redesign this pencil?
- Guide the discussion to show that their natural way of thinking of how to do things is similar to the Engineering Design Process that they will be experiencing.

Performance Task

Read the following task to students…

Hawaii is a place where land is getting scarce and the population of people keeps growing. Notice the amount of buildings and houses that you see around your community. My goodness! We're running out of space! Where will people live in the future? Well, since we don't have enough room to build wide houses, the other way is up! You are the engineer hired to design a tall, tall tower that could house many people. Your task is to build a tall structure that won't break and can hold a golf ball at the top of the building for 2 minutes. Happy building! The future people are counting on you!

Steps of the Process

EDP Step 1: Ask

- Have students identify:
  - The problem of the performance task.
  - What they are creating.
  - The criteria and constraints for making this tower.
- Show students the materials that are available for them to use. Allow students to handle the materials to identify their properties. Consider keeping all of the materials on a "materials table" for easy access.
- Have students:
  - Write further questions they may have about constructing this Tower of the Future.
  - Share questions with class for teacher to answer.
- Stop and go over the criteria for the "Ask" section of the process. Take notes on the Teacher Observation Sheet to monitor student learning.

EDP Step 2: Imagine

- Instruct students to independently brainstorm ideas for building a Tower of the Future and draw or write out ideas in their journal.
- Encourage students to discuss their ideas with the rest of the engineering team. Students must be able to defend their reasons for using specific ideas from their prototype. (Ex. We need a strong base so we should double the strength at the bottom of the structure).
- Tell students that each engineering team may then decide on ONE person's design to use or create ONE new hybrid idea incorporating all the differing ideas.
- Stop and go over the criteria for the "Imagine" section of the process. Take notes on the Teacher Observation Sheet to monitor student learning.

Lesson 9: EDP Step 3: Plan

Designate one person to sketch a diagram of the team's Tower of the Future prototype onto a piece of paper. This sketch should include labels for each of the parts and possible measurements. The sketcher must be sure to incorporate all the agreed upon ideas into the design. Students then list all possible materials that will be needed to create the prototype.

- Inform students that when all team members are satisfied with the prototype design, each member should copy this diagram of the Tower onto their journals.
- Instruct team members to check with each other to see if all drawings and labels are completed and everyone has the same plan to follow.
- Stop and go over the criteria for the "Plan" section of the process. Take notes on the Teacher Observation Sheet to monitor student learning.

Lesson 10: EDP Step 4: Create

- Instruct students to follow their team plan as closely as possible when building their prototype. If they are modifying their original prototype to make your prototype work, guide students to be sure each person writes down and adds that information to their journal diagram plans as well.

- Ask teams to share your prototype Tower of the Future to the large group, stating what modifications were made to the plan and why.
- Stop and go over the criteria for the "Create" section of the process. Take notes on the Teacher Observation Sheet to monitor student learning.

Lesson 11: EDP Step 5: Experiment Test it out!

- Bring the tower to the testing station.
- A golf ball will be placed on top of their structure and timed for 2 minutes. Remind students to record their data, which will include the measuring of the height of the tower in inches from the bottom of the golf ball to the floor.
- Have teams share out their data and the reasons for their results to the class. Chart the heights for each tower and if each tower was strong enough to hold the golf ball for 2 minutes onto a class chart. Each team's data will then be available for students to observe and learn from.
- Stop and go over the criteria for the "Experiment" section of the process. Take notes on the Teacher Observation Sheet to monitor student learning.

Lesson 12: EDP Step 6: Improve

- Have the teams review the results of their data. Why was their tower able/not able to hold the golf ball? (Teacher can guide discussion of the importance of having a strong, wide base and structural beam placement to hold the weight of the golf ball.)
- Repeat the EDP to optimize the product. Students would continue to record the following in their journal….
- Ask: What worked? What didn't work? Why?
- Imagine: Which variables could be changed to make the tower even taller and stable enough to hold the golf ball for 2 minutes.
- Plan: The diagram of the team's 2nd prototype, with parts and measurements labeled.
- Create: Building the second prototype following the team's design.
- Experiment: Their data results from testing their 2nd prototype.
- Write 3 facts comparing the data tables from prototypes 1 and 2.
- Analyze the data and explain your results.

Note: You may go through this EDP cycle many times to get an optimized product that is wanted. It all depends on the amount of time you have available.

