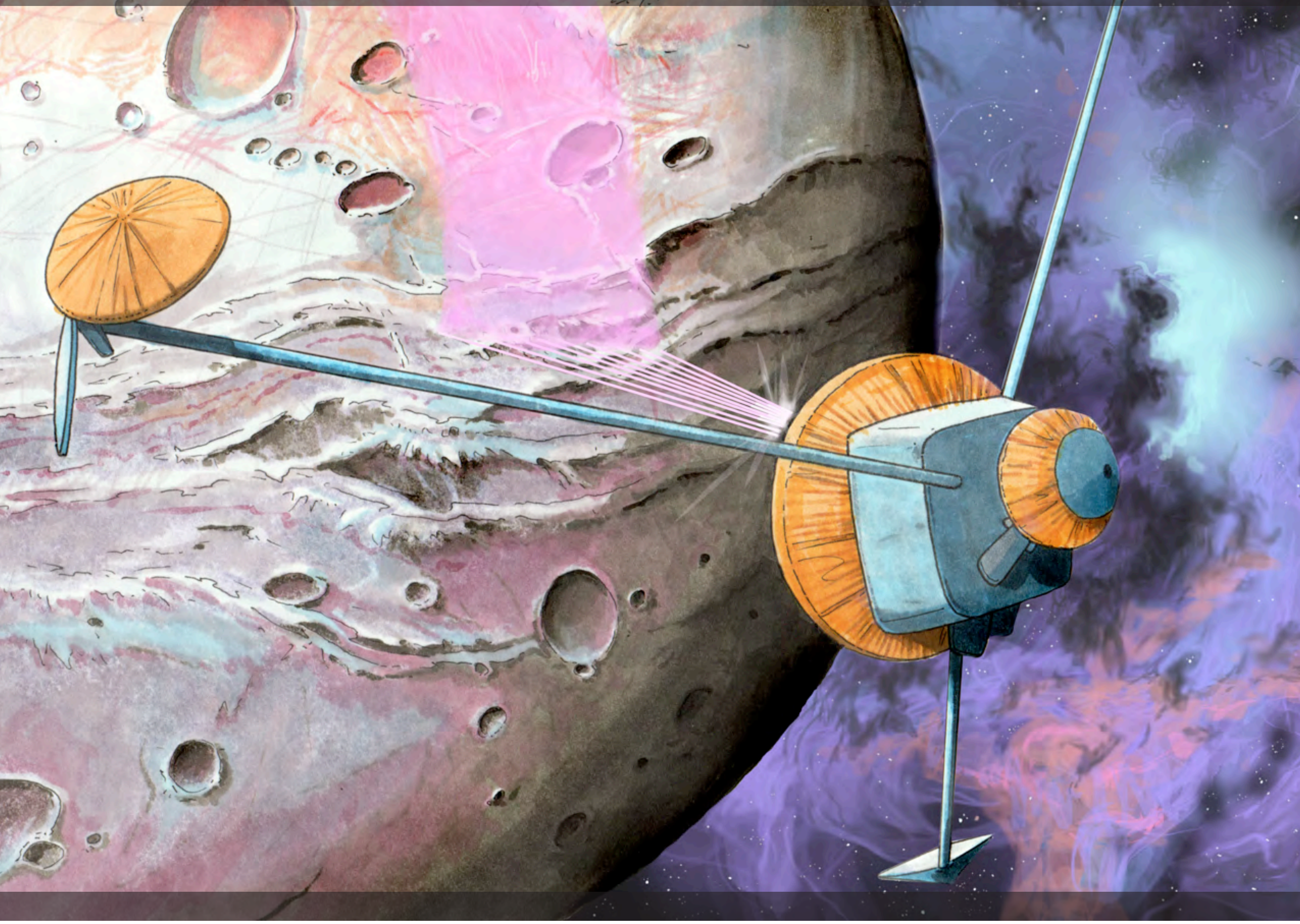
Engineering Everywhere™

Worlds Apart:
Engineering Remote Sensing Devices

Remote Sensing Engineering for Out-of-School Time • Grades 6–8



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EiE Engineering is Elementary®
Developed by the Museum of Science, Boston
Engineering Everywhere™

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Developed by the Museum of Science, Boston

Pilot Sites:

This unit would not be possible without the valuable feedback from our pilot sites!
ACCESS Educational Services, Inc. Bridgeport, CT
Arlington Education Collaborative Arlington, MA
Bagdad Middle School Bagdad, AZ
BASIS Flagstaff Flagstaff, AZ
Boys and Girls Club of Central VA Charlottesville, VA
Boys and Girls Club of Flagstaff Flagstaff, AZ
Boys and Girls Club of Greater Salem Salem, MA
Brentwood Magnet Engineering School Raleigh, NC
Cactus Middle School Casa Grande, AZ
CHARISM West Fargo, ND
Dilcon Community School Winslow, AZ
EdBoost Education Corporation Los Angeles, CA
Girls Inc. of Lynn Lynn, MA
LEAP Afterschool Program San Rafael, CA
Saints Peter and Paul Catholic School Tucson, AZ
Salvation Army Cleveland Temple Corps Cleveland, OH
Seabrook Adventure Zone Seabrook, NH
Show Low Unified School District Show Low, AZ
Sinagua Middle School Flagstaff, AZ
St. Michael School Lowell, MA
STEM Kids NYC New York, NY
Quabbin Regional School District Hubbardston, MA
Veterans Memorial Middle School Brick, NJ
Winthrop Middle School Winthrop, MA

PLANETS

Planetary Learning that Advances the Nexus of Engineering, Technology, and Science (*PLANETS*) is an interdisciplinary and cross-institutional partnership that integrates planetary science, education, technology, and engineering (NASA #NNX16AC53A).

The Center for Science Teaching and Learning at Northern Arizona University (NAU), the U.S. Geological Survey (USGS) Astrogeology Science Center, and the Museum of Science, Boston have partnered to develop, pilot, and research the impact of three curriculum units and related professional development resources (http://planets-stem.org).

The purpose of *PLANETS* is to increase public awareness and use of NASA resources by highlighting the relationship between science, technology, engineering, and mathematics in the context of planetary science in out-of-school time settings.

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Unit Map

Here is an overview of the activities in this unit and how they all fit together.

Prep Activity 1: What is Engineering?

Youth are introduced to the Engineering Design Process as they work together to engineer a tower to support a model antenna.

Prep Activity 2: What is Technology?

Youth match technologies based on the problem they solve and *imagine* ways to *improve* the newer version.

Activity 1: Looking Beyond

Youth use mirrors to change the way light travels in order to see hidden objects.

Activity 2: Secret Messages

Youth explore how manipulating light and color can help them interpret information from a distance that would otherwise be difficult to see.

Activity 3: Taking Shape

Youth engineer a technology that models LiDAR to gather topographical information about the features of a surface.

Activity 4: Create a Remote Sensing Device

Youth work in groups to *create* remote sensing technologies that can collect data about the Mystery Moon.

Activity 5: Improve: Final Launch

Youth will *improve* their remote sensing devices and use them to take a final reading from two locations on the Mystery Moon.

Activity 6: Engineering Showcase

Youth *communicate* their knowledge of remote sensing devices and the information they gathered about the Mystery Moon at the Engineering Showcase.

Table of Contents

About Engineering is Elementary

Engineering is Elementary® (EiE®) fosters engineering and technological literacy among children. Most humans spend over 95% of their time interacting with technology. Pencils, chairs, water filters, toothbrushes, cell phones, and buildings are all technologies—solutions designed by engineers to fulfill human needs or wants. To understand the world we live in, it is vital that we foster engineering and technological literacy among all people, even young children! Fortunately, children are born engineers. They are fascinated with building, taking things apart, and learning how things work. Engineering is Elementary harnesses children's natural curiosity to promote the learning of engineering and technology concepts.

The EiE program has four primary goals:

- Increase children's technological literacy.
- Increase educators' abilities to teach engineering and technology.
- Increase the number of schools and out-of-school time (OST) programs in the US that include engineering.
- Conduct research and assessment to further the first three goals and contribute knowledge about engineering teaching and learning.

The first product developed by the EiE program was the Engineering is Elementary curriculum series. Designed for use in elementary school classrooms, this curriculum is hands-on, research-based, standards-driven, and classroom-tested. For more information about EiE, visit: www.eie.org.

In 2011, EiE began development of Engineering Adventures® (EA), a curriculum created for 3rd–5th grade children in OST environments. EA is designed to provide engaging and thought-provoking challenges appropriate for the OST setting. More information about EA can be found online at: www.engineeringadventures.org.

In 2012 the Engineering Everywhere™ (EE™) curriculum was created. EE is designed to empower middle-school-aged children in OST settings to become engineers and solve problems that are personally meaningful and globally relevant. For more information, visit: www.engineeringeverywhere.org.

Engineering is Elementary is a part of The National Center for Technological Literacy (NCTL) at the Museum of Science, Boston. The NCTL aims to enhance knowledge of technology and inspire the next generation of engineers, inventors, and innovators. Unique in recognizing that a 21st century curriculum must include today's human-made world, the NCTL's goal is to introduce engineering as early as elementary school and continue through high school, college, and beyond. For more information, visit: www.nctl.org.

About Engineering Everywhere

The mission of Engineering Everywhere is to create engaging out-of-school time learning experiences for 6th–8th graders that positively impact youth's attitudes about their abilities to engineer. Our goal is to provide youth with personally meaningful and globally relevant challenges that empower them to problem solve, think creatively, and learn from one another.

The main ideas that guide the developers of EE are listed below.

We believe youth will best learn engineering when they:

- engage in activities that are fun, exciting, and connect to the world in which they live.
- choose their path through open-ended challenges that have multiple solutions.
- have the opportunity to succeed in engineering challenges.
- communicate and collaborate in innovative, active problem solving.

Through EE units, youth will learn that:

- they can use the Engineering Design Process to help solve problems.
- engineers design technologies to help people and solve problems.
- they have the talent and potential to design and improve technologies.
- they, too, are engineers.

As youth work through their engineering design challenges, they will have the opportunity to build their problem solving, teamwork, communication, and creative thinking skills. Most importantly, this curriculum is designed to provide a fun learning opportunity!

Unit Goals

In this unit, youth will be introduced to engineering and the eight-step Engineering Design Process as they work together to engineer remote sensing devices for partner scientists. Youth will *investigate* different technologies used in the field of remote sensing—periscopes, optical filters, and LiDAR—before engineering their own remote sensing devices to solve one of the research problems posed by the scientists.

By the end of the unit, youth will be ready to present what they learned about remote sensing and the Engineering Design Process by sharing the engineering work they have done.

The Engineering Design Process

The Engineering Everywhere Engineering Design Process (EDP) is the backbone of each Engineering Everywhere (EE) unit. It is an eight-step process that guides youth in solving engineering challenges. Our goal for each EE unit is for youth to understand that the EDP can help them solve problems not only in engineering, but also in other areas of their lives.

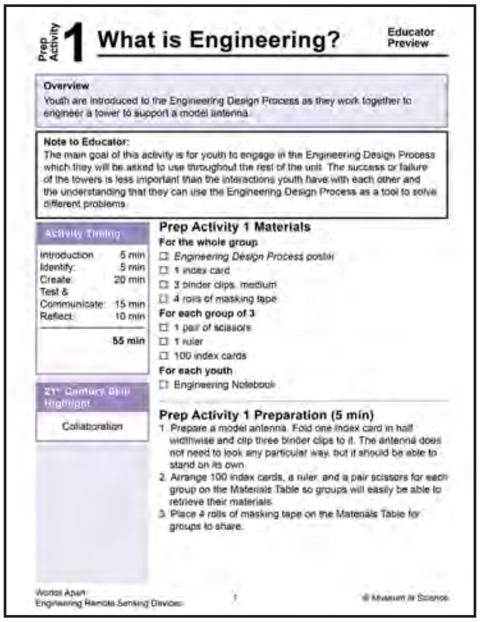
While there are many versions of the EDP used in academic and professional fields of engineering, we developed an eight-step process that builds on the five-step process used in our elementary curriculum. There are guiding questions throughout the activities for the educator to ask to promote discussion about the EDP. There are also sections in the Engineering Notebook to encourage youth to engage in the process.

The EDP begins with identifying a problem that needs to be solved and investigating what has already been done. Next, engineers imagine different solutions and plan their designs. Then, they create and test their designs and make improvements based on the test results. Finally, engineers communicate their findings to others. While the process is shown as linear, youth may jump around to different steps as they are engineering. For example, they may need to imagine and plan new designs in order to improve.

To further highlight the EDP throughout the unit, the steps are italicized in this guide. Youth are also provided with an explanation of each step, which can be seen in their Engineering Notebooks. The EDP used in EE units is illustrated to the right.

Educator Guide Components

An **Educator Preview** with background information, activity timing, key concepts, materials lists, and preparation.



Prep Activity 1 What is Engineering? Educator Preview

Overview
Youth are introduced to the Engineering Design Process as they work together to engineer a tower to support a model antenna.

Note to Educator:
The main goal of this activity is for youth to engage in the Engineering Design Process which they will be asked to use throughout the rest of the unit. The success or failure of the towers is less important than the interactions youth have with each other and the understanding that they can use the Engineering Design Process as a tool to solve different problems.

Activity Timing

Introduction	5 min
Identify:	5 min
Create:	20 min
Test & Communicate:	15 min
Reflect:	10 min
	55 min

21st Century Skill Highlight
Collaboration

Prep Activity 1 Materials
For the whole group
☐ *Engineering Design Process poster*
☐ 1 index card
☐ 3 binder clips, medium
☐ 4 rolls of masking tape
For each group of 3
☐ 1 pair of scissors
☐ 1 ruler
☐ 100 index cards
For each youth
☐ Engineering Notebook

Prep Activity 1 Preparation (5 min)
1. Prepare a model antenna. Fold one index card in half widthwise and clip three binder clips to it. The antenna does not need to look any particular way, but it should be able to stand on its own.
2. Arrange 100 index cards, a ruler, and a pair scissors for each group on the Materials Table so groups will easily be able to retrieve their materials.
3. Place 4 rolls of masking tape on the Materials Table for groups to share.

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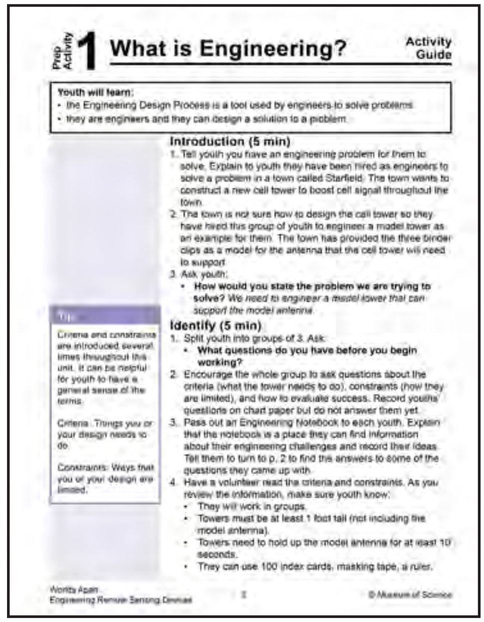
An **Activity Guide** with step-by-step instructions, including discussion questions, extension ideas, and tips.



Prep Activity 1 What is Engineering? Activity Guide

Youth will learn:
- the Engineering Design Process is a tool used by engineers to solve problems
- they are engineers and they can design a solution to a problem

Introduction (5 min)
1. Tell youth you have an engineering problem for them to solve. Explain to youth they have been hired as engineers to solve a problem in a town called Starfield. The town wants to construct a new cell tower to boost cell signal throughout the town.
2. The town is not sure how to design the cell tower so they have hired this group of youth to engineer a model tower as an example for them. The town has provided the three binder clips as a model for the antenna that the cell tower will need to support.
3. Ask youth:
   - **How would you state the problem we are trying to solve?** *We need to engineer a model tower that can support the model antenna.*

Identify (5 min)
1. Split youth into groups of 3. Ask:
   - **What questions do you have before you begin working?**
2. Encourage the whole group to ask questions about the criteria (what the tower needs to do), constraints (how they are limited), and how to evaluate success. Record youths' questions on chart paper but do not answer them yet.
3. Pass out an Engineering Notebook to each youth. Explain that the notebook is a place they can find information about their engineering challenges and record their ideas. Tell them to turn to p. 2 to find the answers to some of the questions they came up with.
4. Have a volunteer read the criteria and constraints. As you review the information, make sure youth know:
   - They will work in groups.
   - Towers must be at least 1 foot tall (not including the model antenna).
   - Towers need to hold up the model antenna for at least 10 seconds.
   - They can use 100 index cards, masking tape, a ruler,

Tip
Criteria and constraints are introduced several times throughout this unit. It can be helpful for youth to have a general sense of the terms.

Criteria: Things you or your design needs to do.

Constraints: Ways that you or your design are limited.

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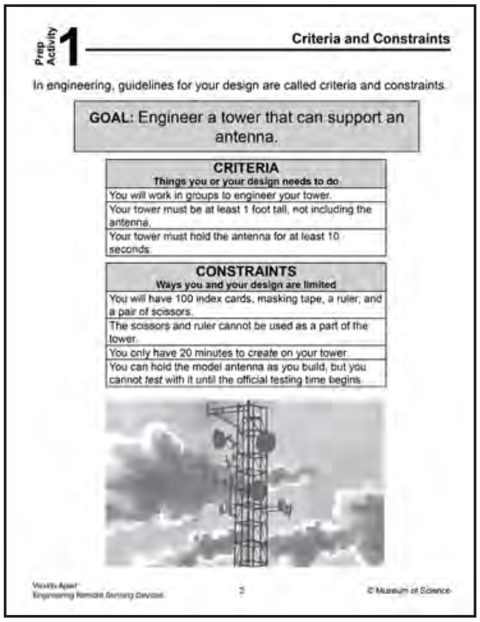
Engineering Notebook pages that allow youth to record their findings and reflect on their learning.



Prep Activity 1 Criteria and Constraints

In engineering, guidelines for your design are called criteria and constraints.

GOAL: Engineer a tower that can support an antenna.

CRITERIA Things you or your design needs to do
You will work in groups to engineer your tower.
Your tower must be at least 1 foot tall, not including the antenna.
Your tower must hold the antenna for at least 10 seconds.

