Naturally Organized

Subject Area(s):
Life Science, Measurement, Problem Solving

Associated Unit:

None

Associated Lesson:

None

Activity Title

Naturally Organized

Grade Level: Grade 2 (2-3)

Time Required 45 minutes/10 days + 5 days testing with no direct instruction

Group Size 3-4 students per group

Expendable Cost per Group US $5-10 depending on prototype materials

Summary Students will work in teams to design a tabletop supply organizer inspired by an insect home of their choosing. Their prototype will store the team's classroom supplies (scissors, crayon boxes, pencils, and glue sticks). Measurement constraints will apply to the prototype. Supplies must be easily retrievable and the organizer must be sturdy enough to withstand everyday classroom wear and tear. The prototype will be tested in the classroom for a period of 5 days.

Engineering Connection: Ants and bees are two of nature's most organized insects. Many species of ants and bees live in colonies. Within these colonies there is structure – everything has a purpose and a place. Engineers observe these structures and apply them to their designs. When people use nature to design solutions to problems it is called biomimicry. Engineers in a variety of fields rely on nature to help them solve problems.

Engineering Category = 1 & 3
Choose the category that best describes this activity's amount/depth of engineering content:

1. Relating science and/or math concept(s) to engineering
2. Engineering Analysis or Partial Design
3. Engineering design process

Keywords
biomimicry
insect
nature
arthropods
bee
ant
habitat
perimeter
collaborative learning
cooperative learning

Educational Standards

State STEM Standards

SC.2.L.17.2 Recognize and explain that living things are found all over Earth, but each is only able to live in habitats that meet its basic needs.*

SC.2.N.1.1: Raise questions about the natural world, investigate them in teams through free exploration and systematic observations, and generate appropriate explanations based on those explorations.

SC.3.N.1.3 Keep records as appropriate, such as pictorial, written, or simple charts and graphs, of investigations conducted.

SC.2.N.1.5: Distinguish between empirical observation (what you see, hear, feel, smell, or taste) and ideas or inferences (what you think).

SC.2.N.1.6: Explain how scientists alone or in groups are always investigating new ways to solve problems.

MAFS.2.MD.1.1: Measure the length of an object to the nearest inch, foot, centimeter, or meter by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.

MAFS.2.NBT.2.5: Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction.

MAFS.2.NBT.2.6: Add up to four two-digit numbers using strategies based on place value and properties of operations.

MAFS.2.G.1.1 Recognize and draw shapes having specified attributes, such as a given number of angles or a given number of equal faces. Identify triangles, quadrilaterals, pentagons, hexagons, and cubes.

Cross Curricular Connections:

LAFS.2.SL.1.1: Participate in collaborative conversations with diverse partners about grade 2 topics and texts with peers and adults in small and larger groups.

LAFS.2.SL.2.4: Tell a story or recount an experience with appropriate facts and relevant, descriptive details, speaking audibly in coherent sentences.

LAFS.2.W.3.7: Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations).

ITEEA Standards

Standard 1. Students will develop an understanding of the characteristics and scope of technology.

A. The natural world and human-made world are different.

B. All people use tools and techniques to help them do things.

C. Things that are found in nature differ from things that are human-made in how they are produced and used.

D. Tools, materials, and skills are used to make things and carry out tasks.

Standard 2. Students will develop an understanding of the core concepts of technology.

A. Some systems are found in nature, and some are made by humans.

B. Systems have parts or components that work together to accomplish a goal.

C. Tools are simple objects that help humans complete tasks.

D. Different materials are used in making things.

E. People plan in order to get things done.

Standard 6: Students will develop an understanding of the role of society in the development and use of technology.

A. Products are made to meet individual needs and wants.

Standard 8: Students will develop an understanding of the attributes of design.

A. Everyone can design solutions to a problem.

B. Design is a creative process.

C. The design process is a purposeful method of planning practical solutions to problems.

D. Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design.

Standard 9: Students will develop an understanding of engineering design.

A. The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others.

B. Expressing ideas to others verbally and through sketches and models is an important part of the design process.

Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

A. Asking questions and making observations helps a person to figure out how things work.

B. All products and systems are subject to failure. Many products and systems, however, can be fixed.

Standard 11: Students will develop the abilities to apply the design process.

A. Brainstorm people's needs and wants and pick some problems that can be solved through the design process.

B. Build or construct an object using the design process.

C. Investigate how things are made and how they can be improved.

Standard 13: Students will develop the abilities to assess the impact of products and systems.

A. Collect information about everyday products and systems by asking questions

NGSS Standards

K-2-ETS1-1: Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

K-2-ETS1-2: Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

K-2-ETS1-3: Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.

CCSS Standards

CCSS.ELA-Literacy.W.2.7: Participate in shared research and writing projects (e.g., read a number of books on a single topic to produce a report; record science observations).

CCSS.ELA-Literacy.W.2.8: Recall information from experiences or gather information from provided sources to answer a question.

CCSS.Math.Content.2.MD.A.1: Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.

CCSS.Math.Content.2.NBT.B.5: Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction.

CCSS.Math.Content.2.NBT.B.6: Add up to four two-digit numbers using strategies based on place value and properties of operations.

CCSS.MATH.CONTENT.2.G.A.1 Recognize and draw shapes having specified attributes, such as a given number of angles or a given number of equal faces.1 Identify triangles, quadrilaterals, pentagons, hexagons, and cubes.

Prerequisite Knowledge

Students should know the difference between an arachnid (spider) and an arthropod (insect). Students should understand that in order to survive in its habitat, an animal must have adequate food, water, shelter, and space. Students should be able to identify two-dimensional and three-dimensional shapes.