<u>Summary and Conclusions</u>

- Have each team share their results of how they changed and improved their Tower, and the reasons for these changes. They may also include what they learned about earth materials and structure.

Lesson 13: Tall Towers in the Real World

<u>Materials</u>

- Images of tall buildings (shown below)
- Computer and LCD Projector if showing images digitally

Procedure

- Show students the following picture:

- Say: This is the Empire State Building. It 1,250 feet in height and has 102 floors. It was the tallest building in 1950.
- Now show the students this picture:

- This is the Burj Khalifa in Dubai. It is 2,722 feet and has 163 floors. It is the tallest building in 2013.
- Consider the following questions to guide your discussion:
    - What do you think has happened to tall buildings over the past 50 years? (They have gotten taller!)
    - Why are we building taller buildings? (More people can live on a finite area of land such as a city).
        - If necessary, use Lego bricks to demonstrate, with a single brick representing a house where 2 people live, and a stack of 3 bricks representing a tower where 6 people live. Compare how many people can live on a 8½ x 5½ inch piece of paper with "houses" situated on it vs. "towers".
    - Based on everything you have learned, what has enabled us to build taller buildings? (Man-made materials created by technology enable us to create stronger materials and taller buildings. Understanding the technology that makes buildings stable enables us to building taller structures.)
    - How have taller buildings changed the way we live? (We live closer together, cities are more crowded.)

Image Sources:

- http://commons.wikimedia.org/wiki/File:Empire_State_Building_ags.JPG
- http://www.flickr.com/photos/nlann/4266235290/
    - http://creativecommons.org/licenses/by-sa/2.0/deed.en

Lesson 14: Summative Assessments

- Have students complete:
    - EDP Assessment
    - EDP Reflections

TEACHING & ASSESSMENT (Steps 4, 5, 6, &7)
Completed by teacher after instruction has taken place

4. Teaching and Collecting of Evidence of Student Learning:
Teacher Notes:

5. Analysis of Student Products/Performances - Formative:
Teacher Notes:

6. Evaluation of Student Products/Performances – Summative (Not necessary for every lesson):
Teacher Notes:

7. Teacher Reflection: Replanning, Reteaching, Next Steps:
Teacher Notes:

Name: _____ Date: _____

Properties of Earth Materials

Data Recording Sheet

	ROCK Data
1.	Observe and record its: • Color: _____ • Size: _____ Draw what it looks like here:
2.	Feel it to describe its texture (i.e., Is it hard, soft, rough, smooth…): _____ _____ _____
3.	Measure its mass using a balance scale: 100 ml of rock = _____ grams
4.	Pour 200 ml of water over the sample in the sieve: 200 ml of water - _____ml of water (in the beaker) = _____ml of water absorbed

	SAND Data
1.	Observe and record its: • Color: _____ • Size: _____ Draw what it looks like here:
2.	Feel it to describe its texture (i.e., Is it hard, soft, rough, smooth…): _____ _____ _____
3.	Measure its mass using a balance scale: 100 ml of sand = _____ grams
4.	Pour 200 ml of water over the sample in the sieve: 200 ml of water - _____ml of water (in the beaker) = _____ml of water absorbed

	SOIL Data
1.	Observe and record its: • Color: _____ • Size: _____ Draw what it looks like here:
2.	Feel it to describe its texture (i.e., Is it hard, soft, rough, smooth…): _____ _____ _____
3.	Measure its mass using a balance scale: 100 ml of soil = _____ grams
4.	Pour 200 ml of water over the sample in the sieve: 200 ml of water - _____ml of water (in the beaker) = _____ml of water absorbed

Compare and contrast the data from the 3 different materials:

What are your observations? _____

_____

_____

_____

_____

_____

_____

What do you wonder? _____

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

"MYSTERY" MATERIAL DATA RECORDING SHEET

1. What wonderings do you now have about Earth materials?

_____
_____
_____

2. What are your first observations of the "Mystery" material?

_____
_____
_____

3. What kind of Earth material do you think the "Mystery" material is? Write your prediction here and tell why you think so.