CONSTRAINTS Ways you and your design are limited
You will have 100 index cards, masking tape, a ruler, and a pair of scissors.
The scissors and ruler cannot be used as a part of the tower.
You only have 20 minutes to *create* on your tower.
You can hold the model antenna as you build, but you cannot *test* with it until the official testing time begins.

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What You Need to Know Before Teaching an EE Unit

Engineering is Fun

The EE team hears this from many OST educators and youth. Engineering is a way of problem solving—a way of thinking about the world—that is very fun and creative. Any time you need to solve a problem in order to reach a goal, you are engineering.

There are No Right or Wrong Answers

There are often many great ways to solve the same problem. Not only is this a good engineering lesson, it is a good life lesson for the youth in your program.

You are a Guide

As the educator, it is your role to guide youth through these activities by encouraging them to pursue and communicate their own ideas, even if you think they might not work. Every problem has many possible solutions and multiple ways to reach them.

Ask Questions

Throughout the activities, you can ask questions prompting youth to share their prior knowledge, predict what they might find, or remind them of criteria that will help them as they engineer. Asking questions like these sets your youth up to succeed and feel confident in their ability to engineer.

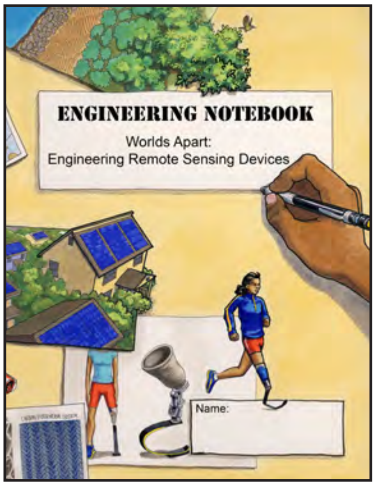
It is Okay to Try It Out

It can be very helpful to try out the engineering challenge yourself—either beforehand or right alongside the youth in your program as they work through the adventures. This can help you understand the challenges they might face.

Support Reflection

Each activity includes 5–10 minutes at the end for youth to communicate with their peers by sharing their work. This gives youth the chance to discuss new ideas, think about their own work and the work of others, and reflect on what was learned. Group reflection can help reduce competition by encouraging youth to support each other as they move through the Engineering Design Process.

Engineering Notebooks



Make a copy of an Engineering Notebook for each youth before you begin working through this Engineering Everywhere unit. Youth will use them as directed in the Educator Guide during every activity.

The Engineering Notebook serves as a central location for youth to record their thoughts and ideas as they move through the unit. Its pages guide youth through the Engineering Design Process, pose questions, and prompt youth to reflect on their engineering work. The time youth spend with their Notebooks during each activity will allow them to create a personalized record of their engineering learning.

There are a few ways you can use the Engineering Notebook. You may want to have groups share one Engineering Notebook as a central recording spot for all group data and findings. This allows group members who enjoy writing and recording to do so. You may also encourage groups to share the responsibility by having group members rotate who records.

Alternate Prep Activities

The two prep activities, “What is Engineering?” and “What is Technology?,” introduce youth to engineering and technology. “What is Engineering?” gives youth the chance to collaborate, experience a mini hands-on engineering challenge, share their designs, and learn about the Engineering Design Process. This activity sets the stage for what they can expect in the rest of the unit.

“What is Technology?” has youth interact with technologies, working with the definition that a technology is anything designed by humans to help solve a problem or meet a need. Most youth think of technology as things that can be plugged into the wall. They do not realize that the items that they interact with every day—including pencils, paper, and water bottles—are also technologies. This activity introduces the definition of technology that they will refer to as they engineer their own technologies to solve the problem presented in the unit.

While the prep activities for Engineering Everywhere are unit-specific, there are alternative prep activities you can use if you would like to reinforce the concepts and vocabulary related to these activities. You can find the alternate activities online at www.engineeringeverywhere.org. If you have questions about these activities, please email engineeringeverywhere@mos.org.

Tips and Tricks for Teaching the Unit

Post a Daily Agenda

Giving youth a sense of the day's activity will help them to plan ahead and manage their time.

Facilitate Teamwork

Being able to work well in teams is an important skill for any engineer. You may want to assign team roles to help youth that struggle with teamwork. Possible roles include: the note taker, the materials gatherer, the tester, and the presenter.

This unit requires a collaborative workspace. Tables, desks, and chairs should be movable. It is a good idea to establish a materials table where you can set up materials for the day. Then, groups can be in charge of gathering their own materials when they are ready.

Invite Others to the Engineering Showcase

The Engineering Showcase, the last activity in the unit, is a big deal! This is a chance for youth to highlight the engineering they have done and share their accomplishments with others. Consider inviting families, program staff, and other youth to come to the Showcase.

Scheduling the Activities

Each activity requires 50-60 minutes of teaching time. We recommend that you budget at least 8–9 hours in order to complete this unit, as some activities may run longer than expected.

You can schedule this unit in several ways: once a week, several times a week, or daily. It is also possible to group certain activities together. The chart below shows which activities are easily taught together. Use this chart to help you plan your schedule.

Prep Activity 1: What is Engineering? Prep Activity 2: What is Technology?	2 hours
Activity 1: Looking Beyond Activity 2: Secret Messages	2-3 hours
Activity 3: Taking Shape	1 hour
Activity 4: Create a Remote Sensing Device Activity 5: Improve	2-3 hours
Activity 6: Engineering Showcase	1 hour

Background

Remote Sensing Engineering

Remote sensing engineering is an interdisciplinary field that deals with the collection of data remotely, or from a distance. It has a wide variety of applications, from creating models of cities or natural landscapes to helping scientists predict the effects of climate change to precisely tracking orbiting satellites. Remote sensing engineers use techniques from many fields, such as cartography, civil engineering, software engineering, and computer science.

In this unit, youth will engineer remote sensing devices to gather and visualize information about a newly discovered moon for scientists at NASA. The data they collect will help the scientists meet their scientific goals, such as gathering data on the geological features of the landscape, looking for evidence of water, or safely landing a rover.

Remote Sensing Technologies

In this unit, we introduce youth to three technologies associated with remote sensing: periscopes, optical filters, and LiDAR.

> Periscopes are tools that use angled mirrors to redirect the path of light from an object to a person's eye. They allow people to observe objects on Earth and in space that are hidden behind obstacles or otherwise out of sight.
>
> Remote sensing technologies can be combined with other technologies, like optical filters, to enhance the information they receive. Optical filters can manipulate light and color to help scientists and engineers categorize the information they are looking at and make sense of complex data.
>
> LiDAR, or Light Detection and Ranging, is a tool that sends out laser pulses from an airplane or spacecraft to a landscape and measures how long those pulses take to return. The data gathered from LiDAR can be used to create precise, three-dimensional maps of the terrain.

Online Resources

The *PLANETS* website (http://planets-stem.org) supports both educators and youth through science extension exercises, educator support materials, and youth content enhancements. Science extension exercises are intended to integrate and apply planetary science concepts with the engineering unit. The educator support materials include immediate management tips and provide additional resources for meeting the unique needs of youth in out-of-school-time settings. Be sure to check out these videos, infographics, and connections to other NASA resources!

Vocabulary

Constraint: A factor that limits how you can solve a problem.

Criteria: The requirements of a design.

Data: Information that is collected through scientific investigation.

Engineer: Someone who uses his or her creativity and knowledge of math and science to design technologies that solve problems.

Engineering Design Process: The steps that engineers use to design technologies to solve a problem.

Landform: A natural feature of a planet's surface, such as a hill, valley, mountain, canyon, or crater.

Laser: A device that generates an intense beam of light.

LiDAR (Light Detection And Ranging): A remote sensing technology that collects data from lasers to map the shape of a landscape.

Optical filter: A technology that manipulates light and color to help reveal visual information.

Periscope: A remote sensing technology that uses mirrors to change the path of light in order to see over or around an object.

Remote sensing: The process of using technology to obtain data about an object from a distance.

Technology: Anything designed by people to solve a problem.

Topography: The arrangement, elevation, or height of the landforms in an area.

Materials List

This kit is prepared for 8 groups of 3.

Quantity	Item
Non-Consumable Items	
1	*Engineering Design Process* poster
1	*Engineering Everywhere Special Report* video
1 set	pattern blocks, 100
8	rulers
8	scissors
50	flat mirrors, approx. 2.5” x 3.5”
100	binder clips, medium, 5/8” capacity, 1 1/4” width
Consumable Items	
1 bottle	white glue
4	shoeboxes with lids, 7” x 5” x 12”
4	tri-fold boards, 48” x 36”
6 sheets	styrofoam, 12” x 12” x 1”
8 packs	crayons, 8 assorted colors
8 packs	highlighters, 6 assorted colors
8	plates, paper, small
8 rolls	tape, masking
20	cups, paper, 3 oz.
24 sheets	cellophane, blue
24 sheets	cellophane, red
40 sheets	craft foam
50	craft sticks
55	cups, paper, 8 oz.
60 sheets	construction paper
60 sheets	copy paper
60 sheets	felt, 9” x 12”
75	manila folders
80	pipe cleaners
100	rubber bands, 3” x 1/8”
1000	index cards
4000	straws, regular
4000	straws, thin*

Materials List (continued)

NOT INCLUDED IN KIT	
1 pad	chart paper
1	utility knife
8	blindfolds
8 packs	markers, 8 assorted colors
9	small boxes or stacked textbooks for obstacles in Activity 1
8–12	optional: curved mirrors or lenses
8–12	optional: recycled containers (e.g., juice cartons, yogurt containers)
4000	optional: straws, thin*

*The thin straws used in this unit are commonly called coffee stirrers or cocktail straws and are typically 1/8” in diameter. Youth use 4,000 thin straws throughout the unit. Consider providing more thin straws for youth to use in Activities 4 and 5.

National Education Standards

Engineering Everywhere units are written with the goal of teaching engineering skills and critical thinking practices. Many Engineering Everywhere units also touch upon a variety of science topics and principles. The engineering standards taught in this unit and the science topic links in this unit are noted below.

		Prep Activity 1: What is Engineering?	Prep Activity 2: What is Technology?	Activity 1: Looking Beyond	Activity 2: Secret Messages	Activity 3: Taking Shape	Activity 4: Create a Remote Sensing Device	Activity 5: Improve	Activity 6: Engineering Showcase
National Science Education Standards	Science as Inquiry	✓					✓	✓	
	Physical Science			✓	✓	✓	✓	✓	✓
	Life Science								
	Earth and Space Science			✓		✓	✓	✓	✓
	Science and Technology	✓	✓	✓	✓	✓	✓	✓	✓
	Science in Personal and Social Perspectives		✓						
	History and Nature of Science								
ITEEA	The Nature of Technology		✓	✓	✓	✓	✓	✓	✓
	Technology and Society		✓						
	Design	✓	✓	✓	✓	✓	✓	✓	✓
	Abilities for a Technological World	✓	✓	✓	✓	✓	✓	✓	✓
	The Designed World								

		Prep Activity 1: What is Engineering?	Prep Activity 2: What is Technology?	Activity 1: Looking Beyond	Activity 2: Secret Messages	Activity 3: Taking Shape	Activity 4: Create a Remote Sensing Device	Activity 5: Improve	Activity 6: Engineering Showcase
Next Generation Science Standards	MS-PS4-2 Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.			✓	✓		✓	✓	
	MS-ESS1-3 Analyze and interpret data to determine scale properties of objects in the solar system.					✓	✓	✓	✓
	MS-ESS2-3 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of past plate motions.						✓	✓	✓
	MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	✓		✓		✓	✓	✓	✓
	MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.		✓						✓
	MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	✓		✓		✓	✓	✓	✓
	MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	✓			✓	✓	✓	✓	

How to Recognize Success Rubric

How do you know if you are leading these activities successfully? This tool will help you keep track of your youth's successful moments and will ask you to identify how your own actions enabled youth to succeed.

Elements of success	What does this look like?	How does the guide help me facilitate this?
Youth are engaged and challenged by the activity. They persist through difficulties.	• Youth are on-task. • Youth are trying out their ideas. • Youth *identify* what is working well in their designs. • Youth troubleshoot their own work. • Youth *improve* their designs.	• Use the bold prompts to **ask open-ended questions** to help youth troubleshoot their work. • Use the bold prompts to **ask youth about what they think is working well** in their designs and what they would like to improve. This will help youth feel more confident about their problem-solving abilities.
Youth do most of the talking, sharing their ideas with each other during the entire activity.	• Youth bring their own ideas to the activity and are comfortable sharing them. • Youth brainstorm and debate within their groups. • Youth share their designs with others. • Youth talk about how their ideas are changing over time.	• Use the bold prompts in the guide to **encourage youth to share and explain their thinking**. • Have youth **collaborate in groups** so they can brainstorm and *create* a design together. • Use the bold prompts in the Reflect section to **help youth share their new ideas about designs.**
Youth value their engineering work as a process, not just as the end result.	• Youth go beyond talking about their design to talking about how they thought of it and why they designed it. • Youth use the Engineering Design Process to describe their actions.	• Use the bold prompts in the guide to **ask youth how they use the Engineering Design Process.** Spending time talking and thinking about their process will help youth see the value in it. • Use the bold prompts to **ask all youth about *improving*** their designs, even if their designs are working well. • **Encourage youth to reflect individually** in their Engineering Notebooks to give them time for their experiences to sink in and be remembered.

How to Recognize Success Rubric Template

How do you know if you are leading these activities successfully? This tool will help you keep track of your youth's successful moments and will ask you to identify how your own actions enabled youth to succeed.

Date: Activity:

Elements of success	Evidence: Where did I see this during the activity?	What was my role in making this happen?
Youth are engaged and challenged by the activity. They persist through difficulties.		
Youth do most of the talking, sharing their ideas with each other during the entire activity.		
Youth value their engineering work as a process, not just as the end result.		

Dear Family, Date: ________________

We are beginning an engineering unit called *Worlds Apart: Engineering Remote Sensing Devices*, a curriculum developed by the Engineering is Elementary program at the Museum of Science, Boston. This week, your youth will be introduced to engineering and the Engineering Design Process as the group works together to engineer a solution to a remote sensing engineering challenge. This unit is set in a real-world context: throughout the unit, your youth will work with teammates to engineer a remote sensing device that is able to gather information about the surface of a model Mystery Moon.

There are many reasons to introduce youth in grades 6–8 to engineering:

- **Engineering projects reinforce topics youth are learning in school.** Engaging students in hands-on, real-world engineering experiences can enliven math, science, and other content areas.
- **Engineering fosters problem-solving skills,** including problem formulation, creativity, planning, and testing alternative solutions.
- **Children are fascinated with building and with taking things apart to see how they work.** By encouraging these explorations, we can keep these interests alive. Describing their activities as "engineering" when youth are engaged in the natural design process can help them develop positive associations with engineering, and increase their desire to pursue such activities in the future.
- **Engineering and technological literacy are necessary for the 21st century.** As our society increasingly depends on engineering and technology, our citizens need to understand these fields.

If you have expertise in geospatial engineering, remote sensing, planetary science, or have any general questions or comments about the engineering unit we are about to begin, please let me know.

Sincerely,

If you have any of the following materials available and would like to donate them, I would greatly appreciate having them by the following date: ______________________ . Thank you!

____________________________ ____________________________

____________________________ ____________________________

____________________________ ____________________________

Prep Activity 1

What is Engineering?

Educator Preview

Overview

Youth are introduced to the Engineering Design Process as they work together to engineer a tower to support a model antenna.

Note to Educator:
The main goal of this activity is for youth to engage in the Engineering Design Process which they will be asked to use throughout the rest of the unit. The success or failure of the towers is less important than the interactions youth have with each other and the understanding that they can use the Engineering Design Process as a tool to solve different problems.

Activity Timing

Introduction	5 min
Identify:	5 min
Create:	20 min
Test & Communicate:	15 min
Reflect:	10 min
	55 min

21st Century Skill Highlight

Collaboration

Prep Activity 1 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ 1 index card
- ☐ 3 binder clips, medium
- ☐ 4 rolls of masking tape

For each group of 3

- ☐ 1 pair of scissors
- ☐ 1 ruler
- ☐ 100 index cards

For each youth

- ☐ Engineering Notebook

Prep Activity 1 Materials Preparation (5 min)

1. Prepare a model antenna. Fold one index card in half widthwise and clip three binder clips to it. The antenna does not need to look any particular way, but it should be able to stand on its own.
2. Arrange 100 index cards, a ruler, and a pair of scissors for each group on the Materials Table so groups will easily be able to retrieve their materials.
3. Place 4 rolls of masking tape on the Materials Table for groups to share.

Criteria and Constraints, p. 2


Prep Activity 1 — Criteria and Constraints

In engineering, guidelines for your design are called criteria and constraints.

GOAL: Engineer a tower that can support an antenna.

CRITERIA Things you or your design needs to do
You will work in groups to engineer your tower.
Your tower must be at least 1 foot tall, not including the antenna.
Your tower must hold the antenna for at least 10 seconds.

CONSTRAINTS Ways you and your design are limited
You will have 100 index cards, masking tape, a ruler, and a pair of scissors.
The scissors and ruler cannot be used as a part of the tower.
You only have 20 minutes to create on your tower.
You can hold the model antenna as you build, but you cannot *test* with it until the official testing time begins.

Worlds Apart: Engineering Remote Sensing Devices 2 © Museum of Science

What is Engineering?

Youth will learn:
- The Engineering Design Process is a tool used by engineers to solve problems.
- They are engineers and they can design a solution to a problem.

Introduction (5 min)

1. Tell youth you have an engineering problem for them to solve. Explain to youth they have been hired as engineers to solve a problem in a town called Starfield. The town wants to construct a new cell tower to boost cell signal throughout the town.
2. The town is not sure how to design the cell tower so they have hired this group of youth to engineer a model tower as an example for them. The town has provided the three binder clips as a model for the antenna that the cell tower will need to support.
3. Ask youth:
   - **How would you state the problem we are trying to solve?** *We need to engineer a model tower that can support the model antenna.*

Identify (5 min)

1. Split youth into groups of 3. Ask:
   - **What questions do you have before you begin working?**
2. Encourage the whole group to ask questions about the criteria (what the tower needs to do), constraints (how they are limited), and how to evaluate success. Record youth's questions on chart paper but do not answer them yet.
3. Pass out an Engineering Notebook to each youth. Explain that the notebook is a place they can find information about their engineering challenges and record their ideas. Tell them to turn to *Criteria and Constraints*, p. 2 to find the answers to some of the questions they came up with.
4. Have a volunteer read the criteria and constraints. As you review the information, make sure youth know:
   - They will work in groups.
   - Towers must be at least 1 foot tall (not including the model antenna).
   - Towers need to hold up the model antenna for at least 10 seconds.
   - They can use 100 index cards, masking tape, a ruler,

Tip

Criteria and constraints are introduced several times throughout this unit. It can be helpful for youth to have a general sense of the terms.