Learning Objectives

After this lesson (unit), students will:

- understand that biomimicry is when people design solutions to problems based on things they observe in nature
- develop an understanding of the engineering design process
- design and create a functional tabletop supply organizer
- communicate research in a collaborative conversation

Materials List

Each group needs:

- 3-4 glue sticks
- 3-4 pencils
- 3-4 scissors
- 3-4 crayons (in box)
- STEM lab notebook
- Insect Investigation Recording Sheet
- lab safety glasses (optional)

To share with the entire class:

- Wild Ideas: Let Nature Inspire Your Thinking by Elin Kelsey
- Bees Build Beehives by Elizabeth Raum
- Mighty Ants: Exploring an Ant Colony by Wiley Blevins
- Animal Architects: Amazing Animals Who Build Their Homes by Julio Antonio Blasco

- Talking Chips (see 'Troubleshooting')
- Chart Paper
- Chart Markers
- variety of commercial organizers
    - ex. mesh holders, 3-drawer compartment organizer, bathroom supply organizer, cosmetic organizer, plastic storage caddy, etc.
- Geosafari Ant Factory (or other similar product)
    - live harvester ants (order 2.5 weeks in advance from supplier listed on Geosafari Factory booklet)
    - 2 cups of sand
    - Seed or grain (ant food)
- collection of insect books (see Supplemental Book Suggestions)
- cardstock
- cardboard
- felt sheets
- foam sheets
- beading wire
- heavy duty packing tape
- wet glue
- stapler
- hot glue
- rulers

Supplemental Book Suggestions:

- Nature Got There First: Inventions Inspired by Nature by Phil Gates
- A Wasp Builds a Nest: See Inside a Paper Wasp's Nest and Watch It Grow by Kate Scarborough (optional)
- Insect Homes (The World of Insects) by Bobbie Kalman
- Ant Cities by Arthur Dorros
- National Geographic Readers: Animal Architects by Libby Romero

Online Research Sites:

- 12 Nests You Won't Believe Were Made by Insects (free) http://www.bbc.com/earth/story/20160113-12-nests-you-wont-believe-were-made-by-insects
- Wild Kratts Creaturepedia (free) http://pbskids.org/wildkratts/creaturepedia/
- Discovery Education (subscription required) https://app.discoveryeducation.com/
- PebbleGo (subscription required) https://www.pebblego.com/choose
- Enchanted Learning (subscription required) http://members.enchantedlearning.com/subjects/insects/printouts.shtml
- Insect Nest Stock Photos (to inspire further research on safe search engine for kids) https://www.dreamstime.com/photos-images/insect-nest.html
- BrainPop, Jr.: Insects (subscription required) https://jr.brainpop.com/science/animals/insects/

Introduction / Motivation

Read the book Wild Ideas: Let Nature Inspire Your Thinking by Elin Kelsey. Have students think, pair up, and share their thinking to the prompts below with a partner.

Before Reading:

- Have you ever had a problem? How did it make you feel? Were you able to solve it? How did you solve it? Did someone or something give you an idea? (pre-assessment)

During Reading:

- What can we learn by watching animals? What problem do you think they might help us solve?
- Are you more like an orangutan or a gibbon? Do you stop and plan how to solve a problem? Or do you just leap right in?
- What do you do when you get frustrated? Do you give up? Or, keep trying?
- Who do you ask for help when you have a problem?

After Reading:

- Scientists study animals and how they think and feel. Engineers, people who design and build, often use what scientists observe in nature to try and solve human problems. When engineers design solutions to problems based on what is observed in nature it is called biomimicry.
- I want you to think of an animal that you know a lot about - perhaps a dog, cat, or a fish. What do you think you could learn from observing that animal?

Extend the Learning:

- Share the book Nature Got There First: Inventions Inspired by Nature by Phil Gates with students or place it in a center for students to read and respond to. Have students share what surprised them in writing or orally with a partner.

Vocabulary / Definitions

Word	Definition
biomimicry*	the imitation of natural biological designs or processes in engineering or invention
engineer	a person who has scientific training and who designs and builds complicated products, machines, systems, or structures
design	to plan and make decisions about (something that is being built or created) **:** to create the plans, drawings, etc., that show how (something) will be made
prototype	an original or first model of something from which other forms are copied or developed
insect	a small animal that has six legs and a body formed of three parts and that may have wings
consensus	a general agreement about something **:** an idea or opinion that is shared by all the people in a group
objective	based on facts rather than feelings or opinions

Lesson Background & Concepts for Teachers

Biomimicry is the art of copying natural biological designs or processes and applying it in engineering or invention. Students will learn about the art of biomimicry in the context of a nonfiction children's book called, Wild Ideas: Let Nature Inspire Your Thinking by Elin Kelsey. The book exposes children to the behavior and thinking of recognizable animals and explains in kid-friendly language how they use their bodies and things in their environment to solve problems. The book also encourages children to have a growth mindset in regards to solving problems. To further build background knowledge, the book Nature Got There First: Inventions Inspired by Nature by Phil Gates can be shared with students.

The focus of this design challenge is on insects because when teaching habitats, insects are often overlooked. Teachers often favor the studying of mammals, birds, reptiles, and fish - neglecting insects. Insects have existed on Earth for hundreds of millions of years, far longer than mammals. Insects, particularly bees and ants, are some of the most organized creatures in nature; everything has a purpose and a place in their lives. During the research phase of this lesson, students will observe ants form rooms by examining an ant factory. The book Mighty Ants: Exploring an Ant Colony by Wiley Blevins explains why ants form rooms and how they maintain order. To extend on the concept of order and organization, the book Bees Build Beehives by Elizabeth Raum explains how bees build their homes. For students curious about how other animals build their homes,Animal Architects: Amazing Animals Who Build Their Homes by Julio Antonio Blasco is a wonderful resource. It teachers students not only how different animal homes are made, but out of what materials and why. Research is an important component of this lesson as it will help students better understand the goals of the design challenge.