_____
_____
_____
_____

4. Test your "Mystery" material and record your results here.

Observe and record its:

- Color: _____
- Size: _____

Draw what it looks like here:

Feel it to describe its texture (i.e., Is it hard, soft, rough, smooth…):

_____

_____

_____

Measure its mass using a balance scale:

100 ml of rock = _____ grams

Pour 200 ml of water over the sample in the sieve:

200 ml of water - _____ml of water (in the beaker) = _____ml of water absorbed

5. Discuss the data with your teammates. What kind of Earth material do you think the "Mystery"

Material is? Write your answer here: _____

What were the properties of this "Mystery" material that led you to this conclusion?

_____

_____

_____

_____

_____

6. The "Mystery" material is: _____

Was your prediction correct? Circle: Yes No

Earth and Man-Made Materials

What are Earth Materials?

- Air
- Water
- Soil
- Sand
- Rocks

Soil

Sand

Rocks

Some **Properties** of Solid Earth Materials

- **Soil**: Absorbs water
- **Sand**: Composed of small tiny grains that are hard to the touch
- **Rocks**: Heavy and hard

What are Properties?

- Hard or Soft
- Stiff or Flexible
- Rough or Smooth
- Transparent or Not Transparent
- Strong or Weak

Why is it Important to Know Their Properties?

- Properties of Earth materials determine how they are used.
- Example:

Why do we use soil rather than sand or rocks to grow plants in?

Natural Materials

- Materials that come from the Earth such as **oil** and **metals**.
- Natural materials also come from living things such as:
  - **Cotton**
  - **Trees**
  - **Rubber**

Man-Made Materials

- Natural materials (including Earth materials) can be changed to create many of the man-made materials we use today.
- Example:

Other Examples of Man-Made Materials Made From Natural Materials

More About Man-Made Materials

Gypsum

Drywall

Why We Create Man-Made Materials

- Durable
- Require less care and maintenance
- Cost-effective

Engineering Using Earth Materials

Flint

Arrowheads

Engineering Using Man-Made Materials

It is flexible because it can be molded easily. It is also lightweight, durable and can resist tear and wear. It is also cheap or affordable. This is why most factories use plastics because they find it affordable.

Image Sources

- Slide 1: http://commons.wikimedia.org/wiki/File:Sand_from_Gobi_Desert.jpg
- *Slide 5: http://www.flickr.com/photos/spursfan_ace/569104124/*
- *Slide 7: http://www.flickr.com/photos/stevendepolo/4625442625/*
- Slide 8:
  - http://commons.wikimedia.org/wiki/File:Iron_disulfide_pyrite.jpg
  - https://commons.wikimedia.org/wiki/File:C4_on_Steel_Rims_-_Flickr_-_Alan_D.jpg
  - http://commons.wikimedia.org/wiki/File:Bright_green_tree_-_Waikato.jpg
  - http://commons.wikimedia.org/wiki/File:LiveScribe_Dot_Paper_-_Mar_2013_03.jpg
- *Slide 9:*
  - *http://commons.wikimedia.org/wiki/File:2008_competition_sandcastle.jpg*
  - *http://www.geograph.org.uk/reuse.php?id=2051402*
- *Slide 10:*
  - *http://www.flickr.com/photos/jsjgeology/8512500151/*
  - *http://creativecommons.org/licenses/by/2.0/deed.en*
- *Slide 12:*
  - http://commons.wikimedia.org/wiki/File:Feuerstein_%28Flint%29_aus_Polen.JPG
  - http://commons.wikimedia.org/wiki/File:Alfl_arrowheads_from_flint_20060717161306.jpg

http://creativecommons.org/licenses/by-nc-sa/2.0/deed.en

Name: _____ Date: _____

EARTH MATERIALS ASSESSMENT

1. Identify the following Earth materials. List at least one property for each Earth material.

	Name of the material: _____ Properties of the material: • _____ • _____ • _____
	Name of the material: _____ Properties of the material: • _____ • _____ • _____
	Name of the material: _____ Properties of the material: • _____ • _____ • _____

2. Why is it important to know the properties of materials?

_____

_____

_____

EARTH MATERIALS ASSESSMENT

Answer Key (Note: Other responses may be acceptable)

1. Identify the following Earth materials and at least one property of each of the materials has.

	Name of the material: _____Sand_____ Properties of the material: • yellow • small and hard • absorbs some water
	Name of the material: _____Soil_____ Properties of the material: • dark brown • soft • absorbs water
	Name of the material: _____Rocks_____ Properties of the material: • gray • hard • absorbs little or no water

2. Why is it important to know the properties of materials?

   The properties of a material determine how it will be used.