Criteria: Things that you or your design needs to do.

Constraints: Ways that you or your design are limited.

and a pair of scissors.
- The scissors and ruler can be used as tools, but cannot be used as a part of the structure.
- Groups will have 20 minutes to build their towers.
- Groups can hold the model antenna as they build, but they cannot *test* with it until the official testing time begins.

Tip

For an additional challenge, you can limit each group's masking tape to anywhere between 1 and 4 feet.

Create (20 min)

1. Pass out 100 index cards, a ruler, and scissors to each group. Have groups share the masking tape.
2. Let groups know they will have 20 minutes to engineer their towers.
3. As groups work, pass around the model antenna so everyone can hold it and get a sense of its weight, but remind youth they cannot *test* with it yet.
4. As you visit each group, ask:
    - **How did your group come up with this design?**
    - **Why do you think your design will work well?**
    - **How are you changing the shape of the cards to make them stronger?**
5. Let groups know when they have 15, 10 and 5 minutes remaining.

Test & Communicate (15 min)

1. When time is up, have groups step away from their designs and take a look at the structures other groups *created*. Ask:
    - **What do you notice that is the same about all of the designs? What is different?** *All towers are made of index cards, some were constructed using similar methods. Some groups used different strategies to build with cards and the towers are different heights.*
2. Point out that every group engineered a different solution to the same problem, and that is great! In engineering, there are always many solutions to the same problem.
3. Have groups take turns *testing*. Before testing, ask:
    - **Tell us about your design. Why did you use the materials the way you did?**
    - **What do you predict will happen during testing?**
4. Allow a group member to measure their tower and then place the model antenna on top to see if it will hold for at least 10 seconds.
5. To help youth recognize that engineers can always *improve*, ask each group:
    - **How would you *improve* your design if you had more time?**

Reflect (10 min)

1. Post the *Engineering Design Process* poster.
2. Explain that engineers use a tool called the Engineering Design Process to help them solve problems. Ask:
   - **How did your group use these steps, or steps like these, as you engineered your model tower?** *Encourage groups to link specific actions to specific steps, for example: we used the* imagine *step when we brainstormed different designs.*
3. Explain that they will continue to use the Engineering Design Process to guide their engineering work throughout the unit.
4. Tell youth that because they all used the Engineering Design Process, they are all engineers!

Prep Activity 2

What is Technology?

Educator Preview

Overview

Youth will match technologies based on the problem they solve and *imagine* ways to *improve* the newer version.

Note to Educator:
Many people think of technologies as things that are "high-tech" or powered by electricity. Technologies are actually any thing designed by humans to solve a problem. Be sure to copy enough Technology Cards so that each youth in your group has one. **Be sure to save the *Remote Sensing Definition* chart paper for use in later activities.**

Activity Timing

Introduction:	5 min
Investigate:	10 min
Imagine and Improve:	15 min
Video:	15 min
Reflect:	10 min
	55 min

21st Century Skill Highlight

Critical Thinking

Prep Activity 2 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ *Technology Match Cards*, pp.13–23 in this guide
- ☐ *Engineering Everywhere Special Report* video
- ☐ chart paper and markers
- ☐ 1 pair of scissors
- ☐ 1 roll of masking tape

For each youth

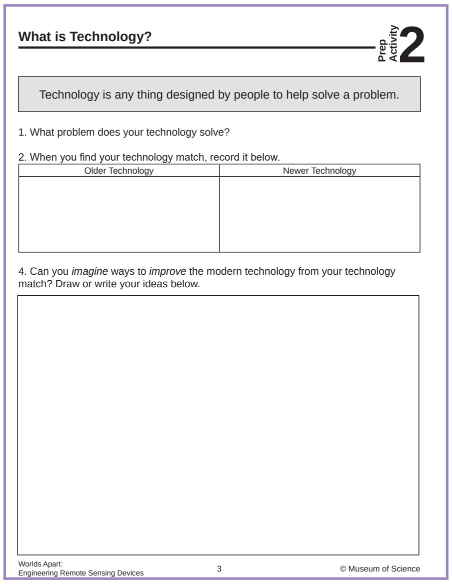
- ☐ Engineering Notebook

Prep Activity 2 Materials Preparation (10 min)

1. Post the *Engineering Design Process* poster.
2. Copy and cut out the *Technology Match Cards*, pp. 13–23 in this guide, so there is one for each student.
3. Watch and prepare to play the *Engineering Everywhere Special Report* video (10:15): eie.org/remote-sensing.

Notebook Pages for Prep Activity 2

What is Technology?, p. 3



What is Technology? Prep Activity **2**

Technology is any thing designed by people to help solve a problem.

1. What problem does your technology solve?

2. When you find your technology match, record it below.

Older Technology	Newer Technology

4. Can you *imagine* ways to *improve* the modern technology from your technology match? Draw or write your ideas below.

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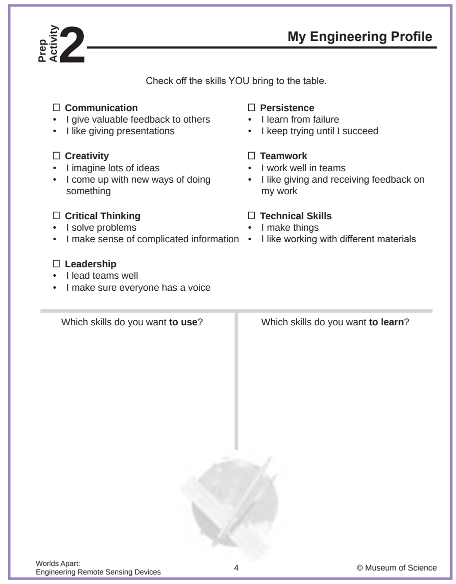
Engineering Remote Sensing Devices 3 © Museum of Science

My Engineering Profile, p. 4



Prep Activity **2** **My Engineering Profile**

Check off the skills YOU bring to the table.

☐ **Communication**
- I give valuable feedback to others
- I like giving presentations

☐ **Creativity**
- I imagine lots of ideas
- I come up with new ways of doing something

☐ **Critical Thinking**
- I solve problems
- I make sense of complicated information

☐ **Leadership**
- I lead teams well
- I make sure everyone has a voice

☐ **Persistence**
- I learn from failure
- I keep trying until I succeed

☐ **Teamwork**
- I work well in teams
- I like giving and receiving feedback on my work

☐ **Technical Skills**
- I make things
- I like working with different materials

Which skills do you want **to use**?	Which skills do you want **to learn**?

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Engineering Remote Sensing Devices 4 © Museum of Science

What is Technology?

Youth will learn:
- A technology is any thing designed by humans to solve a problem.
- Engineers design and *improve* technologies.
- There are always opportunities to *improve* existing technologies.

Introduction (5 min)

1. Tell youth that today they are again going to be working as engineers. They will think about how engineers design and *improve* technologies.
2. Guide youth to think about the word technology. Ask:
   - **What are some technologies you can think of?** *For now, accept all answers.*
3. Write the definition of "technology": *Any thing designed by humans to solve a problem.*
4. Ask:
   - **Based on this definition, do you think people throughout history used technologies? Can you give any examples?** *Yes, things like candles and paper maps might be "old technologies," but they were designed to solve the problems of their time.*
   - **Why do you think technologies change over time?** *People's needs change, better materials are developed over time.*

Investigate (10 min)

1. Show the group a pair of Technology Cards that solve the same problem. Ask:
   - **What problem do these two technologies solve?**
2. Let youth know they will play a game to think more about technology and how it changes over time.
3. Have youth come up to the front of the room and tape a Technology Match Card to each of their backs. Explain that they will need to ask each other questions about the function of the technology without saying what it is, and find someone with a technology that solves the same problem.
4. Give youth a few minutes to talk with each other and try to find a match for their technology.
5. Once all youth have found a partner, have a few pairs share their technology matches. Ask:
   - **What are the technologies you matched? What problem do they both solve?**

Tip

Using the term "engineer" will help youth become more comfortable with it!

Tip

Natural objects on their own are not technologies. People can turn those objects into technologies, however, if they use it to solve a problem. For example, a rock can be used to grind corn or shaped into an arrowhead.

Tip

If youth are not familiar with the technologies on the cards, have them work in groups to figure out the pairs together.

Tip

Encourage youth to find multiple connections between technologies.

Tip

Encourage youth to think creatively about what parts of their technology they might *improve*, or come up with a brand new way to solve the problem.

- **Which technology do you think was engineered first?**
- **Why do you think the newer technology was engineered?** *People were not satisfied with the first technology, the newer technology is easier to use.*

6. Let youth know that engineers are the people who design and *improve* technologies!

Imagine and Improve (15 min)

1. Explain to youth that just as engineers throughout history *improved* the first technology in their pair, engineers today may find ways to *improve* the newer technology even more.
2. Let youth work with their technology partners to *imagine* ways to *improve* their newer technologies. Youth can record their ideas on *What is Technology?*, p. 3 in their Engineering Notebooks.
3. After about 10 minutes, have a few pairs share their improvements with the group, and ask:
   - **Are there other technologies in your life you think engineers should *improve*? Why?**

Special Report Video (15 min)

Tip

Help youth unpack the term “remote sensing technology” even further: “remote” refers to something that is far away or distant, and “sensing” refers to the way we collect and become aware of information.

1. Let youth know you have more to share about the work of engineers. Ask:
   - **What do you think the term “remote sensing” means?**
2. Use chart paper and markers to record youth’s ideas. Accept all answers for now.
3. Explain that youth will watch a short video to learn more about field of remote sensing and the types of technologies that scientists and engineers use. Play the *Engineering Everywhere Special Report* video (10:15): eie.org/remote-sensing.
4. After the video, ask:
   - **How have your ideas about “remote sensing” changed?**
5. Write “*Remote sensing: to collect information from a distance.*” on chart paper and post it on the wall. Ask:
   - **Why might scientists and engineers want to collect information from a distance?** *A place or object they want to learn about is hidden, too far away, or dangerous to visit in person.*
   - **What are some examples of remote sensing technologies that you have seen or used?** *Telescopes, binoculars, cameras, X-ray, etc.*
6. Tell youth that their challenge over the next few days is to engineer remote sensing technologies to help a group of scientists with a problem, just like they saw in the video.

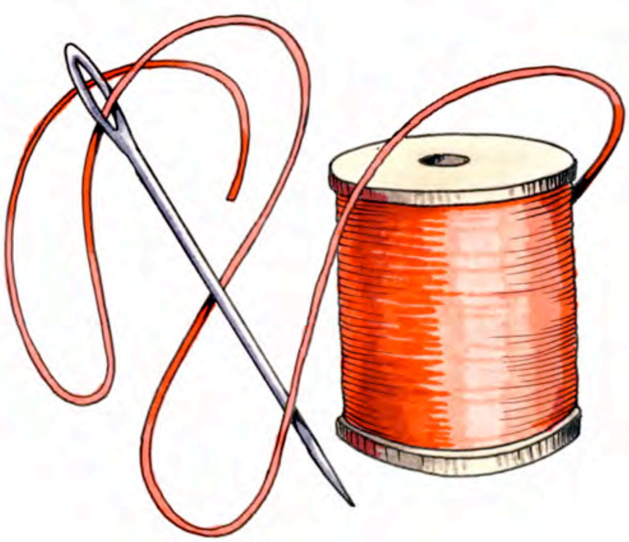
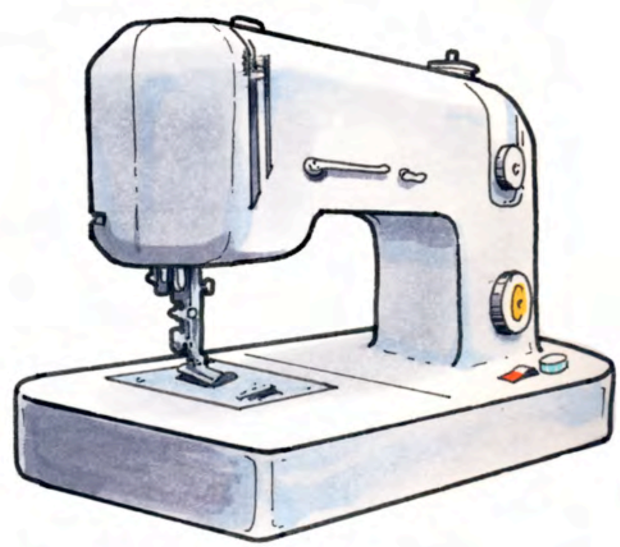
7. Explain the scientists' problem to youth: A new moon has been discovered in the solar system and scientists are interested in learning about its landscape and features before they send astronauts to explore it. They need the help of engineers like you to design remote sensing technologies that can collect information about the moon from a distance, so they will know what to plan for in future explorations.
8. Let youth know that they will learn more about this problem and ways to solve it in the next activity.

Reflect (10 min)

1. Have youth examine the *Engineering Design Process* poster. Ask:
    - **Which steps of the Engineering Design Process did you use today?** *We* identified *a problem,* improved *a technology, and* communicated *our ideas.*
2. Have youth fill out *My Engineering Profile,* p. 4 in their Engineering Notebooks, to reflect on engineering skills they feel are strengths for them, as well as any engineering skills they would like to work on throughout the unit. Giving youth time to fill out *My Engineering Profile* will help reinforce the idea that they are engineers and guide them to reflect on themselves as engineers.

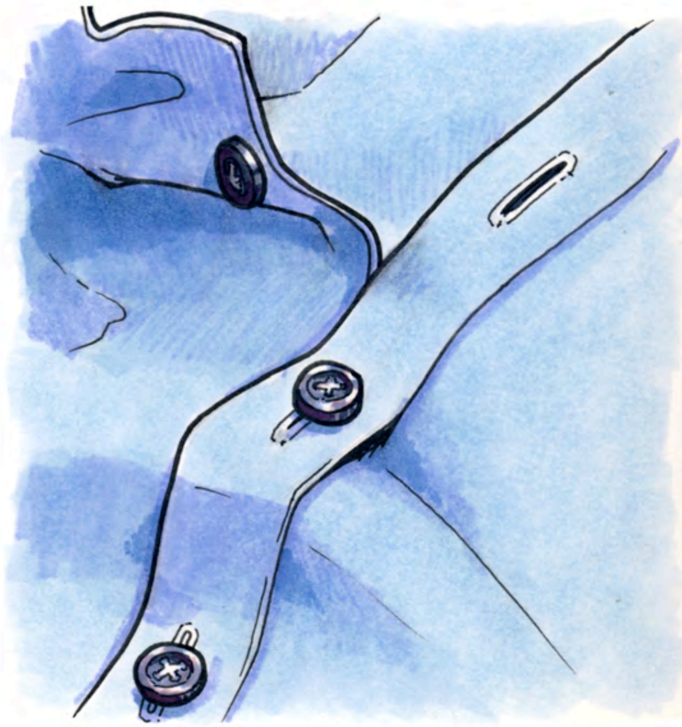
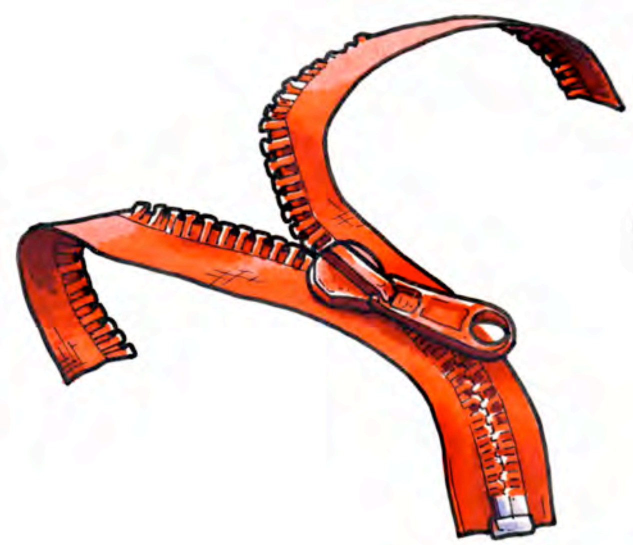
Prep Activity 2