In addition to researching different insects and their habitats, students will analyze commercial tabletop organizers, and work in teams to design, build, test, measure, and evaluate a prototype of a tabletop supply organizer inspired by nature.

Procedure

Activity 1: Guided Research

Before the Activity

Gather Materials: K-W-L-A anchor chart, chart markers, Mighty Ants: Exploring an Ant Colony by Wiley Blevins, class science notebook, Geosafari Ant Factory, 2 cups of sand, ants, water (in pipette), and ant food

With the Students

1. Review what biomimicry is from Day 1 Introduction. Explain to students that today they will think about what ants can teach them about solving problems. Ask students what they already know about ants. Make a list of student responses under the 'K' (know) section of the anchor chart. Next, ask students what questions they have about ants. Record student responses under the 'W' (Wonder) section of the anchor chart.
2. Read aloud Mighty Ants: Exploring an Ant Colony by Wiley Blevins. Pause periodically to reference the K-W-L-A anchor chart and record answers to student questions as they arise.
3. After reading aloud the text, ask students to think, pair up with a partner, and then share what they learned about ants from today's reading. After a sufficient amount of time, have a few pairs share what they, or their partner learned, aloud with the class. Record student responses under the 'L' (Learned) section of the K-W-L-A chart.
4. Draw students' attention to the 'A' (Action) column of the K-W-L-A chart. Pose the question, "Knowing what we know now about ants, what actions do you think we could take? In other words, what can we do with what we learned? What problems could ants help us solve?" Pause to allow students think time, then elicit responses. Record student responses under the 'A' section of the K-W-L-A chart.
5. If organize is not on the K-W-L-A chart yet, share aloud that you think ants might be able to help us organize as they seem to have a place for everything in their colony (i.e. rooms for food, larvae, and the Queen).
6. Tell students that they are going to study the behavior of ants first hand by conducting field research in the classroom. Show students the Geosafari ant factory and the supplies needed to assemble it (sand, water inside pipette, and ant food). Tell students we know that animals need food, water, shelter, and space to survive in their habitat. Gesture toward the supplies and ask students, "If you were an ant, what would you use for _____ (food, water, shelter, space) from this table?" Student responses might be sand for sand for shelter/space, water from the pipette for water, and seeds/grains for food. Assemble the ant factory with the students according to the directions from the Geosafari box. Ask students, "Are we missing anything?" Add the ants after a student suggests doing so. See 'Troubleshooting' for how to structure this process alternatively.
7. Display the Geosafari ant factory in a safe place in the classroom. Allow students to visit the ant factory throughout the day and week, and record observations in a class science notebook.

Activity 2: Guided Research

Before the Activity

Gather Materials: K-W-L-A anchor chart, chart markers,Bees Build Beehives by Elizabeth Raum

With the Students

1. Review what biomimicry is from Day 1 Introduction. Tell students that yesterday they learned about ants and how observing them might help us solve problems. Today students will learn how bees might help them solve problems. Ask students what they already know about bees. Make a list of student responses under the 'K' (know) section of the anchor chart. Next, ask students what questions they have about bees. Record student responses under the 'W' (Wonder) section of the anchor chart.
2. Read aloud Bees Build Beehives by Elizabeth Raum. Pause periodically to reference the K-W-L-A anchor chart and record answers to student questions as they arise.
8. After reading aloud the text, ask students to think, pair up with a partner, and then share what they learned about bees from today's reading. After a sufficient amount of time, have a few pairs share what they, or their partner learned, aloud with the class. Record student responses under the 'L' (Learned) section of the K-W-L-A chart. Ask students, "What is the connection between bees and the ants we learned about last time?" Pause to allow students think time, then elicit responses.
9. Draw students' attention to the 'A' (Action) column of the K-W-L-A chart. Pose the question, "What can we do with what we learned? What problems could bees help us solve?" Pause to allow students think time, then elicit responses. Record student responses under the 'A' section of the K-W-L-A chart. Some students may suggest that they do field research on bees in the classroom, like what was done with the ants. Tell students that it is a wonderful idea, but might be dangerous. Have students think about why it might be dangerous and what limitations there are to having bees in the classroom. Encourage students to do virtual field research instead. There are an abundance of videos on YouTube of bee enthusiasts exploring hives.

Activity 3: Independent Research

Before the Activity

Gather Materials: Bees Build Beehives by Elizabeth Raum, Mighty Ants: Exploring an Ant Colony by Wiley Blevins, Animal Architects: Amazing Animals Who Build Their Homes by Julio Antonio Blasco, a variety of books on insects and their habitats (see Supplemental Book Suggestions), computers with internet access, list of online resources for students to visit, Insect Investigation Recording Sheet

With the Students

1. Review with students: "In the book Wild Ideas, you learned that nature can teach humans a lot about problem solving. When people use nature to design solutions to problems it is called biomimicry. You also learned that ants and bees are two of nature's most organized insects. Everything has a purpose and a place in their colonies, or homes. Today, you will research on your own, or with a partner, other insects and how they live. You will keep notes on what you learn on the Insect Investigation Recording Sheet.
2. Show students the recording sheet and model how to fill it out using information learned from either Bees Build Beehives or Mighty Ants.
3. Pass out recording sheet and spread students around the room to conduct their research using books and online resources. See 'Troubleshooting' for ideas on how to structure this process.
4. After a sufficient amount of time, call the class together, and have students share aloud or with a partner one insect they learned about and what problem they think that insect might help them solve.