Image Sources:

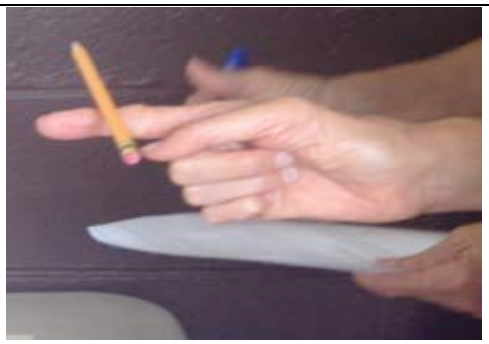
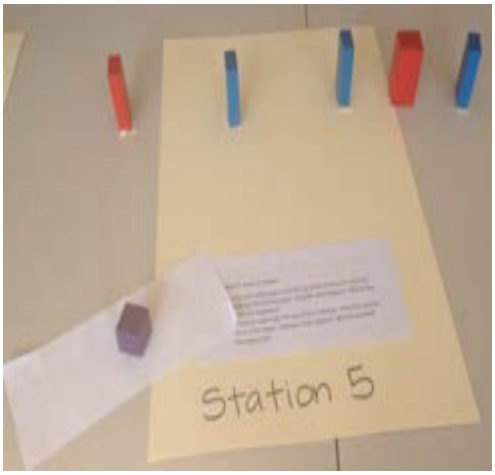
- http://commons.wikimedia.org/wiki/File:HK_Cheung_Chau_Tung_Wan_Beach_Sand_2.JPG
- https://commons.wikimedia.org/wiki/File:Soil.jpg
- http://www.flickr.com/photos/horiavarlan/4800680317/
  - http://creativecommons.org/licenses/by/2.0/deed.e

Elementary Inquiry Rubric

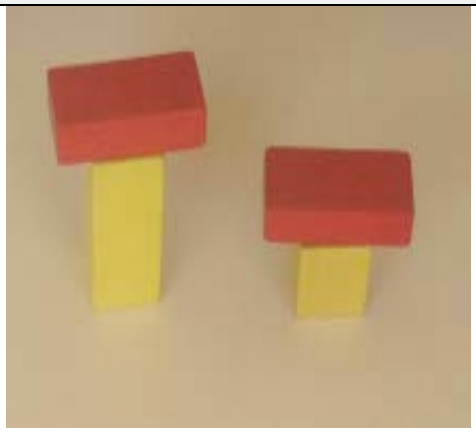
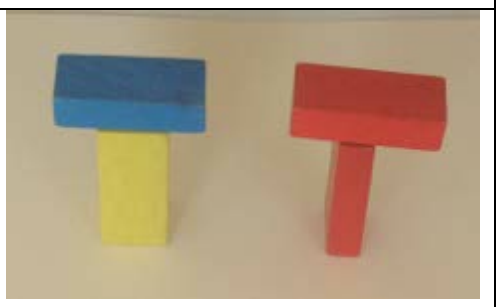
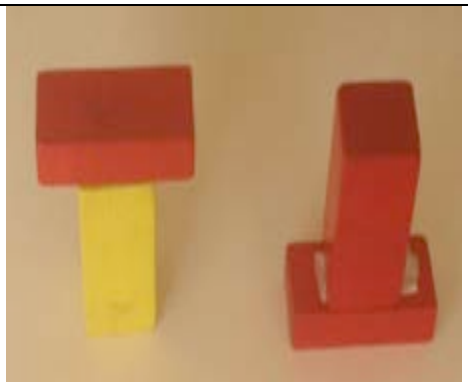
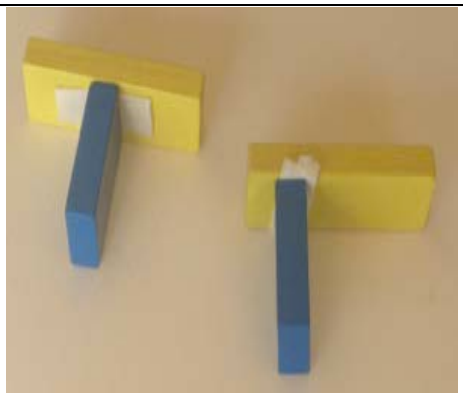
Component	4-More than Adequate Progress (Exceeding the Standards)	3-Adequate Progress (Meeting the Standards)	2-Limited Progress (Approaching the Standards)	1-No Progress (Well Below the Standards)
Research Question	• Question to be answered during the investigation is clearly identified, stated in proper form, & focuses on relevant benchmark(s). It is a meaningful question that drives investigation to help students understand deeply the appropriate benchmark(s). Question is based on initial explorations & observations.	• Question to be answered during the investigation is identified & stated in proper form. Question is based on initial explorations & observations.	• Question to be answered during the investigation is partially identified & stated in somewhat unclear manner.	• Question to be answered during the investigation is irrelevant.
Background Information	• Many relevant & significant background sources used & documented correctly. • Information written in student's own words & shows detail & specific connections to the investigation.	• Several relevant & significant background sources used & documented correctly. • Information written in student's own words.	• Few background sources were used & documented somewhat incorrectly. • Some information is written in student's own words.	• Little or no background sources used. • Information is directly copied from source(s).
Hypothesis	• Hypothesis is clearly stated & testable using the form "If ___, then ___ because _____." It is based on observations & prior research.	• Hypothesis stated in a testable form "If ___, then ___because ___. Hypothesis based on general knowledge & observations.	• Hypothesis is unclear & poorly stated. Hypothesis is loosely connected to observations or general knowledge.	• Hypothesis is missing.
Experimental Design (Materials)	• All materials used in the investigation are reasonable and obtainable. • Materials are correctly listed & accurately described.	• Most materials used in the investigation are reasonable & obtainable. • Most materials are listed & described.	• Some of the materials used in the investigation are reasonable & obtainable. • Some of the materials are listed.	• One or more important materials may not be obtainable. • Materials are listed inaccurately.
Experimental Design (Method)	• Experimental design is well constructed to test the hypothesis. A control is included where appropriate. • The procedure is clear & easy to follow. Anyone should be able to follow the design so that the investigation can be repeated, if needed. The design includes meaningful data sheets. • The investigation is controlled to test one variable.	• Experimental design is adequate to test the stated hypothesis but might need some clarifications. • The procedures are generally complete & in sequence; however, minor modifications are needed. • Attempts to control variables are made but need modifications.	• Experimental design is relevant to the hypothesis, but is not a complete investigation. • The procedures are incomplete & major modifications are needed. • Little attempt to control variables.	• Experimental design is not relevant to the hypothesis. • The procedures are incomplete • There is no control of variables.