Technology Match Cards

 Bicycle	 Scooter
 Needle and Thread	 Sewing Machine

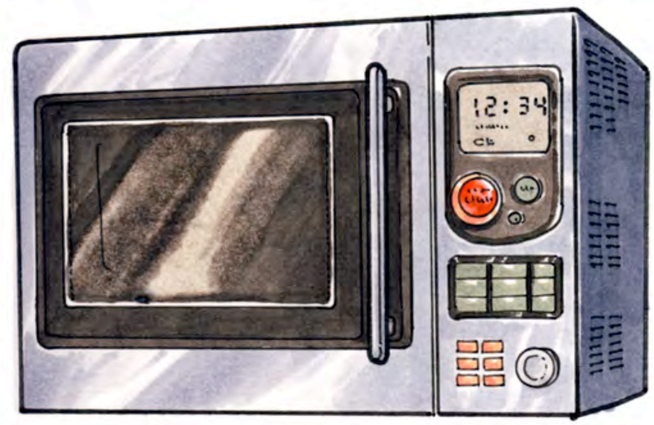
Prep Activity

2 Technology Match Cards

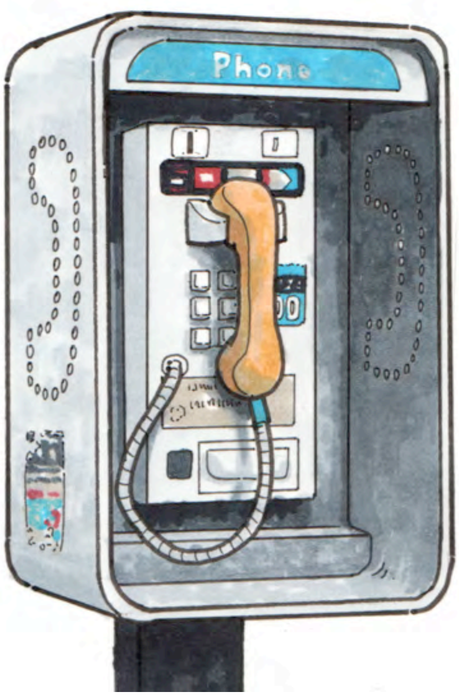
 Buttons	 Zipper
 Coin	 Card

Technology Match Cards

Campfire



Microwave



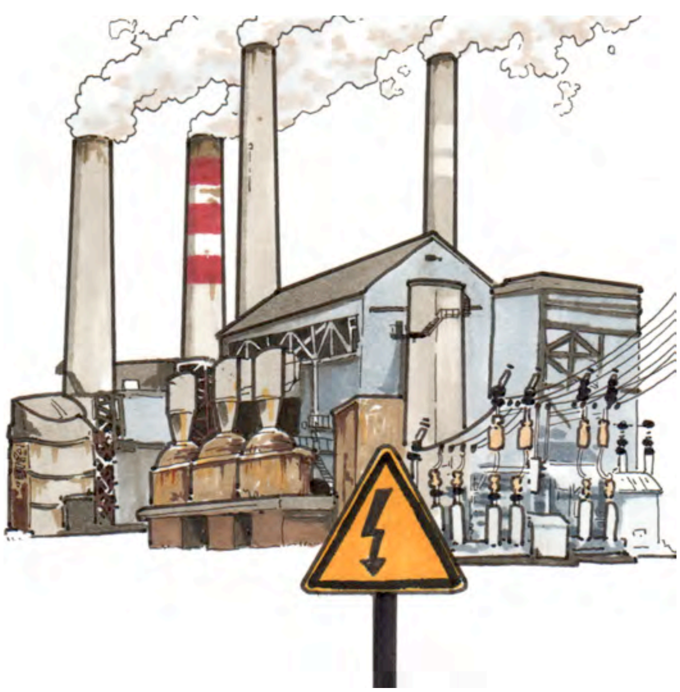
Payphone

Smartphone

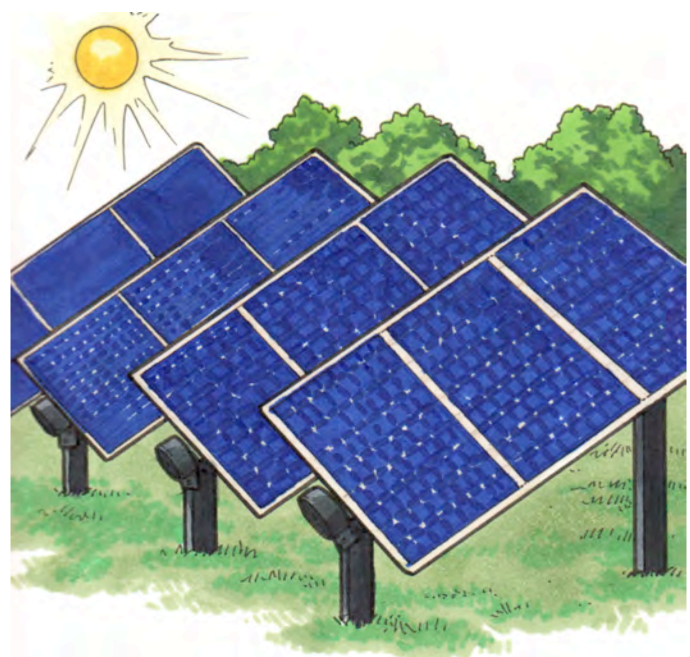
Prep Activity 2 Technology Match Cards

Hourglass

Stopwatch



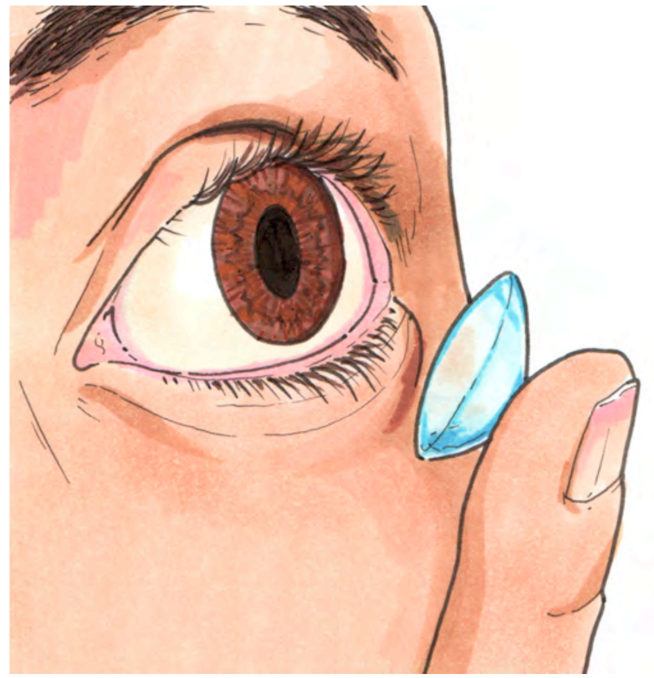
Coal-Burning Power Plant



Solar Power

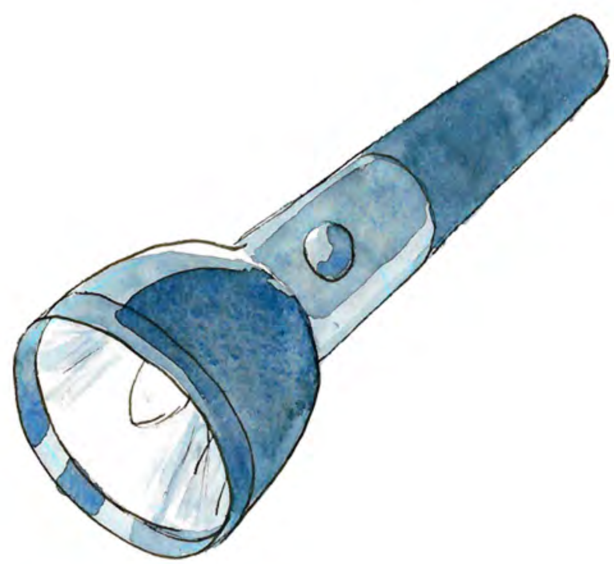
Prep Activity 2 Technology Match Cards

Glasses



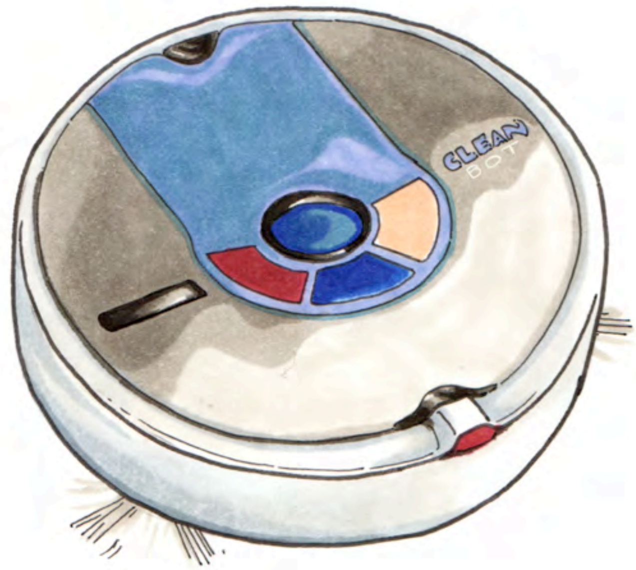
Contact Lenses

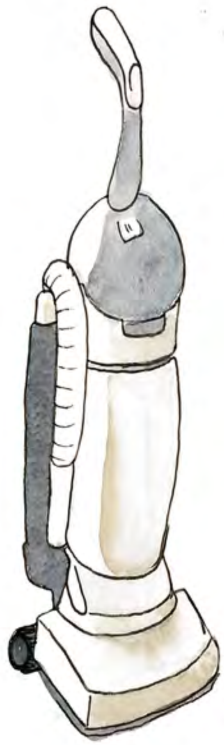
Candle



Flashlight

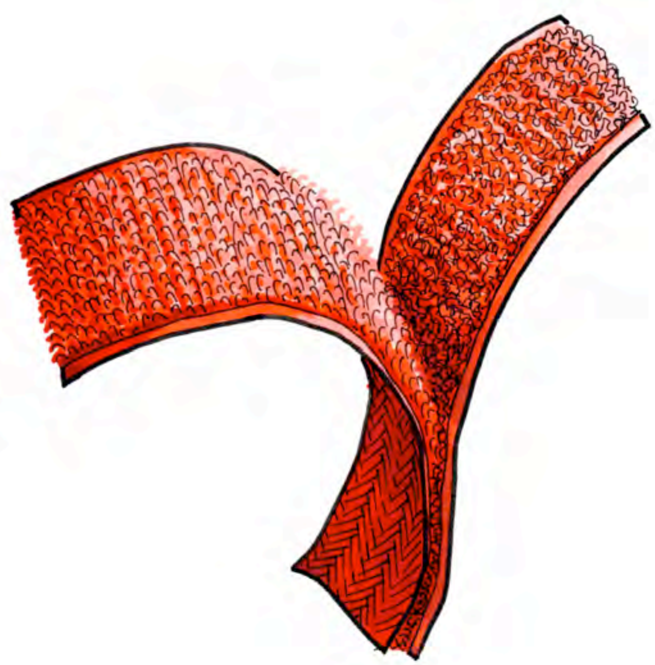
Prep Activity 2 Technology Match Cards





Upright Vacuum

Robotic Vacuum



Shoelaces

Velcro®

Activity **1** # Looking Beyond

Educator Preview

Overview

Youth *investigate* technologies that use mirrors to change the way light travels in order to collect information from a distance.

Note to Educator:
The periscopes youth create in this activity do not use curved mirrors or lenses, so they will not make objects appear closer, like a telescope would. You can add these specialized materials to the challenge if time allows. Providing recycled containers like juice cartons can help youth quickly change the shape of their periscopes as they improve. Bring in a few of these items for youth to use, if available.

Review the preparation for Activities 4, 5, and 6 on p. 26 in this guide. Consider preparing the Space Screens and model landscapes in parts, or set aside at least an hour to assemble them in one session.

Activity Timing

Introduction:	5 min
Investigating Mirrors:	15 min
Periscopes:	30 min
Reflect:	10 min
	60 min

21st Century Skill Highlight

Critical Thinking
Collaboration

Activity 1 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ *Remote Sensing Definition* chart paper
- ☐ 1 box or other obstacle, 7” x 5” x 3” or larger
- ☐ 1 index card
- ☐ 1 pipe cleaner

For the Materials Table

- ☐ 8 packs of crayons
- ☐ 8 packs of markers
- ☐ 25 sheets of construction paper
- ☐ 25 straws
- ☐ optional: curved mirrors or lenses
- ☐ optional: recycled containers

For each group of 3

- ☐ 1 index card
- ☐ 1 manila folder
- ☐ 1 pair of scissors
- ☐ 1 pipe cleaner
- ☐ 1 roll of masking tape
- ☐ 1 small box or other obstacle
- ☐ 6 mirrors
- ☐ 12 binder clips, medium

For each youth

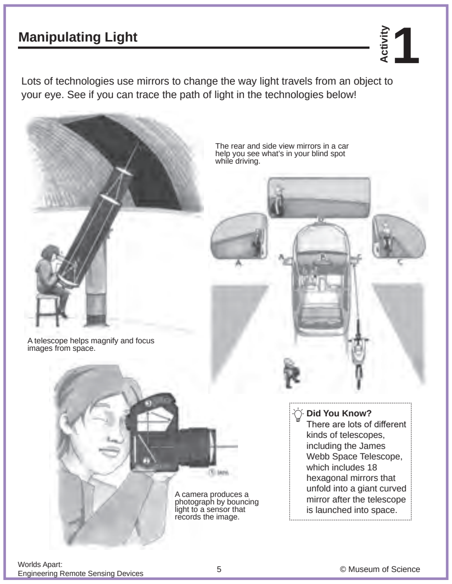
- ☐ Engineering Notebook

Activity 1 Materials Preparation (15 min)

1. Post the *Engineering Design Process* poster and *Remote Sensing Definition* chart paper.
2. Set up a sample obstacle course according to *Obstacle Course Setup*, p. 31 in this guide.
3. Create a Materials Table with the materials listed above.

Notebook Pages for Activity 1

Manipulating Light, p. 5


Manipulating Light

Activity 1

Lots of technologies use mirrors to change the way light travels from an object to your eye. See if you can trace the path of light in the technologies below!

The rear and side view mirrors in a car help you see what's in your blind spot while driving.

A telescope helps magnify and focus images from space.

A camera produces a photograph by bouncing light to a sensor that records the image.

Did You Know?
There are lots of different kinds of telescopes, including the James Webb Space Telescope, which includes 18 hexagonal mirrors that unfold into a giant curved mirror after the telescope is launched into space.

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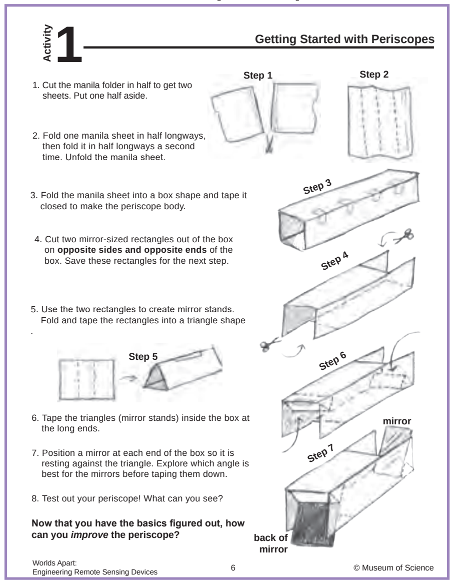
Getting Started With Periscopes, p. 6


Activity 1

Getting Started with Periscopes

1. Cut the manila folder in half to get two sheets. Put one half aside.
2. Fold one manila sheet in half longways, then fold it in half longways a second time. Unfold the manila sheet.
3. Fold the manila sheet into a box shape and tape it closed to make the periscope body.
4. Cut two mirror-sized rectangles out of the box on **opposite sides and opposite ends** of the box. Save these rectangles for the next step.
5. Use the two rectangles to create mirror stands. Fold and tape the rectangles into a triangle shape
6. Tape the triangles (mirror stands) inside the box at the long ends.
7. Position a mirror at each end of the box so it is resting against the triangle. Explore which angle is best for the mirrors before taping them down.
8. Test out your periscope! What can you see?

Now that you have the basics figured out, how can you *improve* the periscope?

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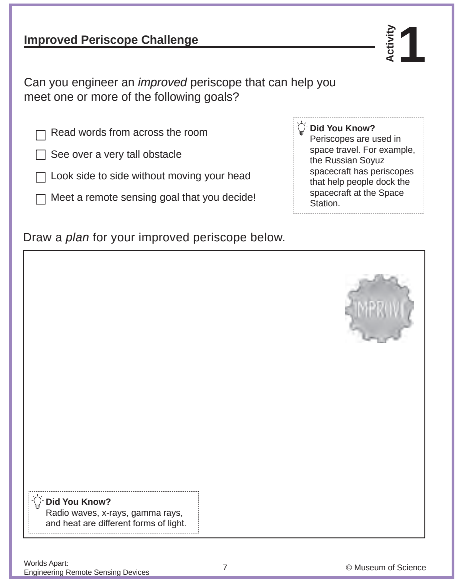
Improved Periscope Challenge, p. 7


Improved Periscope Challenge

Activity 1

Can you engineer an *improved* periscope that can help you meet one or more of the following goals?

- ☐ Read words from across the room
- ☐ See over a very tall obstacle
- ☐ Look side to side without moving your head
- ☐ Meet a remote sensing goal that you decide!

Did You Know?
Periscopes are used in space travel. For example, the Russian Soyuz spacecraft has periscopes that help people dock the spacecraft at the Space Station.

Draw a *plan* for your improved periscope below.

Did You Know?
Radio waves, x-rays, gamma rays, and heat are different forms of light.

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Activity Preparation (continued from p. 25)

Preparation for Activities 4, 5, and 6 (60 min)

The final design challenge for this unit requires the educator to prepare a multi-part model so youth can test their remote sensing devices on the surface of a Mystery Moon. **Consider preparing the following models in parts, or set aside at least an hour to assemble them in one session.**

- Model Landscapes for Site A (2 copies) and Site B (2 copies) on the Mystery Moon
- Space Screens that prevent youth from looking at the model landscapes on the opposite side and represent the distance between the Earth and the Mystery Moon

The complete instructions for building Sites A and B and the Space Screens are outlined on pp. 51–53 in this guide. Since remote sensing engineers would not be able to see the surface of the Mystery Moon up close, it is important that youth use only the remote sensing devices they create to gather information about each site. Keep the model landscapes covered when not in use until groups complete their tests in Activity 5.

Activity 1 Looking Beyond

Activity Guide

Youth will learn:
- They can use mirrors to collect information from a distance by changing the way light travels.
- *Investigate* is an important step of the Engineering Design Process.

Introduction (5 min)
1. Have youth think back to the video they watched in the last activity. Refer to the *Remote Sensing Definition* chart paper from Prep Activity 2 to remind youth of their challenge over the next few days. Ask:
   - **What kinds of problems can remote sensing help us solve?** *Remote sensing can help us solve problems where we need to collect information from a distance.*
   - **What problem do the scientists need help solving?** *They need to collect information about the surface of the Mystery Moon, before they send astronauts to explore it.*
2. Let youth know that today they will *investigate* how they can use mirrors to reveal objects that are difficult to see.
3. Have youth turn to *Manipulating Light*, p. 5 in their Engineering Notebooks, to see how technologies like cars and cameras use mirrors to change the way light travels from an object to your eye.
4. Let youth know that today, they will use mirrors to change the way light travels so they can see objects remotely, even if they are hidden from view.

Investigating Mirrors (15 min)
1. Gather youth around the sample obstacle course you prepared and explain:
   - Each group will build an obstacle course at their tables, similar to the one shown, by drawing on a folded index card, and placing it behind an obstacle.
   - Youth will look through the pipe cleaner hoop, or eyepiece, and *investigate* how to arrange the mirrors on the table to bring the drawing into view, even though it is completely hidden behind the obstacle.
2. Split youth into groups of 3 and have a volunteer collect mirrors and small binder clips for each group.
3. Give groups a few minutes to build their obstacle courses, and start positioning the mirrors to reflect light around the obstacle, until they can see the drawing through the

Tip

Replay the *Special Report* video from (3:07-3:28) to remind youth how scientists and engineers at NASA's Jet Propulsion Laboratory use technologies that change the path of light to collect information from a distance.