Activity 4: Introduce the Design Challenge

Before the Activity

Gather Materials: STEM 'Naturally Organized' lab notebook(class set), pencils, "Nature is Smarter than Us" (https://www.youtube.com/watch?v=4vq8ci4RTUs)

With the Students

1. Gather students in a whole group meeting place. Remind students that they have learned a lot about ants, bees, and other insects this week, and that they have thought really hard about how insects might help people solve problems. Explain that engineers often observe behaviors and structures in nature and apply them to their designs.
2. Show the video, "Nature is Smarter than Us" (see link in 'Before Activity').
3. Introduce the design challenge and define/explain any terms unfamiliar to students, such as prototype, retrievable, and sturdy. The design challenge is listed on the second page of the STEM 'Naturally Organized' lab notebook.

> "You and your team will design a table organizer inspired by an insect home of your choosing. Your prototype will store your team's classroom supplies (scissors, crayon boxes, pencils, and glue sticks). Supplies must be easily retrievable and the organizer must be sturdy enough to withstand everyday classroom wear and tear."

4. Introduce the criteria for the design challenge and define/explain any terms unfamiliar to students, such as consensus, peer review, durability, and functionality. The criteria of the design challenge is listed on the second page of the STEM 'Naturally Organized' lab notebook.

- You will work in teams of 3-4
- You will share your design ideas with your team at a team meeting where you will come to a design consensus
- Your team will share responsibility in creating the prototype and keep notes on the design process
- Your team's prototype will be peer reviewed prior to classroom testing
- Your team's prototype will be tested for durability and functionality in the classroom for a period of 5 school days
- Your team will communicate your results with another team

5. Read students the constraints of the challenge listed under the section titled "Your design must…" on the second page of the STEM 'Naturally Organized' lab notebook. Also read aloud and show students the materials they will be able to use.

Activity 5: Plan and Brainstorm Solutions

Before the Activity

Gather Materials: STEM 'Naturally Organized' lab notebook (class set), pencils, cardstock, cardboard, felt sheets, foam sheets, beading wire, heavy duty packing tape, wet glue, stapler, hot glue, insect books, variety of commercial organizers (ex. mesh holders, 3-drawer compartment organizer, bathroom supply organizer, cosmetic organizer, plastic storage caddy, etc.)

With the Students

1. Gather students in a whole group meeting place. Review the design challenge from the previous activity. Allow students time to ask questions regarding the challenge.
2. Explain to students that in order to create the best tabletop organizer, it is important to know what already exists in stores. Show students several examples of organizers (see 'Before Activity' for suggestions). Place the organizers on tables around the room. Tell students that they will work with the people at their tables and will have 3-5 minutes to examine an organizer using the criteria on page 3 of the STEM lab notebook. After 3-5 minutes, students will rotate to another table and do the same thing. Repeat this process until students have examined at least 2 organizers commercially available.
3. Call students back together. Display page 4 of the STEM 'Naturally Organized' lab notebook. Read aloud the questions on the page and allow time for questions. Tell students that they will complete page 4 independently. After students finish page 4, they need to independently brainstorm at least 2 *different* solutions inspired by the insect of their choosing in response to the design challenge. Students are expected to draw and label their design solutions on page 5 of the STEM lab notebook.
4. After all students have completed page 4 and the independent brainstorm boxes on page 5 of their STEM lab notebooks, tell students that tomorrow they will share their solutions with the people at their table and decide as a group what solution is the best path to take. It is important to end the activity before coming to a group consensus. The reason being, students who were not able to brainstorm more than one solution will now have time after school to discuss their thinking with their families and then come back in the morning with fresh ideas.

Activity 6: Team Consensus

Before the Activity

Gather Materials: STEM 'Naturally Organized' lab notebook (class set), pencils, talking chips (see 'Troubleshooting' for ideas)

With the Students

1. Gather students in a whole group meeting place. Review the steps taken yesterday in the engineering design process (research, plan, brainstorm solutions). Tell students that today they will share their design solutions with the people at their tables and come to a team consensus. A team consensus is when all members of the team agree to an idea. In order to come to a consensus and make sure everyone has time to share, students will have 'talking chips'. *If your students have never used 'Talking Chips'I suggest practicing this structure prior to this lesson with a non-academic topic such as favorite candy or sports team.*
2. Model how 'Talking Chips' work: Each student in the group will get 1 colored talking chip. When someone on the team wants to share an idea, he/she will place the talking chip in the center of the table. Once a student places a chip in the center, he/she has 30 seconds to talk. No one else may speak until the 30 seconds are up. Everyone must share at least one solution they brainstormed. *It may be helpful to display a timer on the Smartboard to manage transitions.*
3. After all group members have shared, call the class's attention, and announce it is now time to come to a team consensus. Have students collect their talking chips from the center of the table, for a new round of sharing will begin. Pass out additional talking chips to each team. Each student will now have 4 talking chips. The teacher will pose the question, "What solution, or combination of solutions, do you like best and why?" When someone on the team wants to share their opinion, he/she will place a talking chip in the center of the table. Once a student places a chip in the center, he/she is the only one allowed to talk. No one else may speak until that student is done. Everyone must share their opinion on the matter at least once. *If students are having a hard time coming to a consensus, help the group see how they could combine ideas*
4. After a sufficient amount of time, call the class's attention, and instruct students to draw and label the design the team agreed upon on page 5 of the STEM lab notebook.. Remind students that everyone on the team should have the SAME design drawn.
5. Once all teams have drawn and labeled their final design solution, tell the students that tomorrow, they will begin to construct their prototypes.