Component	4-More than Adequate Progress (Exceeding the Standards)	3-Adequate Progress (Meeting the Standards)	2-Limited Progress (Approaching the Standards)	1-No Progress (Well Below the Standards)
Data	• Data are well organized & neatly presented. • Graphs & tables are labeled, summarized & titled correctly. Graphs & tables accurately & meaningfully present the data.	• Data are organized & presented in an appropriate manner. Minor errors are present. • Graphs & tables are labeled, summarized & titled.	• Data are poorly organized & the presentation is inappropriate. Major errors are present. • Graphs or tables are not labeled, titled, or summarized correctly or may be missing.	• Data are not organized or & the presentation is inappropriate or data are not shown. • Graphs &/or tables are poorly done or missing.
Data Analysis	• Highlights of the data are well summarized, capturing the significant details to provide the evidence needed to answer the research question. • Important relationships, patterns, & changes observed throughout the investigation are included in the summary to make deep & meaningful connections of understandings.	• Most of the obvious highlights are summarized with clarity & some detail. • Some comparisons & relationships are made to show connections of understanding.	• Some obvious highlights are summarized but may include misconceptions. • Connections are not always logical. Some patterns & relationships are not based on the data collected.	• Highlights of the data collected may not be included. • There is no connection between the summarized data & the actual data collected.
Discussion / Conclusion	• Conclusion includes a reasoned decision about the hypothesis & is fully supported by data. Conclusion also includes possible sources of error, what was learned in the investigation & implications/next steps of investigation.	• Conclusion includes a decision about the hypothesis & is supported by data. Conclusion also includes what was learned in the investigation.	• Conclusion includes a decision about the hypothesis but is not supported by data.	• Conclusion is not related to the hypothesis & data support is lacking or missing or no conclusion was included in the investigation.