Tip

If youth already have a basic understanding of how light travels, consider running the Exploring Mirrors and Periscope portions of this activity as stations, and have youth choose where to spend their time.

Tip

Consider assigning roles for group members to keep everyone focused on the challenge.

eyepiece. As they are working, check in and ask:

- **What was hard about using mirrors to try to see behind the obstacle?** *Youth may say it was difficult see the whole drawing right away, keep changing the angle of the mirrors, or adjust the mirrors to be very precise.*
- **What advice would you give to other groups?** *Youth may suggest that it helps to move the mirrors a little bit at a time and make sure they are secure in the mirror stands.*

Periscopes (30 min)

1. After groups practice manipulating light using mirrors, have them turn to *Getting Started With Periscopes*, p. 6 in their Engineering Notebooks. Let youth know they can use this page to *create* a technology that uses mirrors to collect information from a distance.
2. Give groups about 20 minutes to build a basic periscope and test it out on the optical obstacle course. As they work, circulate around to each group and ask:
   - **What is working well about your periscope design?**
   - **What can be *improved*?**
3. As groups find success, have them turn to *Improved Periscope Challenge*, p. 7 in their Engineering Notebooks and revisit the Materials Table for additional materials. Ask them to design a periscope that can help them meet one or more of the following goals:
   - See over a very tall obstacle
   - Look side to side without moving their heads
   - Meet another goal that youth decide
4. Let groups know when they have 10 and 5 minutes left.

Reflect (10 min)

1. As youth finish engineering their periscopes, have each group share their design and the challenge they chose with the full group. Encourage groups to explain how they modified the basic periscope to meet their specific challenge.
2. After all groups have shared, let youth know that in the activities ahead, they will get to combine their periscopes with other technologies to create a detailed picture of the distant landscapes on the Mystery Moon.
3. Gather youth in front of the Engineering Design Process poster. Ask:
   - **What steps of the Engineering Design Process did you use today?** *All groups* investigated*. Some groups* planned, created, tested *and* communicated *if they completed the periscope challenge.*
4. Remind youth that remote sensing technologies that use

Tip

Youth may choose to improve on the basic periscope in a number of ways, such as changing the shape of the periscope body or adding handles to easily change the angle of the mirrors inside.

Tip

While youth may find it easy to move around the room to see around obstacles, remind them that working from behind the controls of a spacecraft or telescope would be much harder!

Tip

If there is not enough time to discuss each periscope design with the full group, consider having groups pair up and share with each other.

mirrors are just one way scientists and engineers collect information from a distance. Youth will learn about another type of technology that can reveal information in the next activity.

5. Congratulate youth on their excellent engineering work today.
6. Remind youth to disassemble their periscopes and return the mirrors and binder clips to the Materials Table for use in later activities.

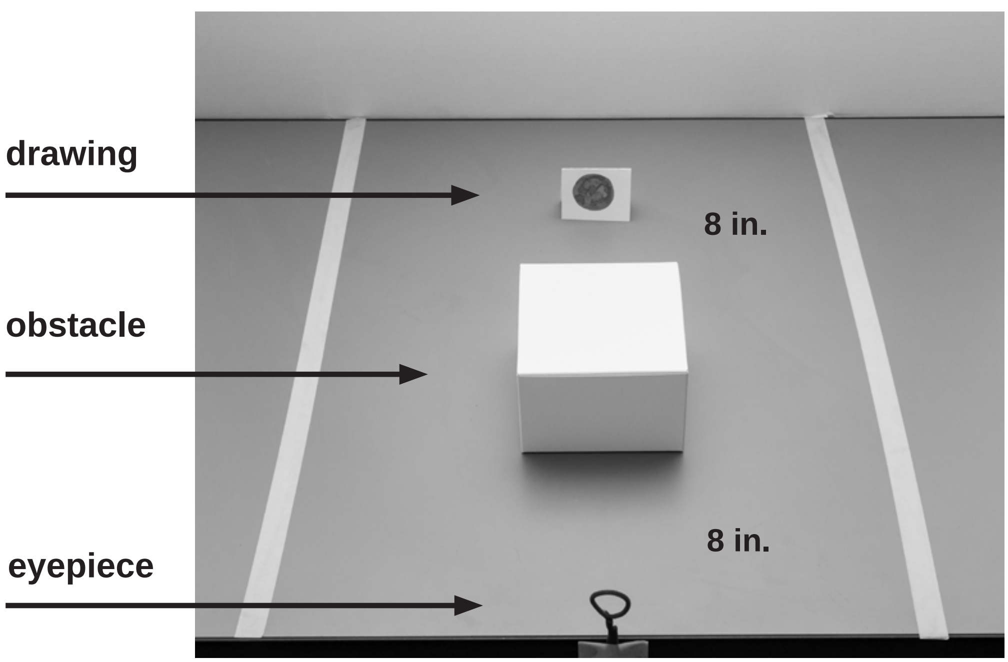
Activity
1 Obstacle Course Setup

Make an eyepiece

- Take a pipe cleaner and twist a loop about 1 inch in diameter, curling the pipe cleaner around itself to close the loop.
- Bend the excess back.
- Tape the eyepiece to the edge of a table.

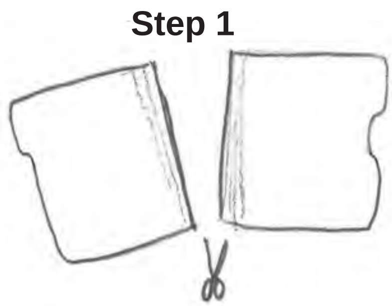
Set up a sample optical obstacle course

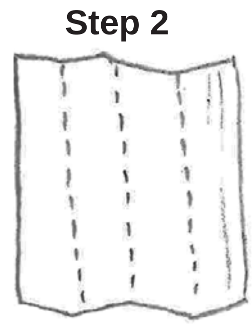
- Fold an index card in half so it stands upright and make a drawing that youth will try to see using the mirrors.
- Place an obstacle, like a box or stacked textbooks, between the eyepiece and the drawing. The obstacle should be about 8 inches away from the drawing and 8 inches away from the eyepiece.
- Use masking tape to make boundary lines around the obstacle course. Youth can arrange their mirrors anywhere inside these lines.



Activity 1 Getting Started with Periscopes

1. Cut the manila folder in half to get two sheets. Put one half aside.



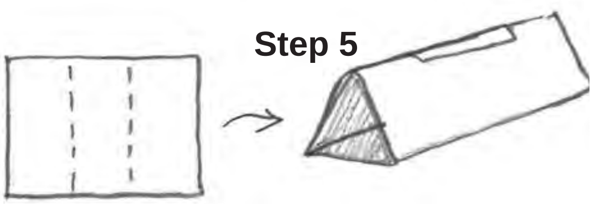


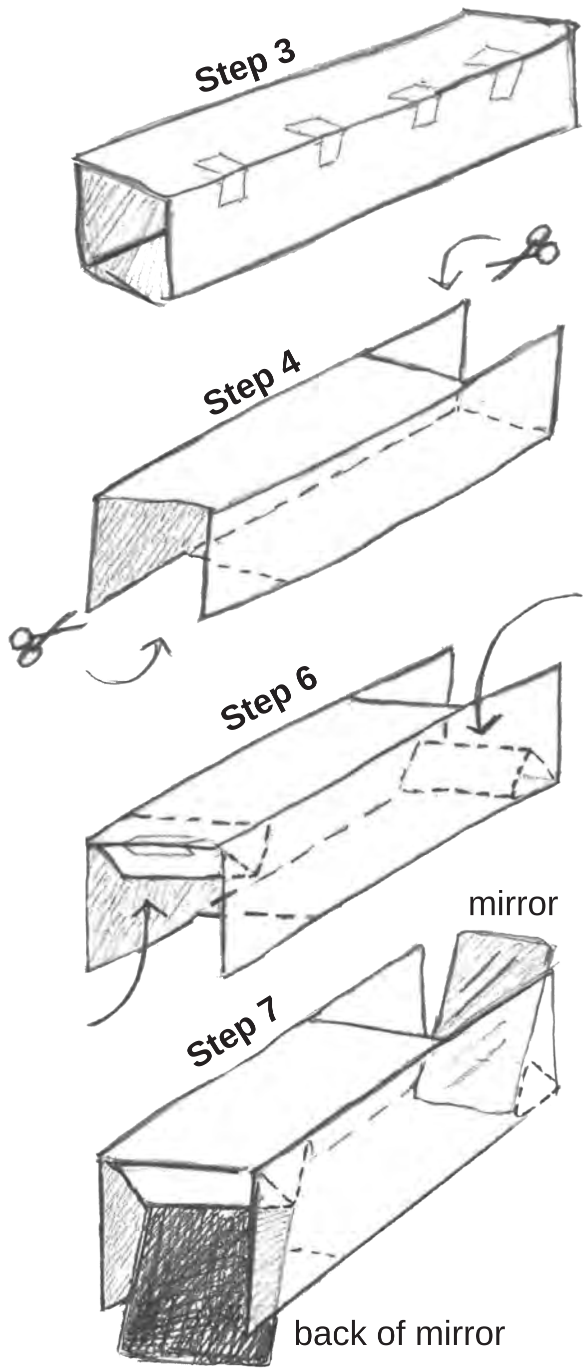
2. Fold one manila sheet in half longways, then fold it in half longways a second time. Unfold the manila sheet.

3. Fold the manila sheet into a box shape and tape it closed to make the periscope body.

4. Cut two mirror-sized rectangles out of the box on **opposite sides and opposite ends** of the box. Save these rectangles for the next step.

5. Use the two rectangles to create mirror stands. Fold and tape the rectangles into a triangle shape
.





6. Tape the triangles (mirror stands) inside the box at the long ends.

7. Position a mirror at each end of the box so it is resting against the triangle. Explore which angle is best for the mirrors before taping them down.

8. Test out your periscope! What can you see?

Now that you have the basics figured out, how can you *improve* your periscope?

Activity 2 Secret Messages

Educator Preview

Overview

Youth manipulate light and color to reveal visual information.

Note to Educator:
Remote sensing technologies can be combined with other technologies, like optical filters, to enhance the information they receive. While the filters themselves are not a remote sensing technology, youth will explore how these tools can work together to reveal and help make sense of information from a distance.

Youth will work in groups of 4 for this activity so they can easily split into pairs to test their secret messages.

Review the preparation for Activities 4, 5, and 6 on p. 36 in this guide. Consider preparing the Space Screens and model landscapes in parts, or set aside at least an hour to assemble them in one session.

Activity Timing

Introduction:	5 min
Investigate:	25 min
Secret Messages:	20 min
Reflect:	5 min
	55 min

21st Century Skill Highlight

Critical Thinking
Communication

Activity 2 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ *Remote Sensing Definition* chart paper
- ☐ chart paper and markers
- ☐ 50 sheets of copy paper
- ☐ 1 pair of scissors
- ☐ 1 roll of masking tape
- ☐ 2 sheets of cellophane, blue
- ☐ 2 sheets of cellophane, red

For each youth

- ☐ Engineering Notebook

For each group of 4

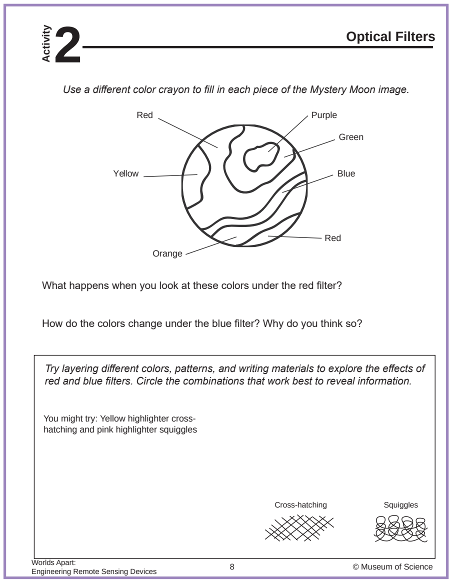
- ☐ 1 box of crayons
- ☐ 1 pack of highlighters, assorted colors

Activity 2 Materials Preparation (10 min)

1. Post the *Engineering Design Process* poster and the *Remote Sensing Definition* chart paper.
2. Draw the *Optical Filter Investigations* chart, p. 36 in this guide, on the chart paper and post it near the *Engineering Design Process* poster.
3. Prepare a Materials Table with the materials listed above.

Notebook Pages for Activity 2

Optical Filters, p. 8



Activity **2** **Optical Filters**

Use a different color crayon to fill in each piece of the Mystery Moon image.

What happens when you look at these colors under the red filter?

How do the colors change under the blue filter? Why do you think so?

Try layering different colors, patterns, and writing materials to explore the effects of red and blue filters. Circle the combinations that work best to reveal information.

You might try: Yellow highlighter cross-hatching and pink highlighter squiggles

Cross-hatching Squiggles

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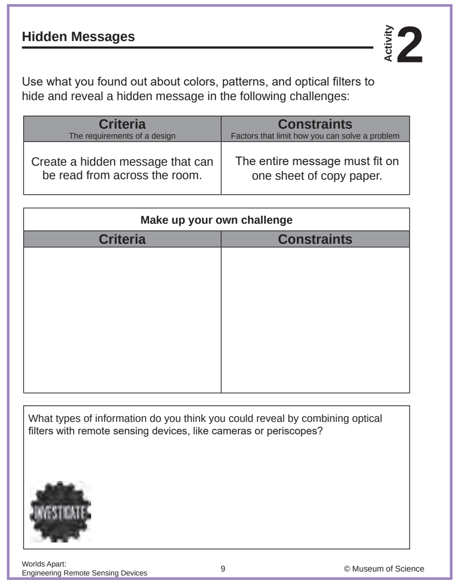
Hidden Messages, p. 9



Hidden Messages Activity **2**

Use what you found out about colors, patterns, and optical filters to hide and reveal a hidden message in the following challenges:

Criteria The requirements of a design	Constraints Factors that limit how you can solve a problem
Create a hidden message that can be read from across the room.	The entire message must fit on one sheet of copy paper.

Make up your own challenge	
Criteria	**Constraints**

What types of information do you think you could reveal by combining optical filters with remote sensing devices, like cameras or periscopes?

INVESTIGATE

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Chart for Activity 2

Optical Filter Investigations

Colors and Writing Materials	Filter

Activity Preparation (continued from p. 35)

Preparation for Activities 4, 5, and 6 (60 min)

The final design challenge for this unit requires the educator to prepare a multi-part model so youth can test their remote sensing devices on the surface of a Mystery Moon. **Consider preparing the following models in parts, or set aside at least an hour to assemble them in one session.**

- Model Landscapes for Site A (2 copies) and Site B (2 copies) on the Mystery Moon
- Space Screens that prevent youth from looking at the model landscapes on the opposite side and represent the distance between the Earth and the Mystery Moon

The complete instructions for building Sites A and B and the Space Screens are outlined on pp. 51–53 in this guide. Since remote sensing engineers would not be able to see the surface of the Mystery Moon up close, it is important that youth use only the remote sensing devices they create to gather information about each site. Keep the model landscapes covered when not in use until groups complete their tests in Activity 5.

Activity 2 Secret Messages

Youth will learn:
- They can combine technologies, like optical filters, with remote sensing devices to reveal information.
- Manipulating colors can help them make sense of complex visual data.

Tip

Replay the *Special Report* video from (2:14-3:54) to remind youth how scientists and engineers at NASA's Jet Propulsion Laboratory combine remote sensing technologies in spacecraft like the Mars Reconnaissance Orbiter.

Tip

Youth may be familiar with photo-editing filters that use light and color to highlight certain aspects of a photo. Other types of image filters operate inside a camera, and collect specialized information about a subject before the photo is snapped.

Introduction (5 min)

1. Have youth think back to the previous activities. Ask:
   - **What is the problem the scientists are trying to solve?** *They need to find out what the surface of the Mystery Moon is like, before astronauts can go there.*
2. Explain to youth that the scientists need help finding out about the minerals astronauts might find on the Mystery Moon. These minerals are difficult to identify just by looking at the surface. Ask:
   - **Why might scientists want to know which minerals are on the Mystery Moon?** *There might be water there, or signs of life. They might want to know how the moon was formed.*
   - **Has anyone seen or used a technology that helps reveal hidden information?** *Accept all answers. Youth may say X-rays, photographic filters, polarized sunglasses, infrared cameras, blacklight/UV light, etc.*
3. Explain that technologies that manipulate light and color, like the examples youth gave, can be combined with remote sensing devices to help the scientists find out even more about the Mystery Moon.
4. Hold up a piece of cellophane. Explain that youth will *investigate* optical filters like this cellophane, which hides certain colors and reveals others, to help them make sense of complex visual data.

Investigating Optical Filters (25 min)

1. Show youth the materials they will investigate today (crayons, highlighters, and different colors of cellophane).
2. Split youth into groups of 4 and assign one person from each group to gather paper, crayons, highlighters, and two sheets of red and blue cellophane from the Materials Table.
3. Explain that youth will share materials among their group but may work independently for this part of the activity.
4. Have youth turn to *Optical Filters*, p. 8 in their Engineering Notebooks and follow the instructions, using crayons to color

> **Tip**
>
> Since white reflects all colors, it creates a visual distraction with both red and blue cellophane. Patterns that use white space, like cross-hatching or squiggles, hide messages better than solid color.

> **Tip**
>
> Youth who are interested can learn more about another remote sensing technique that uses light and color, called spectrometry, in the Science Extension Activity for this unit.

> **Tip**
>
> If groups finish early, have them use extra manila folders and tape to combine their optical filters with familiar technologies, like glasses.

in the image of the Mystery Moon.

5. Have youth cut the cellophane into half sheets so each youth has one half sheet of each material and *investigate* how the colors in their drawing change, with and without cellophane filters placed over them.
6. As youth are working, circulate among the groups and ask:
   - **Which colors disappear under the red filter?** *Red, orange, yellow.*
   - **Which colors become easier to see under the red filter? Why do you think that is?** *Blue, green. The red cellophane blocked all the colors that are similar to red and enhanced the ones that are similar to blue.*
   - **Do you see a difference if you fold the filter in half? In quarters?** *Yes, the effect of the filter becomes stronger, making certain colors easier to see.*
7. Have youth continue their investigations by *creating* and *testing* their own combinations of colors and patterns on p. 8 in their Engineering Notebooks.