Activity 7: Develop and Build Prototype

Before the Activity

Gather Materials: STEM 'Naturally Organized' lab notebook (class set), pencils, cardstock, cardboard, felt sheets, foam sheets, beading wire, heavy duty packing tape, wet glue, stapler, hot glue, insect books, job tags, "What is engineering: How different disciplines work together to create a vending machine" (https://www.youtube.com/watch?v=3KQm8cHmqIw)

With the Students

*This activity may extend into Day 8

1. Gather students in a whole group meeting place. Review the steps taken yesterday in the engineering design process (research, plan, brainstorm solutions, decide on a solution). Tell students that today they will construct a prototype of their solution. Explain that a prototype is an original or first model of something from which other forms are copied or developed. To develop, or make, the prototype each member of the team will have a specific engineering job.
2. Show the video "What is engineering: How different disciplines work together to create a vending machine" (see link in 'Before Activity'). After the video, discuss as a class how engineers worked together in the context of creating the vending machine.
3. Display page 6 and 7 of the STEM lab notebook. Explain that each person on the design team will have one of the jobs listed on page 6 or 7 and that each job is important. Read aloud the job descriptions for each job and allow time for students to ask questions. Tell students that as part of their job, they will be required to take careful notes. Notes may include diagrams, numbers, pictures, or words. Notes should be legible and understandable to anyone reading them, so try to be as clear as possible.
4. Have students think silently about what job they may want on their engineering design team, then give a thumbs up to indicate they are done thinking.
5. Send students back to their team tables. Have students go around the table sharing what job they would like to do and why. If a team is having a hard time coming to a decision, have them draw slips from a bag or play rock-paper-scissors.
6. Once teams have decided on jobs, pass out name tags with jobs written on them. Name tags will help make it easier for students to remember who is supposed to be doing what. Tell students that everyone can help build parts of the prototype and that everyone is also responsible for fulfilling their individual job description. Only the materials manager may get materials from the supply table for the group.
7. As students are working, circulate around the room and ask students about their designs. Questions may include: Can you tell me about your design? What materials are you using and why? How big do you think this is going to be? You may offer suggestions to students, however, please do not do any of the work for the students. Be looking to see that students are taking notes regarding the process. See 'Troubleshooting' for tips on how to manage this process.

Activity 8: Prototype Peer Review

Before the Activity
Gather Materials: STEM 'Naturally Organized' lab notebook (class set), pencils, cardstock, cardboard, felt sheets, foam sheets, beading wire, heavy duty packing tape, wet glue, stapler, hot glue, insect books,

With the Students

1. Call students to the whole group meeting area. Tell students that yesterday they did a fantastic job working in their engineering design teams to build their prototype. If any team did not finish building their prototype, they will have some time to finish today.
2. Display page 8 of the STEM lab notebook. Tell students that in addition to finishing up their prototypes today, they will also do a Prototype Peer Review. Explain that peer reviews are an important part of the design process. Their purpose is to give the creators feedback that can be in turn used to improve the solution. To conduct a Prototype Peer Review, teams will exchange prototypes and STEM lab notebooks with another team. The peer reviewer will write his/her name on the STEM lab notebook belonging to the prototype. The peer reviewer will be responsible for writing at least one thing he/she liked about the prototype ('glow') and one thing he/she thinks could be improved ('grow').
3. Once a peer has reviewed a prototype, STEM lab notebooks and prototypes will be returned, and teams will have the rest of the time to read the reviews and make any changes to their design.

Activity 9: Test Design Over 5 days, record data, evaluate solution

Before the Activity
Gather Materials: STEM 'Naturally Organized' lab notebook (class set), pencils (3-4 per group), glue sticks (3-4 per group), scissors (3-4 per group), and 48 crayons (2 boxes), rulers

With the Students

1. Call the class's attention. Tell students that you are so proud of the work they have accomplished and you are excited to announce that today they will receive a new set of school supplies to test their prototypes.
2. Ask students to place their prototype at the center of their team table. Hand each team member per table a set of school supplies. Instruct teams to fill the supply organizer they created with the school supplies you passed out.
3. Remind students that their design prototypes will be tested over the course of 5 whole school days. Tell students that over the course of 5 days, the organizers will be tested for durability and functionality. No changes may be made to the prototypes once testing has begun (e.g. students may not tape a part back on that has fallen off).
4. AFTER 5 WHOLE DAYS OF SCHOOL, have students turn to page 9 in their STEM lab notebooks and independently complete the Yes/No questionnaire in regards to the prototype. After, have students evaluate their solution to the design challenge. Remind students to be objective in their evaluations. Explain, if needed, that to be objective one must focus on the facts not one's feelings about the design.

Activity 10: Communicate Results

Before the Activity
Gather Materials: STEM 'Naturally Organized' lab notebook (class set), ruler, commercial supply organizer

With the Students

1. Gather students in a whole group meeting place. Tell students that after brainstorming, designing, creating, testing, and evaluating their solution, it is time to communicate their results. Tell students, "Communication is an important part of the engineering design process. Engineers share their work with others by writing papers, speaking at conferences, and reaching out to members of communities. When engineers share their work, everybody benefits. People become more informed and are therefore better able to make decisions about important things in their lives."
2. Display page 10 of the STEM lab notebook. Model how to complete the table of technical details for a commercial supply organizer. Model how to measure and record the length of each side of the prototype with a ruler, and how to add up the numbers to get a total in centimeters. For prototypes that are curved, model how to use string to measure the distance around the object. Send students back to their team tables to complete page 10 of the STEM lab notebook.
3. After a sufficient amount of time, call students back to the whole group meeting place. Display page 11 of the STEM lab notebook. Tell students that they will now communicate their results with another team. They will use a conversation guide. The conversation guide is broken into 5 topics of discussion. The topics are what would typically be discussed in a real research paper submitted by an engineer. Model how to complete the conversation guide.

   Example:

   Topic 1: Introduction
   Our team designed a school supply organizer. It was inspired by a wasp's paper nest. We chose this insect's home because we liked the cylinder shape of the compartments.