Discovery Learning Stations Instructions: Page 1

Station	Materials	Instructions	Example
1 Find the Center of Gravity	• Balancing Bird *Note: The balancing bird can be purchased from Flinn Scientific. Item number is AP9301. Cost is just $5.00. Flinn has what is called the "Pallette Program" and shipping for orders over $100 is FREE!*	• Place bird on your finger and find the balancing point. Mark the center point with a dot on your bird picture.	
2 Find the Center of Gravity	• 1 rectangular wooden block	• Place the block on your finger. Find the balancing point. Mark the center point with a dot on your block picture.	
3 Find the Center of Gravity	• 1 pencil	• Place the pencil on your finger. Find the balancing point. Mark the center point with a dot on your pencil picture.	
4 Bases of Support	• 5 rectangular wooden blocks • 1 square wooden block • 1 8½ x 2" piece of paper with an "X" drawn in the middle	• Place the white paper over the top of the 2 columns. Place the cube on the X of the paper. Describe what happens. Why do you think this happened? • Place the paper over the top of the 3 columns. Place the cube on the X of the paper. Describe what happens? Why do you think this happened?	

Discovery Learning Stations Instructions: Page 2

Station	Materials	Instructions	Example
5 Short or Tall	• 4 rectangular wooden blocks, 3 of the same size and 1 that is shorter • Masking tape	• Gently shake the board beneath the structures. Which stays standing longer? Mark the building that is still standing. • Replace the structures the way you first found them for the next group to use.	
6 Wide or Narrow	• 4 rectangular wooden blocks of equal size • Masking tape	• Gently shake the board beneath the structures. Which stays standing longer? • Replace the structures the way you first found them for the next group to use.	
7 Top Heavy or Bottom Heavy	• 4 rectangular wooden blocks • Masking tape	• Gently shake the board beneath the structures. Which stays standing the longer? • Replace the structures the way you first found them for the next group to use.	
8 Over the Center of Gravity and Not Over the Center of Gravity	• 4 rectangular wooden blocks • Masking tape	• Stand each structure so the blue block is on the ground. Which structure is more stable?	

Station Cards

Station 1:

Place bird on your finger and find the balancing point. Mark the center point with a dot on your bird picture.

Station 2:

Place the block on your finger. Find the balancing point. Mark the center point with a dot on your block picture.

Station 3:

Place the pencil on your finger. Find the balancing point. Mark the center point with a dot on your pencil picture.

Station 4:

- Place the white paper over the top of the 2 columns. Place the cube on the X of the paper. Describe what happens. Why do you think this happened?
- Place the paper over the top of the 3 columns. Place the cube on the X of the paper. Describe what happens. Why do you think this happened?

Station 5:

- Gently shake the board beneath the structures. Which stays standing longer? Mark the building that is still standing.
- Replace the structures the way you first found them for the next group to use.

Station 6:

- Gently shake the board beneath the structures. Which stays standing longer?
- Replace the structures the way you first found them for the next group to use.

Station 7:

- Gently shake the board beneath the structures. Which stays standing the longer?
- Replace the structures the way you first found them for the next group to use.

Station 8:

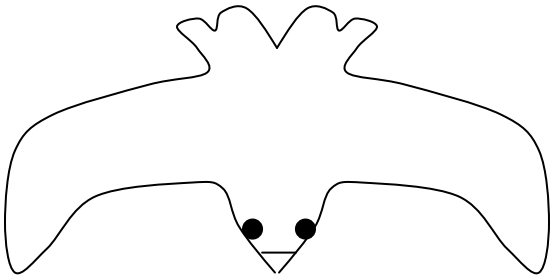
Stand each structure so the blue block is on the ground. Which structure is more stable?

Name: _____ Date: _____

Tower of the Future Stations Recording Sheet

Station 1: Find the center of gravity.

Place bird on your finger and find the balancing point. Mark the center point with a dot on the picture below.



Observations:

_____

_____

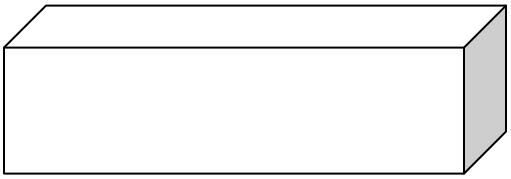
Why do you think this happened?

_____

_____

Station 2: Find the center of gravity.

Place the block on your finger. Find the balancing point. Mark the center point with a dot on the picture below.