Hidden Messages (20 min)

1. Gather the group back together and let youth know they will now use what they learned about manipulating light and color to communicate a secret message to a partner.
2. Have youth turn to *Hidden Messages*, p. 9 in their Engineering Notebooks, to review the criteria and constraints of their challenge.
3. Give youth 5 minutes to write a message and hide it by scribbling over it with crayons and highlighters.
4. As groups finish, have partners trade messages and figure out what type of filter can help them read the hidden message clearly.
5. Have youth keep track of what they learn on *Hidden Messages*, p. 9 in their Engineering Notebooks.

Reflect (5 min)

1. Gather youth together in front of the *Engineering Design Process* poster and the *Optical Filter Investigations* chart. Ask:
   - **Which steps of the Engineering Design Process did we use today?** Investigate, create, *and* test.
2. Have a few volunteers share their secret messages with the rest of the group and record successful combinations on the *Optical Filter Investigations* chart. Ask:
   - **Which combinations of colors and filters worked well to reveal the hidden message?**
   - **How might you combine optical filters with remote**

sensing technologies, like periscopes, to help the scientists solve their problem? *We could add an optical filter to a periscope or camera to reveal information about the surface of the Mystery Moon.*

3. Save the *Optical Filter Investigations* chart for use in later activities.
4. Congratulate youth on their hard work and thorough investigations.
5. Let youth know that next time, they will learn about a remote sensing technology that uses lasers to map the shape of a surface.

Taking Shape

Overview

Youth will model a remote sensing device called LiDAR by engineering a technology to produce a 3D image of a landscape.

Note to Educator:

In this activity, each group will use several dozen straws to model the distance measured by lasers in their model LiDAR technology. Like real LiDAR, the straws provide data on the height and shape of a landscape from above. Unlike LiDAR, this model relies on physically touching the surface to make an impression using straws of a fixed length.

Complete the preparation for Activities 4, 5, and 6 on p. 42 in this guide before the next session.

Activity Timing

Introduction:	5 min
Investigate:	10 min
Mapping a Test Surface:	30 min
Reflect:	10 min
	55 min

21st Century Skill Highlight

Creativity
Collaboration

Activity 3 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ *Remote Sensing Definition* chart paper
- ☐ 1 set of 100 pattern blocks
- ☐ 20 paper cups, 8 oz.
- ☐ 20 rubber bands
- ☐ 20 sheets of craft foam
- ☐ 20 sheets of felt

For each group of 3

- ☐ 1 pair of scissors
- ☐ 1 paper plate, small
- ☐ 1 roll of masking tape
- ☐ 1 ruler
- ☐ 200 straws, regular size
- ☐ 250 straws, thin
- ☐ optional: 1 blindfold

For each youth

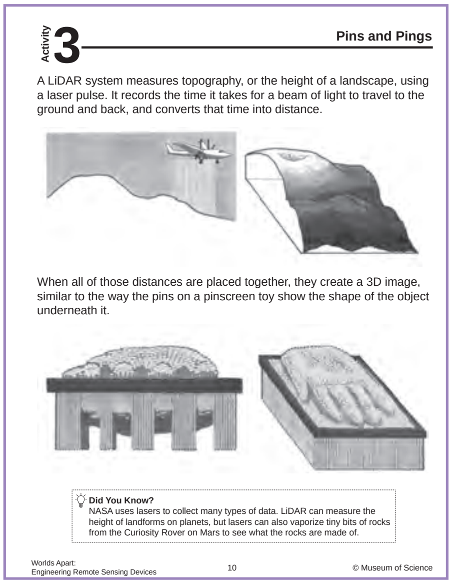
- ☐ Engineering Notebook

Activity 3 Materials Preparation (10 min)

1. Post the *Engineering Design Process* poster and the *Remote Sensing Definition* chart paper.
2. Arrange all materials on the Materials Table.
3. Bundle a handful of straws together using a rubber band or craft foam and tape, to demonstrate how youth can keep the straws packed together in their model LiDAR device.

Notebook Pages for Activity 3

Pins and Pings, p. 10


Activity 3 Pins and Pings

A LiDAR system measures topography, or the height of a landscape, using a laser pulse. It records the time it takes for a beam of light to travel to the ground and back, and converts that time into distance.

When all of those distances are placed together, they create a 3D image, similar to the way the pins on a pinscreen toy show the shape of the object underneath it.

Did You Know?
NASA uses lasers to collect many types of data. LiDAR can measure the height of landforms on planets, but lasers can also vaporize tiny bits of rocks from the Curiosity Rover on Mars to see what the rocks are made of.

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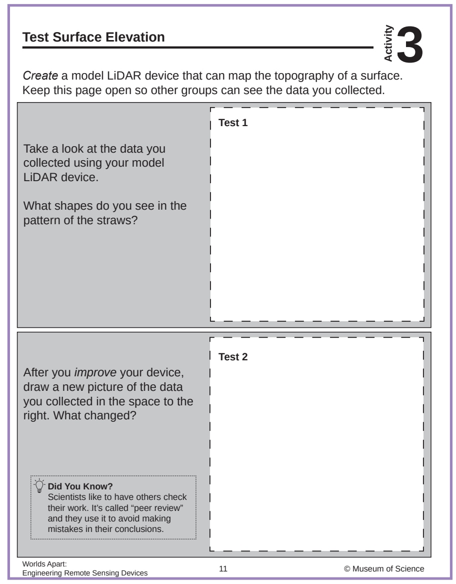
Test Surface Map, p. 11


Test Surface Elevation Activity 3

Create a model LiDAR device that can map the topography of a surface. Keep this page open so other groups can see the data you collected.

Take a look at the data you collected using your model LiDAR device.

What shapes do you see in the pattern of the straws?

Test 1

After you *improve* your device, draw a new picture of the data you collected in the space to the right. What changed?

Test 2

Did You Know?
Scientists like to have others check their work. It's called "peer review" and they use it to avoid making mistakes in their conclusions.

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Activity Preparation (continued from p. 41)

Preparation for Activities 4, 5, and 6 (60 min)

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Example model LiDAR device and test surface

Youth will learn:

- Scientists and engineers use remote sensing devices to gather information about the topographical features of a landscape.
- Engineers often use models to represent the technologies or materials they are investigating.

Introduction (5 min)

1. Remind youth that a group of scientists is interested in finding out more about the landscape and features of the Mystery Moon before they send astronauts to explore it. They need the help of engineers to design remote sensing technologies that can collect the data they need, even from far away. Ask:
   - **What remote sensing technologies have we learned about already?** *Periscopes, optical filters, and other technologies that manipulate light and color to reveal information.*
2. Explain to youth that the scientists need to know more about the topography, or the arrangement, elevation, and height, of the landforms on the Mystery Moon. Ask:
   - **What kinds of landforms would you expect to find on the Mystery Moon?** *Craters, flat areas, mountains.*
3. Have youth think back to the *Special Report* video they watched earlier. Ask:
   - **How do you think we could collect information about the shape of a landscape that is far away?** *Accept all answers.*
4. Tell youth that scientists and engineers use a remote sensing technology called LiDAR (or "Light Detection And Ranging") to map the shape of landscapes from a distance.

Investigate (10 min)

1. Have youth turn to *Pins and Pings*, p. 10 in their Engineering Notebooks. Have a volunteer read the information about LiDAR and pinscreens. Ask:
   - **How is the pinscreen similar to LiDAR?** *They both measure topography and create a 3D image.*
   - **How are they different?** *LiDAR collects data from a distance by using a laser pulse that moves across an area. The pins in a pinscreen are all the same length and need to physically touch an object to measure its*

Tip

Replay the *Special Report* video from (3:54-5:19) to remind youth how scientists and engineers at NASA's Jet Propulsion Laboratory use LiDAR to collect topographical information from a distance.

Tip

Some animals, such as bats and whales, have evolved the ability to remotely sense their surroundings using sonar, which relies on bouncing sound waves instead of light.

topographic data.

2. Let youth know that scientists often use models to represent the technologies or materials they need to *investigate*, when the real thing is too big, expensive or dangerous.
3. Hold up a straw. Explain to youth that they will use straws as a model for the laser used in LiDAR. Ask:
   - **How is the straw a good model for the LiDAR laser?** *It models the distances measured by the laser.*
   - **How is the straw not a good model for the LiDAR laser?** *In order to work in this case, it needs to actually touch the surface, so it is not really remote sensing.*
4. Split youth into groups of 3 and give each group two boxes of 100 straws.
5. Help youth become familiar with the procedure for collecting topographical data by having them loosely hold a small bundle of straws in both hands and press one end of the bundle onto small, flat objects with a recognizable shape, like the scissors or rolls of tape on their tables. Ask:
   - **What happens when the straws hit an object?** *The tops of the straws remain raised, showing the object's shape.*
   - **How can you tell when the straws hit a flat area?** *The straws are all the same height in one area.*

Tip

Encourage youth to keep a careful grip on the straws to prevent them from dropping onto the floor.

Mapping the Test Surface (30 min)

1. Let groups know they will make a test surface by stacking and taping pattern blocks to a paper plate. They will then trade their test surface with another group and *create* a device that can measure the topography of that surface.
2. Give groups a few minutes to make a test surface and *create* their model LiDAR device.
3. Explain to groups that when they *test*, they should look at the raised shape in the straws, using a ruler to measure any differences in height, and draw the shape in the first box on *Test Surface Elevation*, p. 11 in their Engineering Notebooks.
4. Have groups choose a volunteer who will operate the model LiDAR device while blindfolded. The volunteer will not be able to see the test surface and will rely on directions from the rest of the group during testing.
5. Have a volunteer from each group put on a blindfold and have groups exchange test surfaces when they are ready.
6. As groups are testing, ask:
   - **What information were you able to collect with your model LiDAR device?** *The general shape and height of objects on the test surface.*
   - **How might this information be useful to the**

Tip

If youth are not comfortable expressing the data they collected in a drawing, have them recreate the shapes from the test surface using pattern blocks.

    scientists? *They could see if there are any flat surfaces where they could land a spacecraft on the Mystery Moon.*
7. After groups test, tell them that a new material is now available. Give each group a box of thin straws and ask:
    - **How do you predict this new material will impact the data you collect?** *Accept all answers.*
8. Give youth a few minutes to add thin straws to their model LiDAR devices and collect data from the test surface again.
9. Have youth make a new drawing of the data they collected using the thin straws, and keep their Engineering Notebooks open to page 11.

Reflect (10 min)

1. Have groups take a few minutes to walk around the room and look at the drawings for each test surface as well as the model LiDAR devices youth created. Ask:
    - **What differences do you notice between Test 1 and Test 2?** *They show the same objects at different levels of detail. Edges are more defined in Test 2.*
    - **Did the new material impact the data you collected the way you thought it would?**
2. Guide youth to recognize that the drawings from Test 2 represent a higher resolution image. Smaller straws *improve* the quality of the readings because there are more data points in the same size area, just like more pixels on a screen create a sharper, higher-resolution image.
    - **Why might the scientists want to use a high resolution image?** *So they can look at specific features of a landscape in as much detail as possible.*
    - **Can you think of a reason the scientists might want to use a lower resolution image?** *They might have budget constraints, or want to map a bigger area using less detailed data as a trade-off.*
3. Gather youth around the *Engineering Design Process* poster. Ask:
    - **Which steps of the Engineering Design Process did you use today?** Investigate, create, test, *and* improve.
4. Congratulate youth on all the great engineering work they did today! Let youth know that next time, they will learn more about the scientists and start designing remote sensing devices that can help them with their missions.
5. Remind youth to disassemble their technologies and return the materials to the Materials Table for use in later activities.

Tip

If youth are unfamiliar with the idea of trade-offs, guide them to think about how improving one variable, like resolution, might negatively impact other aspects of their design, like cost or overall size.

Activity 4 Create a Remote Sensing Device

Educator Preview

Overview

Youth work in groups to *plan, create*, and *test* remote sensing devices that can collect information about the Mystery Moon.

Note to Educator:
Before beginning this activity, make sure you have finished preparing the Mystery Moon model landscapes and Space Screens. There should be two models each of Site A and Site B, one behind each Space Screen, so multiple groups can access them during testing. Save groups' designs and any remaining materials for the next activity.

Activity Timing

Introduction:	5 min
Imagine and Plan:	10 min
Create and Test:	30 min
Reflect:	10 min
	55 min

21st Century Skill Highlight

Critical Thinking
Collaboration

Activity 4 Materials

For the Mystery Moon Sites and Space Screens

- ☐ *Mineral Paper*, pp. 53–73 in this guide
- ☐ 1 bottle of white glue
- ☐ 1 roll of masking tape
- ☐ 1 utility knife
- ☐ 4 tri-fold boards
- ☐ 4 shoeboxes with lids, approx. 7” x 5” x 12”
- ☐ 6 styrofoam sheets, 12” x 12” x 1”
- ☐ 20 paper cups, 3 oz.
- ☐ 20 pieces of felt
- ☐ optional: 1 set of pattern blocks
- ☐ optional: 4 blindfolds

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ 12 sheets cellophane, blue
- ☐ 12 sheets cellophane, red
- ☐ 20 mirrors
- ☐ 25 manila folders
- ☐ 25 paper cups, 8 oz.
- ☐ 25 sheets of construction paper
- ☐ 25 sheets of craft foam
- ☐ 25 sheets of felt
- ☐ 60 binder clips, medium
- ☐ 100 rubber bands
- ☐ 2000 straws, regular
- ☐ 2000 straws, thin

For each group of 3

- ☐ 1 pair of scissors
- ☐ 1 roll of masking tape
- ☐ 1 ruler

For each youth

- ☐ Engineering Notebook

Activity 4 Materials Preparation (50 min)

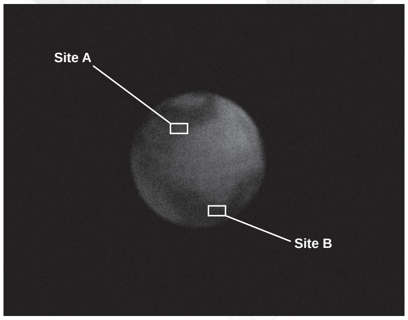
1. Post the *Engineering Design Process* poster.
2. Post the *Remote Sensing Definition* chart paper and *Optical Filter Investigations* chart paper from previous activities.

Notebook Pages for Activity 4

Mystery Moon, p. 12

Activity **4** — **Mystery Moon**

This is the only picture we have of the newly discovered moon, taken through a telescope. There are two sites that scientists have decided to explore further with remote sensing technologies.



Remote Sensing Engineering Challenge:

Your final design challenge is to engineer a remote sensing device (or devices) to collect information about the surface of the Mystery Moon for one of the three scientists.

Worlds Apart: Engineering Remote Sensing Devices 12 © Museum of Science

Scientist Cards, p. 13

Scientist Cards — Activity **4**

Scientist: **Jaime, planetary geologist**

"I am interested in the landscape of the moon. What color is the surface? Are there any mountains, valleys, or craters?"

Criteria	Constraints
Identify the landforms (mountains, valleys, craters) at Site A and Site B.	You may only use the available materials to complete your design.
Identify the colors at Site A and Site B.	You will have two sessions to engineer your remote sensing device(s).

Scientist: **Caris, planetary geologist**

"I am interested in landing a rover on this moon. Sending a rover will allow us to collect samples and more closely examine what the moon is made of. Is there a flat, open space where the rover could land safely?"

Criteria	Constraints
Identify an area for the rover to land.	You may only use the available materials to complete your design.
The landing area must be large enough for the rover to land safely (3" x 4").	You will have two sessions to engineer your remote sensing device(s).

Worlds Apart: Engineering Remote Sensing Devices 13 © Museum of Science

Scientist Cards, p. 14

Activity **4** — **Scientist Cards**

Scientist: **Alex, biologist**

"I want to know if this moon can support life. One of the most important elements to support life is water. Are there any sites that show evidence of water?"

Criteria	Constraints
Identify places on the Mystery Moon where water (represented by a triangle shape) is present. Look for landforms, like canyons, that suggest the presence of water.	You may only use the available materials to complete your design. You will have two sessions to engineer your remote sensing device(s).

Did You Know? Many animals can see a different range of colors than humans can, including the mantis shrimp, which has eyes that are like the color sensors NASA uses in spacecraft!

Did You Know? NASA planetary scientists have telescopes that can tell us about solar systems far beyond our own.

Worlds Apart: Engineering Remote Sensing Devices 14 © Museum of Science

Remote Sensing Plan, p. 15

Remote Sensing Plan — Activity **4**

Sketch a *plan* for your remote sensing device(s) in the space below. After you *test*, mark areas of your design that you would like to *improve*.

What information is your scientist interested in?
What technologies will help you collect the data they need?

Scientist: ____________ **Criteria:** ____________

How will you *improve*? You can use new materials, try a different resolution, make your devices smaller and more compact, or *improve* in another way!

PLAN

Worlds Apart: Engineering Remote Sensing Devices 15 © Museum of Science

Guidelines for Collecting Data, p. 16

Activity **4** — **Guidelines for Collecting Data**

When collecting data with your remote sensing device...

DO:
1. Only put your hands through the opening in the Space Screen to push down on straws.
2. Move device from left to right.
3. Be careful when using the Space Screen so it does not fall over or break.

DO NOT:
1. Peek around the sides or into the Space Screen opening.
2. Put your face closer to the Space Screen than the edge of the table.
3. Try to touch the inside of the model landscapes through the Space Screen.

Some of the scientists are interested in the minerals on the surface of the Mystery Moon. Use the key below to help decode your findings:

Minerals	Symbol
Water, ice	▲
Iron	●
Magnesium	★

Did You Know? NASA scientists and engineers can sometimes make mistakes, so they plan, test, and re-plan all human missions several times, to make sure that the astronauts involved are kept as safe as possible.

Worlds Apart: Engineering Remote Sensing Devices 16 © Museum of Science

Data Collection, pp. 17–18

Data Collection — Activity **4**

Use this page to record any data that you collect using your remote sensing device(s). Be sure to visit Site A and Site B.

Site A

Did You Know? Some of NASA's first spacecraft sent their data to Earth so slowly that engineers could color in the image by hand, dot-by-dot.