4. Have students work with a teammate to fill in the blanks on the conversation guide. Each teammate should have the conversation guide completed in their individual STEM lab notebook.
5. After a sufficient amount of time, call the class back to the whole group meeting area and model how to take turns communicating using the conversation guide.

   Example: Group 1 shares first, Group 2 shares second

   Topic 1: Introduction
   Our team designed a school supply organizer. It was inspired by a wasp's paper nest. We chose this insect's home because we liked the cylinder shape of the compartments.

   Topic 1: Introduction
   Our team designed a supply organizer. It was inspired by a bee's home. We chose this insect's home because we thought it would be easy to make the compartments and we like hexagons.

6. Pair up teams to begin communicating their results. Listen in on student conversations and provide assistance as needed. As students wrap up their conversations, ask students to share what they have learned about how engineers solve problems (post assessment).
7. After students have communicated their results with another team, have students individually complete the Engineering Design Rubric on page 12 of their STEM lab notebooks (embedded activity assessment).

Attachments (printables)

Naturally Organized STEM lab notebook

Insect Research Form

Safety Issues

- Due to the high temperature at which glue guns heat glue, ONLY the teacher will use the glue gun
- Remind students that are using craft wire to be careful poking the wire through materials as it is sharp
- Students will need to be instructed on how to properly use a stapler without stapling fingers and without breaking the stapler
- Remind students that when using scissors to cut away from their bodies and to never hand them to someone tip first
- Safety glasses must be worn at all times to protect eyes from clippings while students are building their prototypes

Troubleshooting Tips

- Depending on the number of students you have and the amount of research resources available, you may want to split the class in half or put students into small groups, and rotate students every 10-15 minutes to different research sites.

- If students are not familiar with what an engineer is and what they do, show the 4 minute and 30 second YouTube video, *What's an Engineer? Crash Course Kids #12.1* (https://www.youtube.com/watch?v=owHF9iLyxic) or the 4 minute and 18 second video, *What's an Engineer?* (https://www.youtube.com/watch?v=bipTWWHya8A). The book, Rosie Revere, Engineer by Andrea Beaty is also a great introductory text to engineering (http://storytimefromspace.com/rosie-revere-engineer-2/)

- It may be helpful to show students a diagram of an ant or bee home to help explain what it means to draw and label

- Talking Chips are a classroom management strategy used to manage group discussions. They ensure equitable participation among groups. Talking Chips can be colored slips of paper, colored poker chips, colored math counters, colored Unifix cubes, or even pennies. I recommend using colored materials such as poker chips or linking cubes so each person on each team can be assigned a different color. When students have different colored Talking Chips from one another, it is easy to see who has contributed to the discussion, how many times they have contributed, and who has not made a contribution.

- Students may need additional time to build their prototypes. Consider allowing them extra time in the morning during morning work or during indoor recess.

- Taking notes is a challenging task for second graders. Have the class completely stop what they are doing at least twice during the prototype building stage, and have students jot down notes in their lab notebooks.

- Be mindful of job assignments. If you have a student that struggles with writing, it may not be a good idea for them to be the manufacturer.

- When completing the lab notebook, encourage English Language Learners to use pictures to communicate their thinking.

Investigating Questions

- What is the problem?
- What materials will I use to create my prototype? Why?
- What insect's home will inspire my design? Why?
- What can nature teach us about organization?
- What would nature do?
- What would nature NOT do?
- How do I construct a prototype that allows everyone at my table to easily access supplies?
- How do I construct a prototype that is 80 cm or less around and does not obstruct the view of mine or another team's?
- How will I construct my prototype to withstand long term classroom use?
- Did I come up with the best design? Why or why not?
- What would I do differently to make my solution better?

Assessment

1. **Pre-Activity Assessment:**

Open Up Conversation from Motivation Activity: "Have you ever had a problem? How did it make you feel? Were you able to solve it? How did you solve it? Did someone or something give you an idea?"

2. **Activity Embedded Assessment**

Engineering Design Process Rubric (page 12 of the STEM lab notebook)

3. **Post-Activity Assessment**

Closing Conversation in small groups: "How do engineers solve problems?"

Activity Extensions

Allow students to redesign their prototypes after the final activity. Have them record the changes they have made and why. Allow students to test their new design by giving it to another classroom. Elicit feedback from the testing classroom and continue to improve designs for universal use.

Students could create a mock product page for Amazon or office supply store advertising their product. Students could present their product to potential buyers such as the school principal, secretary, or treasurer.

Activity Scaling

- For lower grades, have students brainstorm and then design a supply organizer with a partner based on the home of an ant or bee. Have students use nonstandard units of measurement, such as Unifix cubes, to find the perimeter of the organizer and its height. Have students test their designs in the classroom for 2 days, and then have students reflect on their design. Later, students could present their results with another pair of students.
- For higher grades, assign materials a price, and place a budget cap on the amount of money students can spend on materials to build their organizer. Assign additional design constraints related to mass and volume. It could also be required that the design have some sort of moving part.

Additional Multimedia Support

Document cameras are a great classroom resource to enlarge and display important information on an interactive whiteboard.

Online timers are helpful for students to monitor their time spent on tasks and their talking time during team meetings.

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Classroom Testing Information

This lesson was tested in Meagan Vaughn's second grade classroom at J.J. Finley Elementary on September 21 - October 10, 2018.

Naturally Organized

Insect Investigation

Name: _____

Insect Name	Description/Drawing of Home

Image 1

Image file: bee

ADA Description: image of a bee with yellow and black stripes with wings extended.