Observations:

_____

_____

Why do you think this happened?

_____

_____

Station 3: Find the center of gravity.

Place the side of the pencil on your finger. Find the balancing point. Mark the center point with a dot on the picture below.

Observations:

_____

_____

Why do you think this happened?

_____

_____

Station 4: Bases of support

1. Place the white paper over the top of the 2 columns. Place the cube on the X of the paper. What happens? Why?
2. Place the paper over the top of the 3 columns. Place the cube on the X of the paper. What happens? Why?

Observations:

_____

_____

_____

Why do you think this happened?

_____

_____

Station 5: Short or Tall

Gently shake the board beneath the structures. Which stays standing longer?

☐ Short Building ☐ Tall building

Observations:

_____

_____

Why do you think this happened?

_____

_____

Station 6: Wide or Narrow

Gently shake the board beneath the structures. Which stays standing longer?

☐ Wide Base ☐ Narrow Base

Observations:

_____

_____

Why do you think this happened?

_____

_____

Station 7: Top Heavy or Bottom Heavy

Gently shake the board beneath the structures. Which stays standing longer?

☐ Top Heavy ☐ Bottom Heavy

Observations:

_____

_____

Why do you think this happened?

_____

_____

Station 8: Center of Gravity

Stand each structure so the blue block is on the ground. Which structure is more stable?

☐ center of gravity over the support base

☐ center of gravity **not** over the support base

Name: _____ Date: _____

Tower of the Future Engineering Design Process Journal

Performance Task: Hawaii is a place where land is getting scarce and the population of people keeps growing. Notice the amount of buildings and houses that you see around your community. My goodness! We're running out of space! Where will people live in the future? Well, since we don't have enough room to build wide houses, the other way is up! You are the engineer hired to design a tall, tall tower that could house many people. Your task is to build the tallest structure that you can without having it break. It must be able to support the weight of a golf ball at the top of the tower for 2 minutes. Happy Building! The future people are counting on you!

Criteria/Constraints:

- 50 straws, 50 pipe cleaners, and 25 paper clips will be provided. You may not have more.
- There must be a place for a golf ball to fit and stay at the top of the tower.
- No more than 20% of the ball can be embedded within the top of the tower.
- Height measurements will be taken from the bottom of the golf ball to the floor.
- You can only use what you have to hold your tower together. Tape is not allowed.

What is the problem? _____

_____

What are you being asked to design? _____

_____

STEP 1: ASK: Ask questions that pertain to completing the performance task.

1. _____

_____

2. _____

_____

3. _____

STEP 2: IMAGINE: Use your background knowledge of material properties and structures to design a prototype of your tall building. These are some ideas you should consider when creating your building: base support, balance/support, location of the support beams, weight distribution, and construction materials.

Draw your possible designs and label the parts. Be ready to share and discuss your design and explain the rationale for your design choices. Your design team will be choosing one to develop.

STEP 3: PLAN: Draw the diagram of your team's prototype. Label each part. Also state the type of material used for each part and the possible measurements.

Side View:
Top View:

STEP 4: CREATE: Build your prototype tower following your team's design. Keep to the plan.
What modifications did you need to make in order to be sure that your design would hold together and work?

STEP 5: EXPERIMENT:

Data Table 1

	Height in cm	**Amount of time the tower could hold the golf ball**
Prototype 1		

STEP 6: IMPROVE:
ASK: Looking at your data, answer the following questions:

- What worked? Why? _____
  _____

- What didn't work? Why? _____
  _____

Things to Consider	Did it work?	Why or why not?
Base Support	Yes A little No	
Balance/Stability	Yes A little No	
Weight distribution	Yes A little No	
Location of open space/Support beams	Yes A little No	
Construction materials	Yes A little No	
Other	Yes A little No	

IMAGINE: Which variable(s) will you change in order to make your tower taller and still able to hold the golf ball? What is your rationale for changing each variable?

_____

_____

_____

_____

_____

_____

_____

PLAN: Draw out a diagram of your team's 2nd prototype. Remember to label your parts, state the type of material used for the part, and possible measurements.

Side View:

Top View:

CREATE: Build your 2nd prototype following your team's design. Keep to the plan. Use the materials listed as well as the measurements that your group decided upon.