Worlds Apart: Engineering Remote Sensing Devices 17 © Museum of Science

Activity Preparation (continued from p. 45)

Activity 4 Materials Preparation (continued)

3. Prepare the Mystery Moon sites and Space Screens by following the instructions on pp. 51–53 in this guide.
4. Create a Materials Table with the materials above.

Create a Remote Sensing Device

Youth will learn:

- Using the steps of the Engineering Design Process can help guide them to a successful solution.
- Engineers use what they learn in the *identify* and *investigate* step to inform their design decisions.
- Engineers often collaborate with scientists to determine the criteria and constraints of a project.

Introduction (5 min)

1. Let youth know that today they will start the final design challenge with their groups. Have them turn to *Mystery Moon,* p. 12 in their Engineering Notebooks, to read about the challenge and the two sites that scientists have identified for further exploration.
2. Invite youth to look at the Space Screens and explain that the closed shoeboxes behind the screens contain model landscapes of the two sites on the Mystery Moon, Site A and Site B. Ask:
   - **Why do you think these Space Screens are important? What might they represent?** *Remind youth that remote sensing allows us to collect information from places that are far away or inaccessible. Explain that youth will explore Site A and Site B from the opposite side of the Space Screen, to represent the distance between the Earth and the Mystery Moon, using only the remote sensing devices they* create*.*

Tip

If youth have struggled with previous activities or concepts, consider starting them with the first scientist, Jaime. Once successful, youth can select a more challenging mission to engineer for.

Imagine and Plan (10 min)

1. Split youth into groups of 3.
2. Give groups a chance to read the *Scientist Cards*, pp. 13–14 in their Engineering Notebooks, and choose a scientist to work with.
3. Have youth turn to *Guidelines for Collecting Data*, p. 16 in their Engineering Notebooks to *imagine* how they might use their remote sensing devices before they *plan*.
4. Remind youth about the materials they can use in their designs and the types of technologies they learned about: periscopes, optical filters, and LiDAR. Let them know that scientists often combine different remote sensing devices in a single spacecraft to collect all the information they need.
5. Give groups a few minutes to *imagine* and *plan* their designs,

keeping the scientist's criteria and constraints in mind. Youth can record their ideas on *Remote Sensing Plan*, p. 15 in their Engineering Notebooks.

6. As groups are *planning*, circulate around the room and ask:
   - **What types of information will you look for on the Mystery Moon?**
   - **Which remote sensing technologies will help you collect the data your scientist needs?**

Create and Test (30 min)

1. After groups have finished *planning*, have them gather materials from the Materials Table and begin *creating* their remote sensing devices. Make sure youth know their device should be able to fit through the opening in the Space Screen.
2. When groups are ready to *test* their remote sensing devices, remove the lids from the shoeboxes so that they can collect information from Sites A and B.
3. Have groups record what they learn about the sites on *Data Collection*, pp. 17–18 in their Engineering Notebooks. While they are working, ask:
   - **Is your remote sensing device working the way you *imagined* it would?**
   - **What types of data can you collect?**
   - **Are you meeting your scientist's criteria?**
4. Let groups know when they have 10 and 5 minutes remaining.

Tip

Youth can use pattern blocks from Activity 1 to *test* their device's ability to collect data before testing on Sites A and B.

Tip

It is OK if groups need more time to collect data from both Site A and Site B. They will have time to finish working on their designs in the next activity.

Reflect (10 min)

1. Have groups come together to share their remote sensing technologies. Ask each group:
   - **Was there anything that surprised you about collecting data with your remote sensing device?**
   - **How might you *improve* your design?**
2. Let youth know that they will have time to *improve* their remote sensing devices in the next activity.
3. Have groups gather around the Engineering Design Process poster and ask:
   - **Which steps of the Engineering Design Process did you use today?** *We* imagined*,* planned, created *and* tested *our designs to collect data about the Mystery Moon.*
4. Label and store groups' designs in a safe location so they can *improve* them in the next activity.
5. Congratulate youth on their excellent engineering work!

Activity 4 Mystery Moon Assembly

The final design challenge requires the educator to prepare model landscapes so youth can test their remote sensing devices on the surface of a Mystery Moon.

Site A. *Prepare two shoeboxes for Site A, each with the following features:*

Must Have	Consider Adding
Lots of mineral paper printed with triangles, the symbol for water	Mountains or varied terrain using styrofoam sheets
No flat, open spaces	Paper cups to create landforms

- Each page of mineral paper contains triangles, which is the symbol for water. You can be strategic about where you cut and place them in each site.

Site B. *Prepare two shoeboxes for Site B, each with the following features:*

Must Have	Consider Adding
Flat, open space, at least 3” x 4”	Mineral paper, different colors
	Craters, dips in terrain using styrofoam sheets

- Use a utility knife to cut foam sheets and build layers, or stack objects from around the room.

Activity

4 Space Screen Assembly (p. 1)

You will need to assemble 4 Space Screens in total, 1 for each model of Site A and 1 for each model of Site B.

Materials: tri-fold board, ruler, utility knife, felt, scissors, duct tape

Step 1

Use a utility knife to cut a 9” x 20” rectangle approximately 10 inches from the bottom of the trifold board.

Step 2

Cut a 1-inch-wide fringe across four pieces of felt, leaving enough space around the edges to tape each piece to the board.

Step 3

Tape the two pieces of felt to each side of the board so the hole is completely covered.

Step 4

Label two of the screens “Site A” and two of the screens “Site B.”

If time allows, decorate all screens using paint or stickers. Decorating the screens will provide a visual reminder that the screen represents a significant distance between Earth and the Mystery Moon.

Activity

4 Space Screen Assembly (p. 2)

1. Position the Space Screen at the edge of a table so youth can easily access it and reach inside.

2. Tape one of the model landscapes to the table directly underneath the hole in the Space Screen. Keep the lid on the shoebox until groups are ready to test.

3. Tape the Space Screen to the table for extra stability.

4. Repeat to complete the remaining three Space Screens.

5. Position the Space Screens back to back or against a wall, so the model landscapes remain hidden as much as possible.

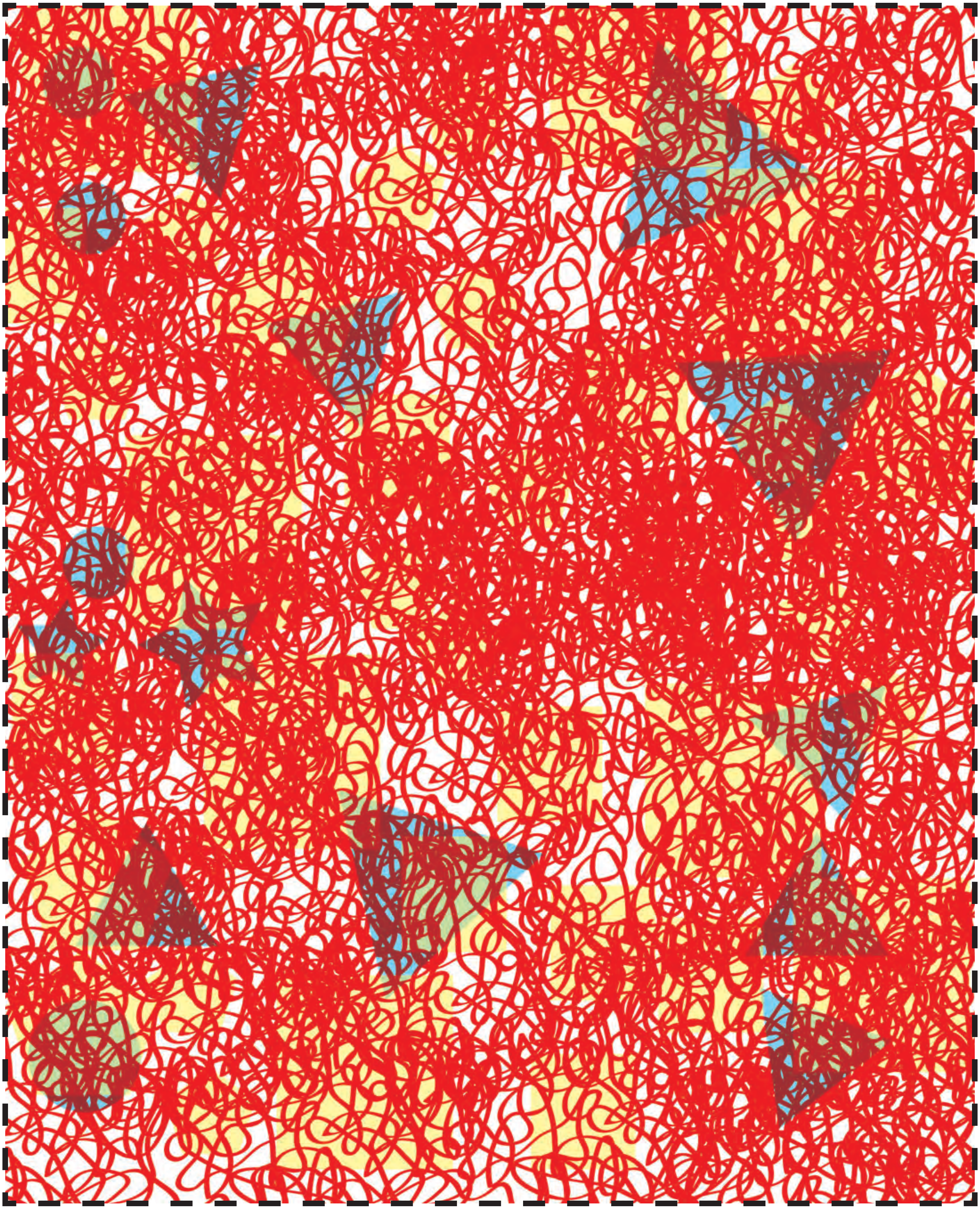
6. Optional: Place a blindfold at each Space Screen to encourage communication between the person operating the remote sensing device and the rest of the group, and prevent peeking into the model landscapes while testing.

Behind the Space Screen

The model landscapes are positioned correctly if youth are able to reach through the Space Screen and collect data from the surface of each site.

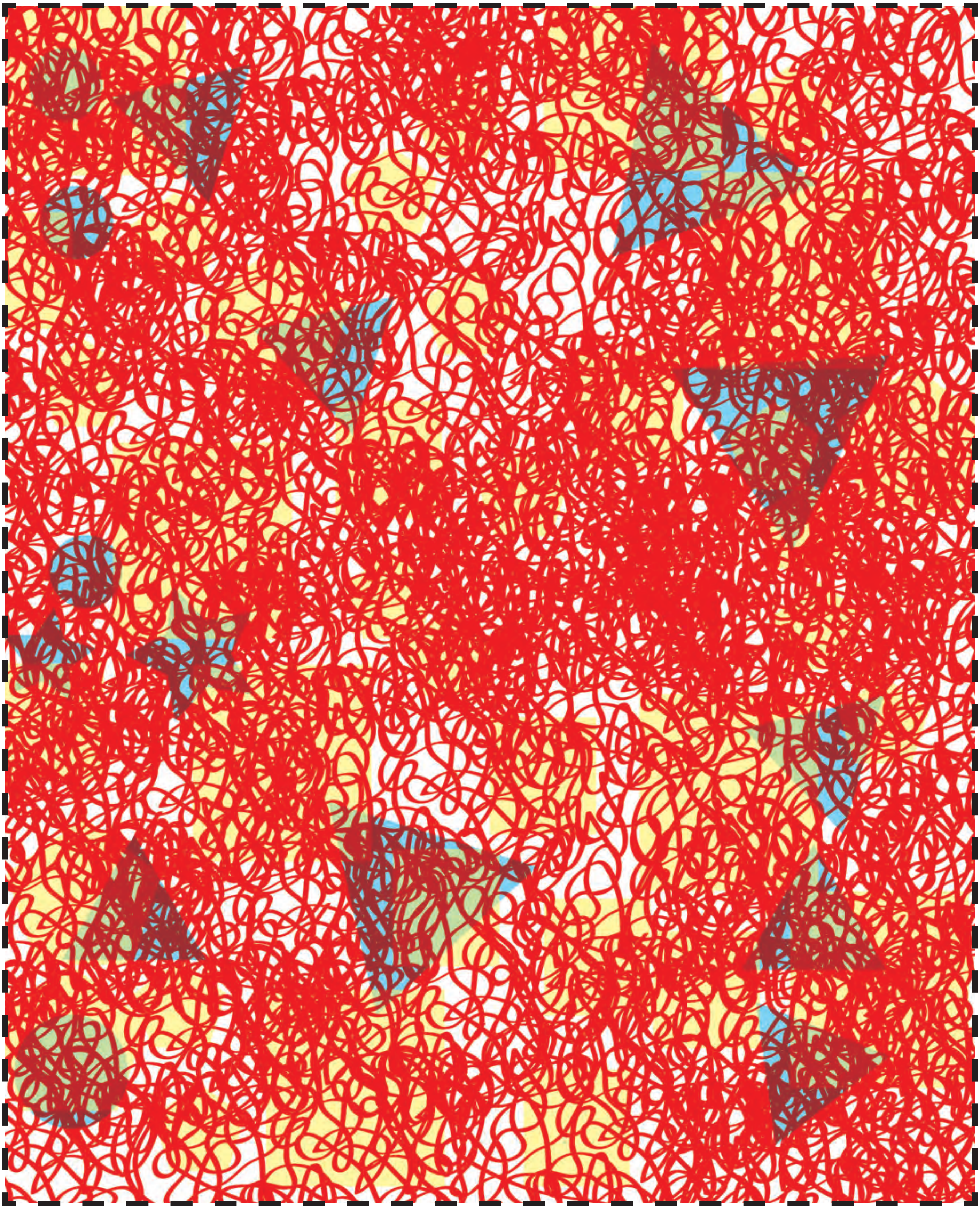
Activity **4**

Mineral Paper: Site A, Model 1 (p. 1)



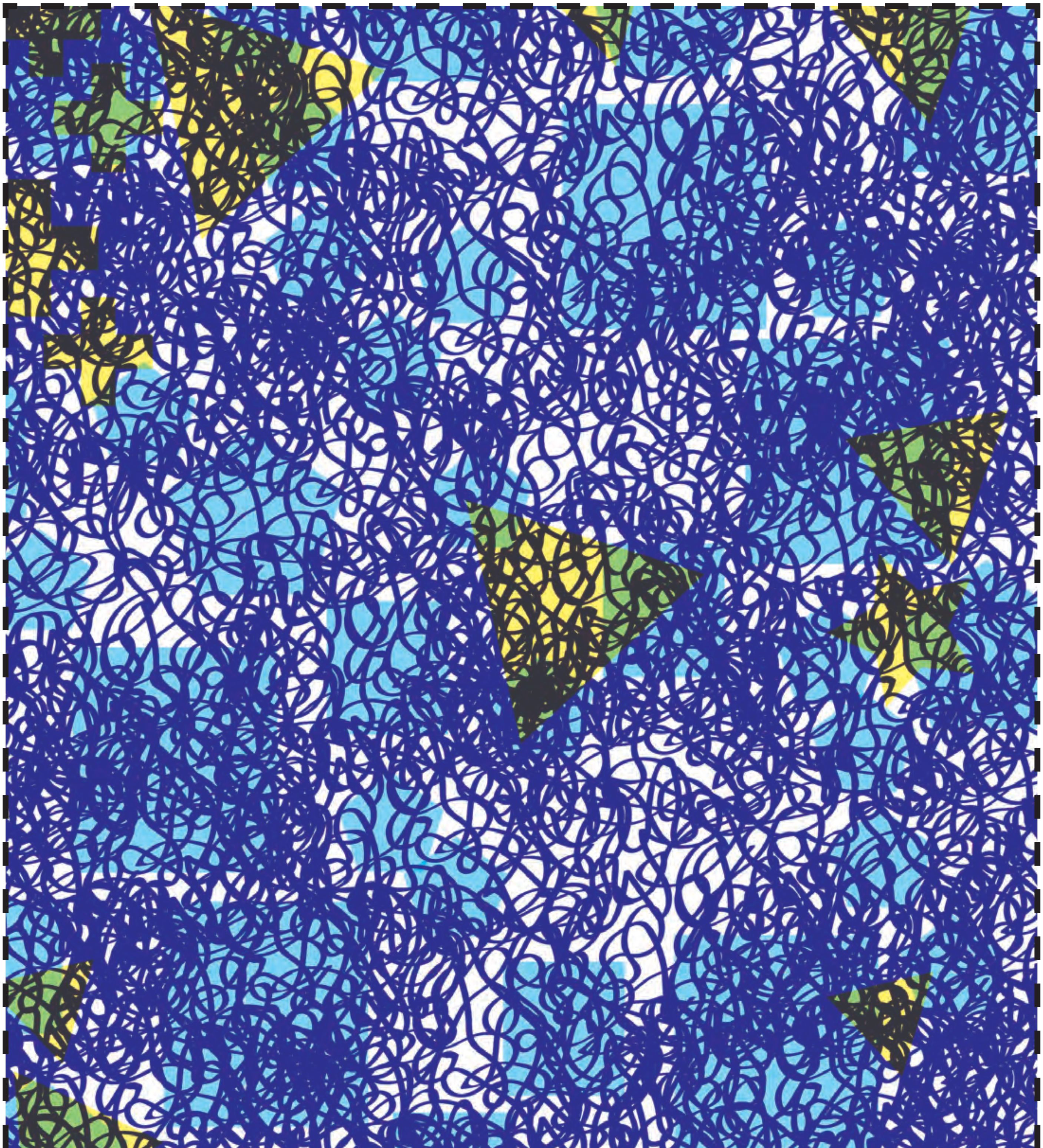
Activity **4**

Mineral Paper: Site A, Model 2 (p. 1)