Source/Rights: ©
https://pixabay.com/en/honey-bee-bug-insect-buzz-yellow-40998/

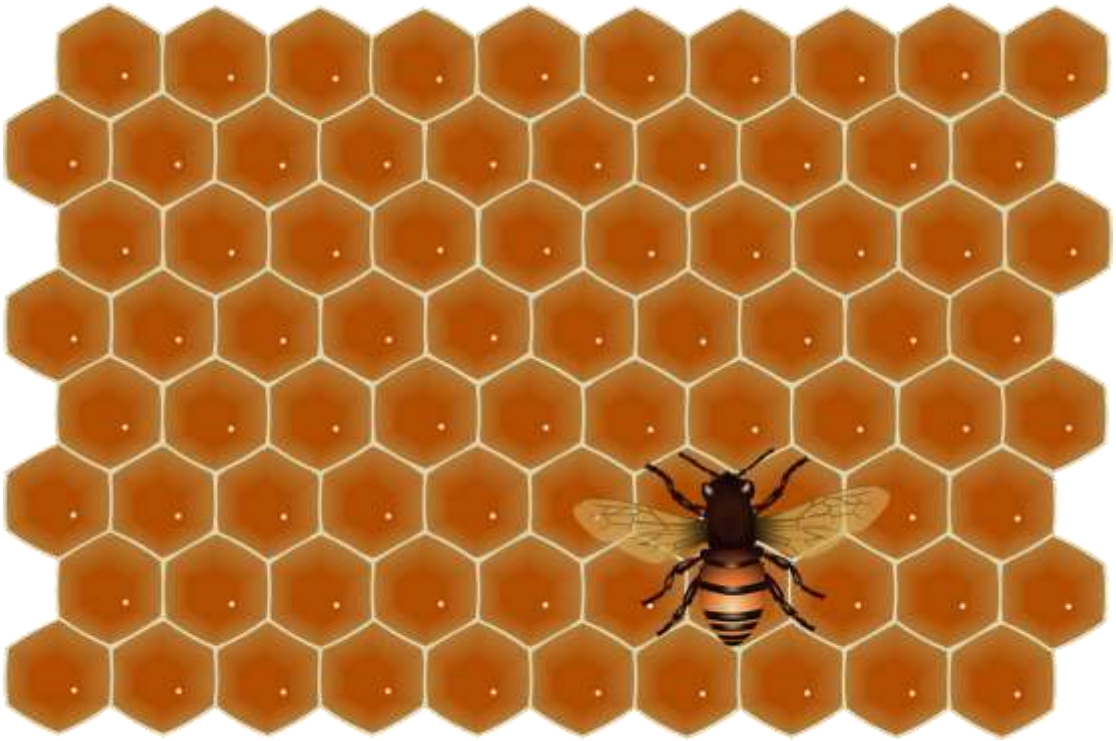
Image 2

Image file: ant

ADA Description: black ant crawling

Source/Rights: ©
https://commons.wikimedia.org/wiki/File:Ant_(Jacob_Eckert).svg

Naturally Organized



Name: _____

Background: In the book Wild Ideas you learned that nature has taught humans a lot about problem solving. When people use nature to design solutions to problems it is called biomimicry. Ants and bees are two of nature's most organized insects. Many species of ants and bees live in colonies. Within these colonies there is structure – everything has a purpose and a place. Engineers observe these structures and apply them to their designs.

Design Challenge: You and your team will design a table top organizer inspired by an insect home of your choosing. Your prototype will store your team's classroom supplies (scissors, crayons, pencils, and glue sticks). Supplies must be easily retrievable and the organizer must be sturdy enough to withstand everyday classroom wear and tear.

Criteria:

- You will work in teams of 3-4
- You will share your design ideas with your team at a team meeting where you will come to a design consensus
- Your team will share responsibility in creating the prototype and keep notes on the design process
- Your team's prototype will be peer reviewed prior to classroom testing
- Your team's prototype will be tested for durability and functionality in the classroom for a period of 5 school days
- Your team will communicate your results with another team

Your Design:

- Must be inspired by an insect's home
- Must allow easy access of materials
- Cannot obstruct yours or another team's view of the SmartBoard
- Cannot be more than 80 cm around

Suggested Materials:

- cardstock
- cardboard
- foam sheets
- felt sheets
- beading/craft wire
- tape
- wet glue
- scissors
- stapler (w/teacher assistance)
- hot glue (w/teacher assistance)

Naturally Organized

Team members: _____ _____

_____ _____

Research

Organizer # _____	**Organizer # _____**	**Organizer # _____**
1. Does the organizer allow easy access to supplies? **Yes** **No**	1. Does the organizer allow easy access to supplies? **Yes** **No**	1. Does the organizer allow easy access to supplies? **Yes** **No**
2. Does the organizer obstruct the view of yours or another team's? **Yes** **No**	2. Does the organizer obstruct the view of yours or another team's? **Yes** **No**	2. Does the organizer obstruct the view of yours or another team's? **Yes** **No**
3. What is the organizer made of? _____ _____	3. What is the organizer made of? _____ _____	3. What is the organizer made of? _____ _____
4. What does the organizer use to separate materials (e.g. drawers, dividers)? _____ _____	4. What does the organizer use to separate materials (e.g. drawers, dividers)? _____ _____	4. What does the organizer use to separate materials (e.g. drawers, dividers)? _____ _____
5. Additional Notes:	5. Additional Notes:	5. Additional Notes:

Naturally Organized

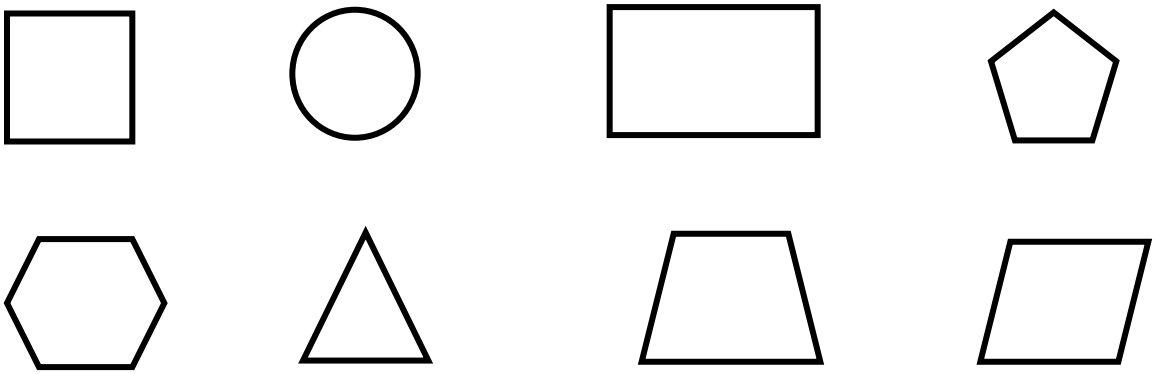
Plan

1. What is the problem? *Restate the design challenge in your own words.*

2. What materials will you use to create your prototype? Why?

3. What insect's home will inspire your design? Why?

4. What 2-dimensional shape(s) will you use in your design?



Naturally Organized

Brainstorm Solutions

Draw and label your ideas.

Solution #1

Solution #2

Team Design Consensus:

Develop and Build your Prototype

Materials Engineer – I will pay attention to what materials my team selects and how they are used. I will make sure materials are shared with all members of the team.

LAB NOTES

Manufacturing/Process Engineer – I will carefully observe and record the steps my team performs to create our prototype.

LAB NOTES

Structural Engineer – I will make sure our prototype is 80cm or less around and can support the size and weight of our supplies. I will frequently use my ruler to measure the prototype as it is being built.

LAB NOTES

Biological Engineer – I will make sure our design is inspired by nature. I will frequently ask questions throughout the design process such as, "What would nature do?" or "What would nature NOT do?"

LAB NOTES

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Prototype Peer Review

Name of Peer Reviewer: _____

GLOW Write down at least 1 thing you liked about the prototype.

GROW Write down at least 1 thing you think could be improved.

Naturally Organized

Test your Solution

	Yes	No
Does your prototype allow everyone at your table to easily access supplies?		
Is your prototype 80 cm or less around?		
Does your prototype obstruct the view of yours or another team's?		
Is your prototype still intact and self-standing after 5 days of classroom use?		

Evaluate your Solution

1. Do you think you came up with the best design? Why or why not?

2. What would you differently to make your solution better?

Naturally Organized

Communicate Your Results

Technical Details of Final Product

Item Name	
Product Dimensions *Record the length of each side of your prototype* **If your design's base is a circle, record the circumference in cm*	
Color(s)	
Material Type Record the materials used to create your prototype	
Size *Add up the length of each side of your prototype and record the total in centimeters (cm)* **If your design's base is a circle, record the circumference in cm*	

Naturally Organized

Communicate Your Results

Directions: You and a teammate will meet with another team that has completed the same design challenge as you. You will use this conversation guide to compare and contrast your designs.

Topic 1: Introduction

Our team designed a _____. It was inspired by
(what you made for the design challenge)

_____. We chose this insect's home because
(name of insect and type of home)

_____.
(list reasons)

Topic 2: Methods

We made our tabletop organizer out of _____.
(list materials used)

We chose these materials because _____.
(list reasons)

It was challenging to _____.
(list what was hard to do)

Topic 3: Results

After 5 days of testing, we discovered _____.
(list things that happened to your prototype)

Topic 4: Discussion

We think our design (worked/did not work) well because _____.
(list reasons)

If we could change anything to make it better, we would _____.
(list reasons)

Topic 5: Acknowledgments

I like how….
That was a great way to…
Nice work showing…
You showed great effort when...

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Engineering Design Process Rubric

Design Brief Rubric	**I did not.**	**I did with *A LOT* of help from a teammate or teacher.**	**I did with *SOME* help from a teammate or teacher.**	**I did this all on my own.**
I identified the problem to be solved.				
I brainstormed more than one solution to the problem.				
I created and labeled a sketch of the final prototype.				
I included notes related to my engineering job in the design process.				
I measured the table organizer correctly with appropriate measurement tools.				
I completed the Prototype Peer Review for another team and wrote objective feedback.				
I tested the organizer to make sure it was durable, less than 80cm around, did not obstruct anyone's view, and allowed for easy access of supplies.				
I evaluated my solution objectively.				
I contributed to a conversation with another team on the results of my team's design.				

Image 1

Image file: bee

ADA Description: image of a bee with yellow and black stripes with wings extended

Source/Rights: © https://pixabay.com/en/honey-bee-bug-insect-buzz-yellow-40998/

Image 2

Image file: ant

ADA Description: image of a black ant crawling

Source/Rights: © https://commons.wikimedia.org/wiki/File:Ant_(Jacob_Eckert).svg

Image 3

Image file: bee on honey comb

ADA Description: image of a honey bee on a rectangular shaped honeycomb

Source/Rights: © https: //pixabay.com/en/honey-bee-flying-work-insect-42905/

Image 4

Image file: lightbulb

ADA Description: image of a black and white lightbulb with lines coming out of the bulb

Source/Rights: © https://cdn.pixabay.com/photo/2013/07/12/18/54/idea-153974_640.png

Image 5

Image file: flower

ADA Description: image of a black and white flower with seven petals and 3 small leaves attached to the stem

Source/Rights: © https://www.publicdomainpictures.net/pictures/60000/velka/flower-outline-coloring-page.jpg