EXPERIMENT:

Data Table 2

(Copy data from Data Table 1) →

	Height in cm	Amount of time able to hold golf ball
Prototype 1		
Prototype 2		
Differences Between the Prototypes		

Write at least three facts from the data table above.

Fact 1	
Fact 2	
Fact 3	

Data Analysis: Compare the data from Prototype 1 and Prototype 2.

1. Which prototype was more effective? (circle) **Prototype 1** **Prototype 2**

Use your background knowledge of material properties and structures and your data to explain your answer.

_____

_____

_____

_____

_____

IMPROVE: If you had more time and materials, what would you do to optimize your tower even more? Explain your thinking.

Engineering Design Process Rubric

	Advanced (ME)	Proficient (M)	Partially Proficient (DP)	Novice (WB)
ASK	• Clarifies the problem clearly • Forms the conditions and limitations on their own • Obtains information from prior knowledge and other sources with citation by self	• Clarifies the problem • States all the conditions and limitations • Obtains information from prior knowledge by self	• Needs more clarification of the problem • States most conditions and limitations • Obtains information from prior knowledge (drawn out by teacher)	• Problem is unclear • States few (or no) conditions and limitations • Information given by teacher
IMAGINE	• Brainstorms a variety of innovative ideas • Innovative ideas are relevant to the problem	• Brainstorms a complete idea • Idea is relevant to the problem	• Brainstorms an incomplete idea • Idea is somewhat relevant to the problem	• Unable to brainstorm ideas, teacher assistance needed • Brainstormed ideas have little relevance to the problem
PLAN	• Chooses the best possible idea that is testable • Draws a useable and accurate prototype design with more than 2 views to scale • Lists all materials needed that are affordable, obtainable, and safe	• Chooses one idea that is testable • Draws a useable prototype design with multiple views to scale • Lists all materials needed	• Chooses an idea that may be testable • Draws a somewhat useable prototype design with multiple views with inaccurate or incomplete measurements • Most materials needed are listed	• Chooses an idea that is not testable • Draws an unusable prototype design with one or more views • Incomplete or inaccurate lists of materials (assistance needed)
CREATE	• Able to follow their design plan accurately • Able to improve original design to optimize performance	• Able to follow their design plan, with some inaccuracies • Able to add to the original design to make the design work	• Able to follow most of their design plan with multiple inaccuracies • Able to add to the original design, but design may still not work	• Unable to follow their design plan • Sticks to original design although it may not work
EXPERIMENT	• Collects and records detailed data accurately and completely • Analyzes data by comparing patterns and relationships accurately with logic	• Collects and records data accurately and completely • Analyzes data by showing patterns or relationships accurately	• Collects and records data. Some data may be incomplete or inaccurate. • States obvious patterns or relationships	• Data collection inaccurate and incomplete • States obvious patterns or relationships with assistance
IMPROVE	• Reviews data to make logical decisions to optimize product • Repeats process until an optimized product is reached with greatly improved data	• Reviews data to make decisions to redesign product • Repeats process to optimize a product. Data may/may not show improvement.	• Reviews data to make decisions to redesign product with assistance • Repeats process to improve product with some assistance	• Unable to review data to make decisions to redesign product (assistance needed) • Does not repeat process to improve product or repeats process with much assistance

Name: _____ Date: _____

Engineering Design Process Reflections

What did you learn about the Engineering Design Process?

_____

_____

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_____

_____

Which part was easy for you? Why?

_____

_____

_____

_____

_____

_____

Which part was harder for you? Why?

_____

_____

_____

_____

_____

_____

Name: _____ Date: _____

Engineering Design Process Assessment

1. Write the letter (A-F) that matches each of the Engineering Design Process steps.

1. Ask: _____ 2. Imagine: _____ 3. Plan: _____ 4. Create: _____ 5. Experiment: _____ 6. Improve: _____	A. Test out prototype and collect data. B. Brainstorm ideas of possible solutions. C. Identify the problem and get more information about that problem. D. From your possible solutions, chose the best idea and draw a prototype. E. Review data and redesign your product to make it better. F. Follow the plan and make your design.

2. Describe what you did in this project for each step of the Engineering Design Process.

Ask: _____
_____

Imagine: _____
_____

Plan: _____
_____

Create: _____
_____

Experiment: _____
_____

Improve: _____
_____

3. Why do people engage in the Engineering Design Process?

_____
_____
_____