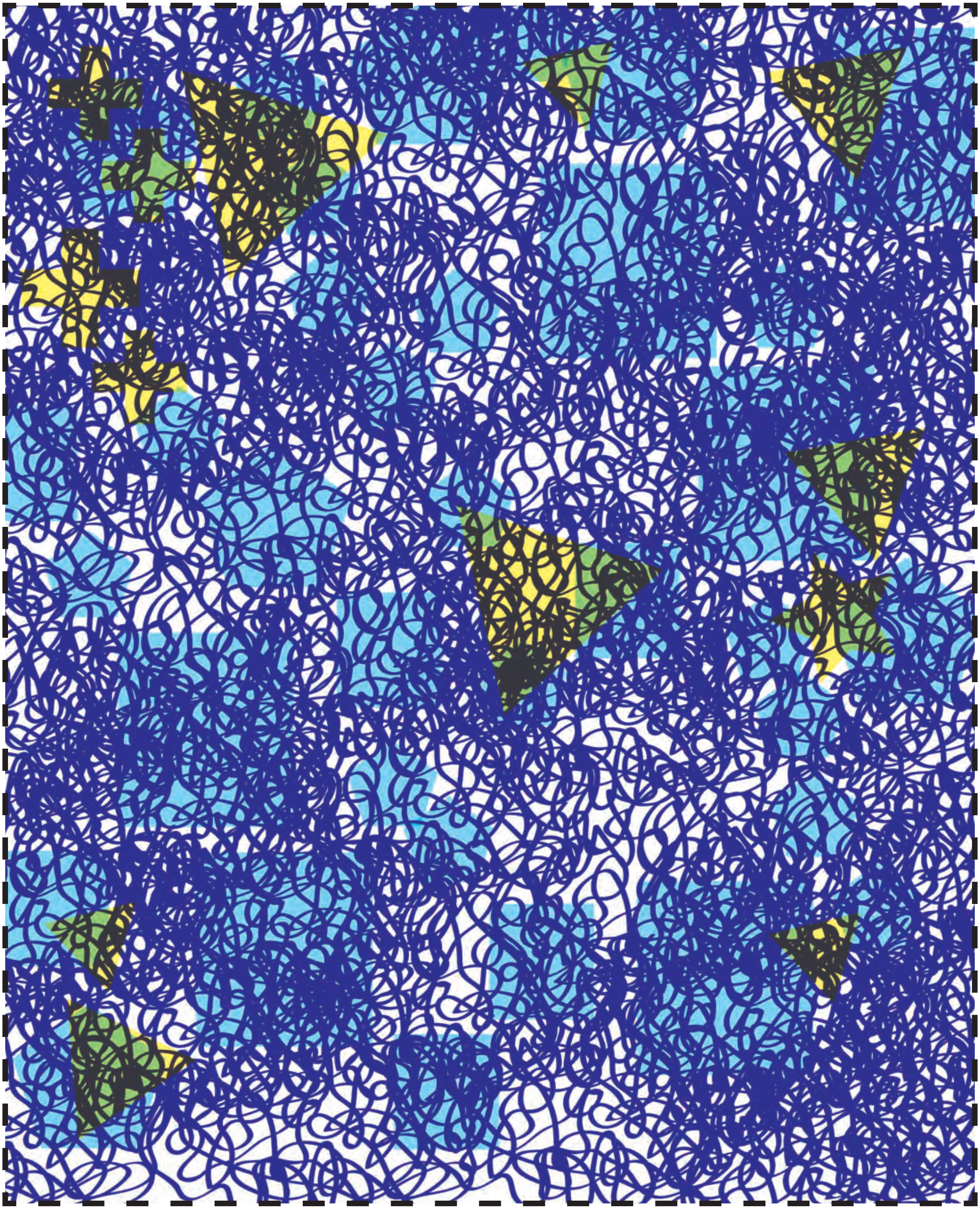
Activity **4**

Mineral Paper: Site A, Model 1 (p. 2)

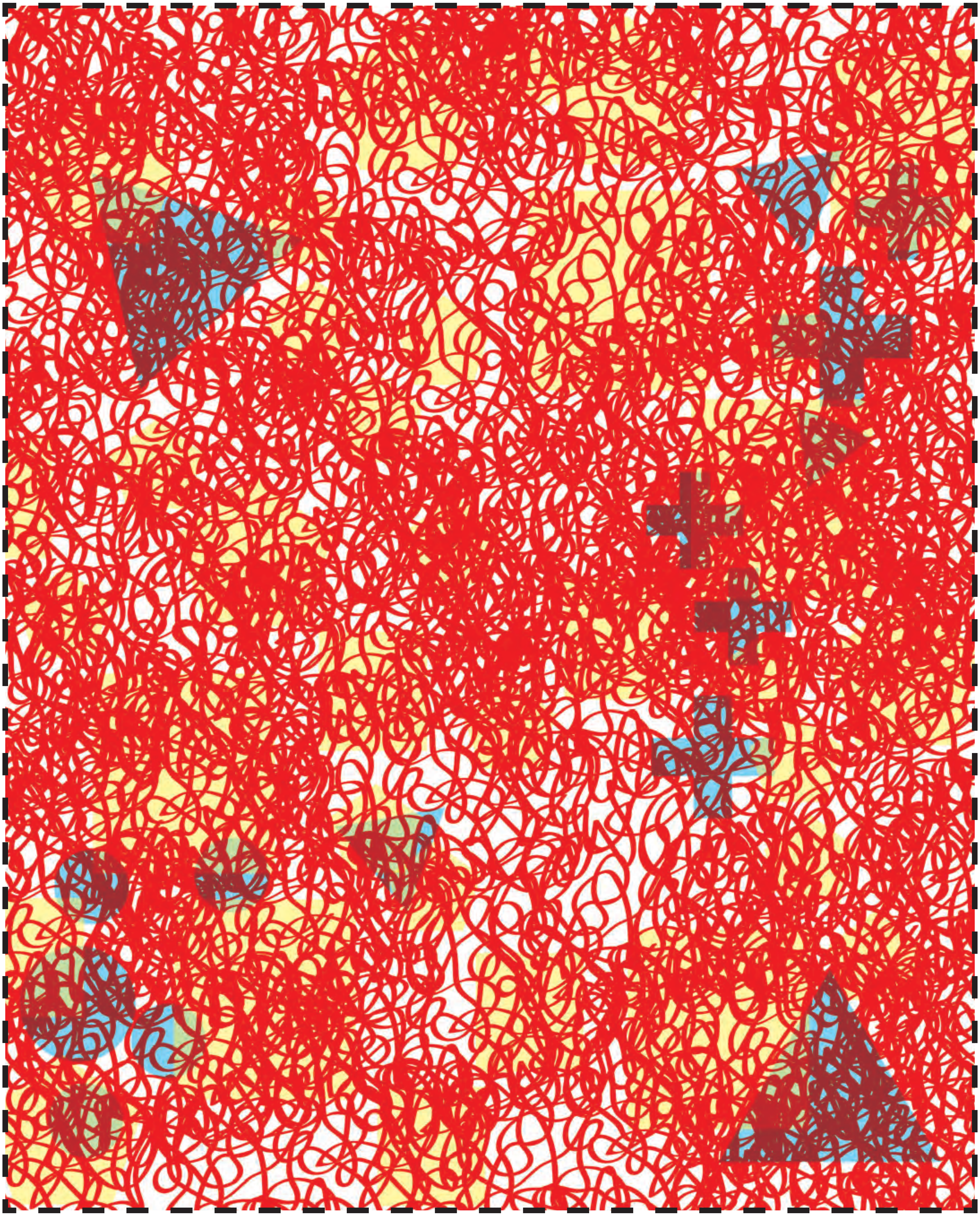


Activity

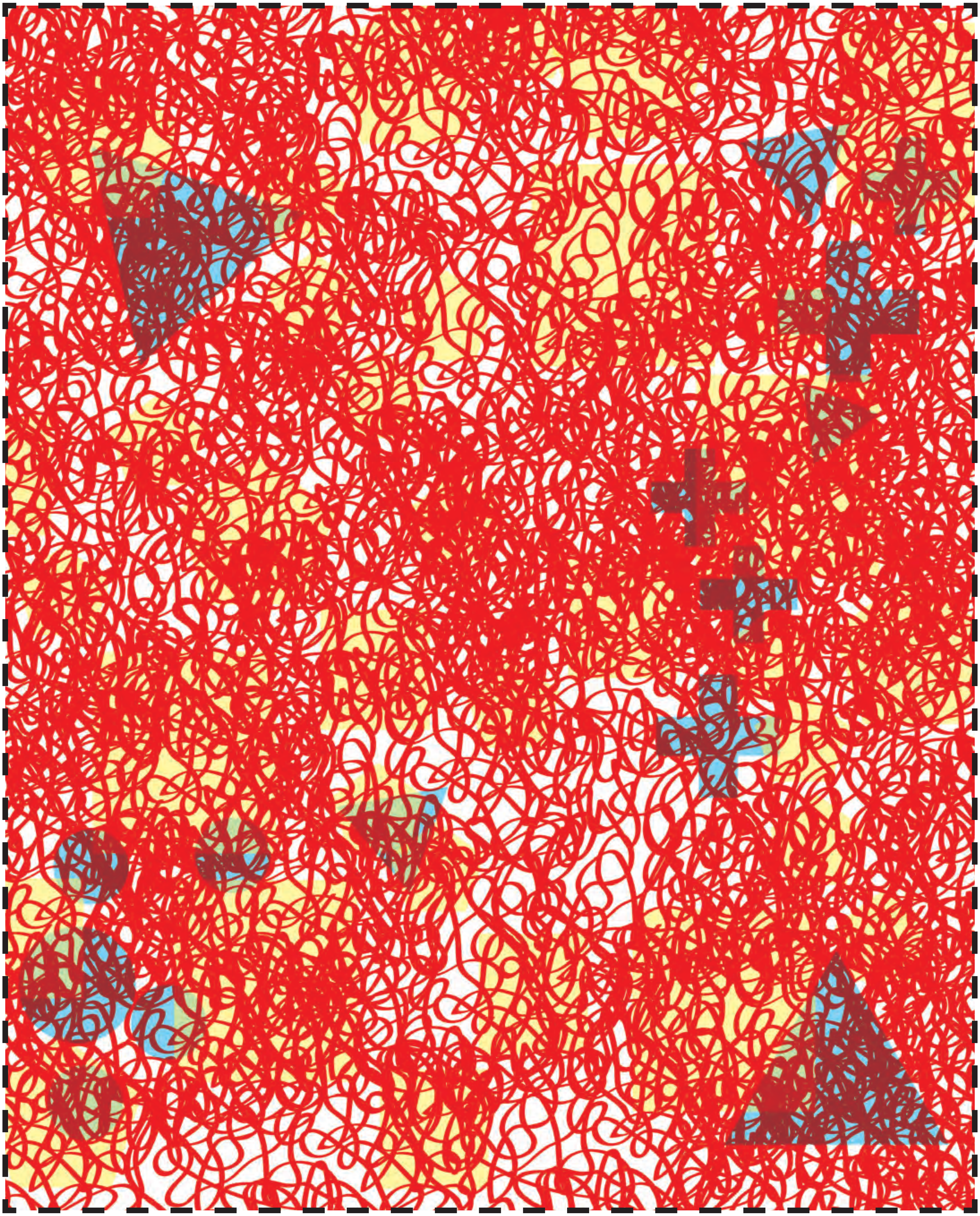
4 Mineral Paper: Site A, Model 2 (p. 2)



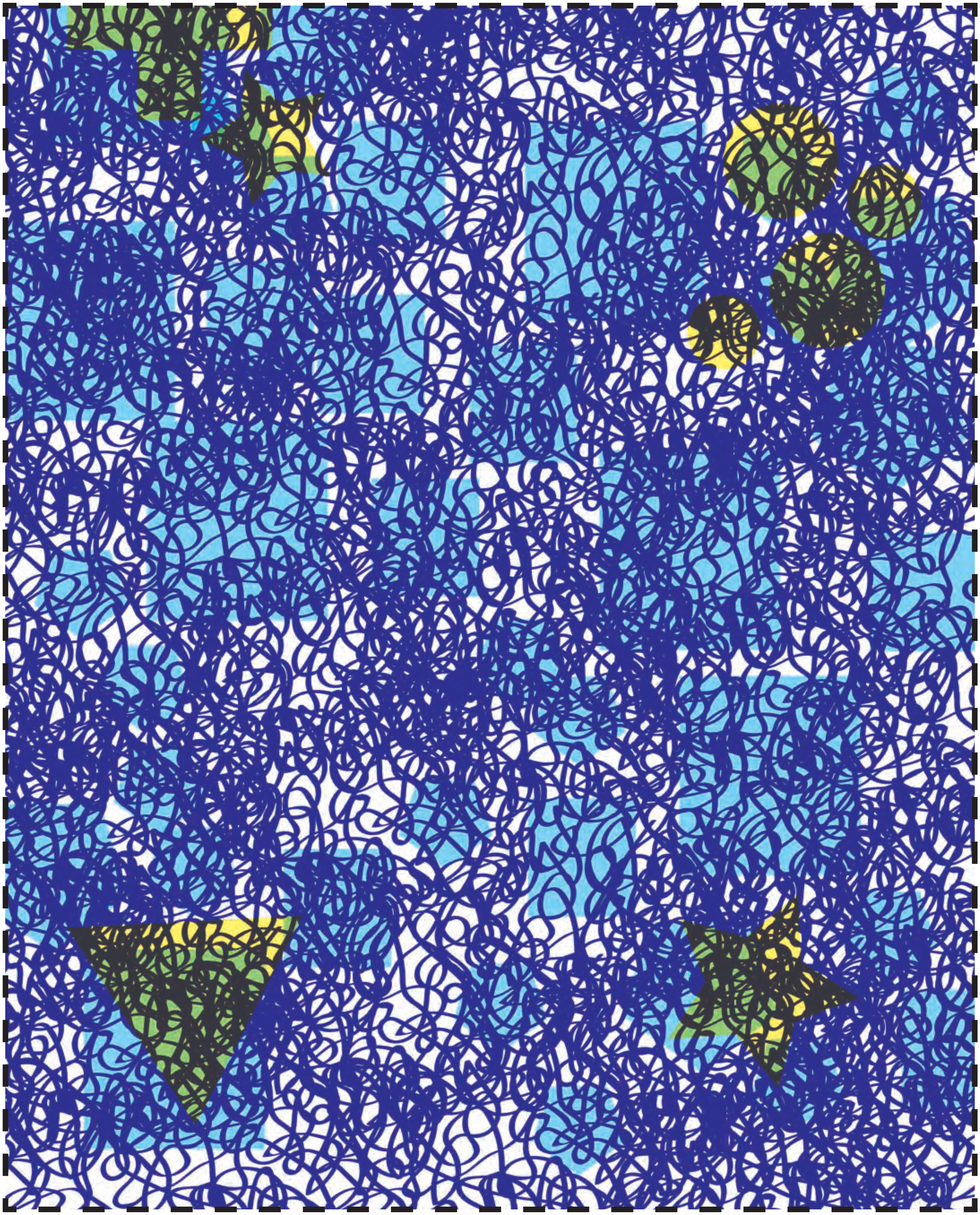
Activity 4 Mineral Paper: Site A, Model 1 (p. 3)



Activity 4 Mineral Paper: Site A, Model 2 (p. 3)

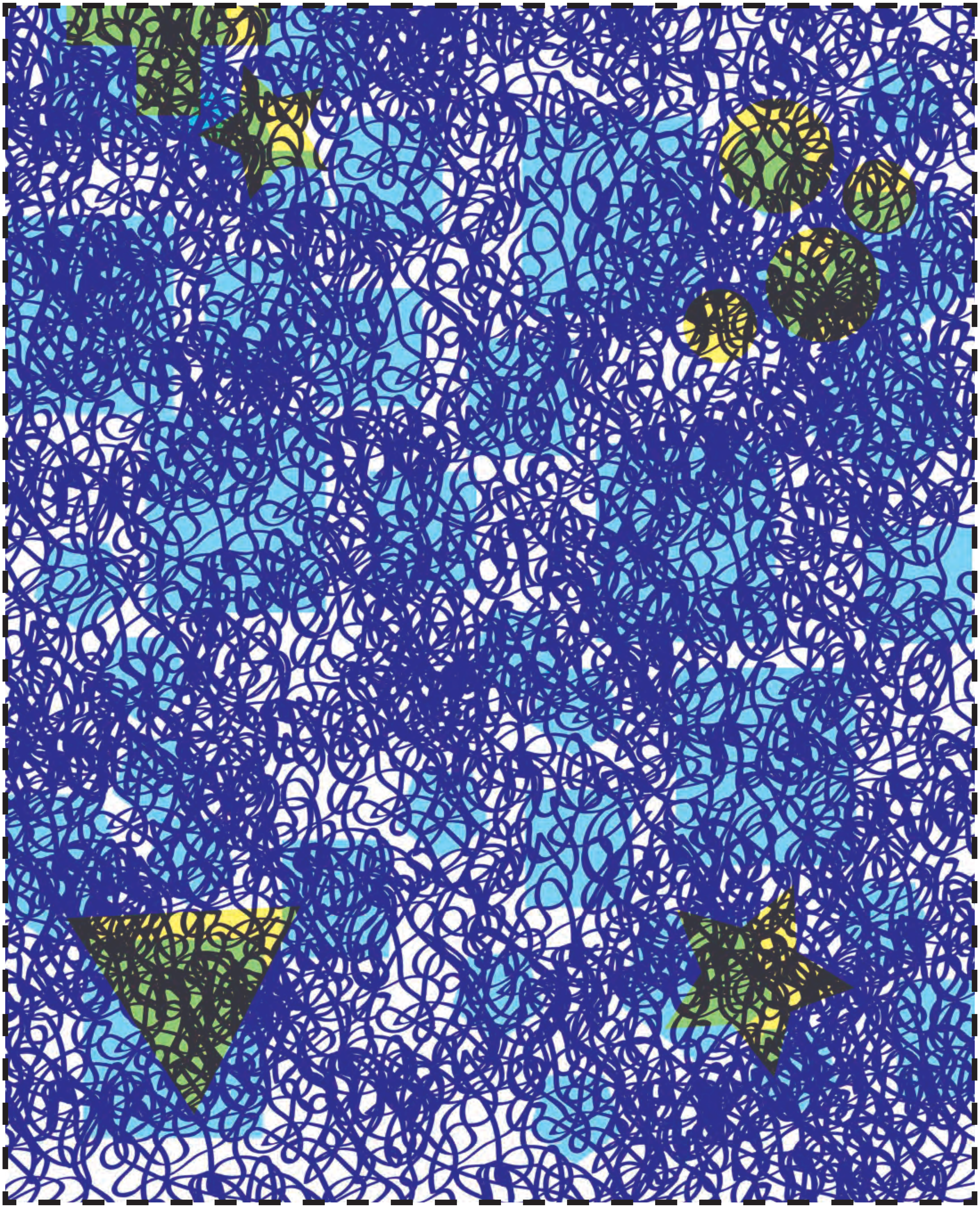


Mineral Paper: Site B, Model 1 (p. 1)



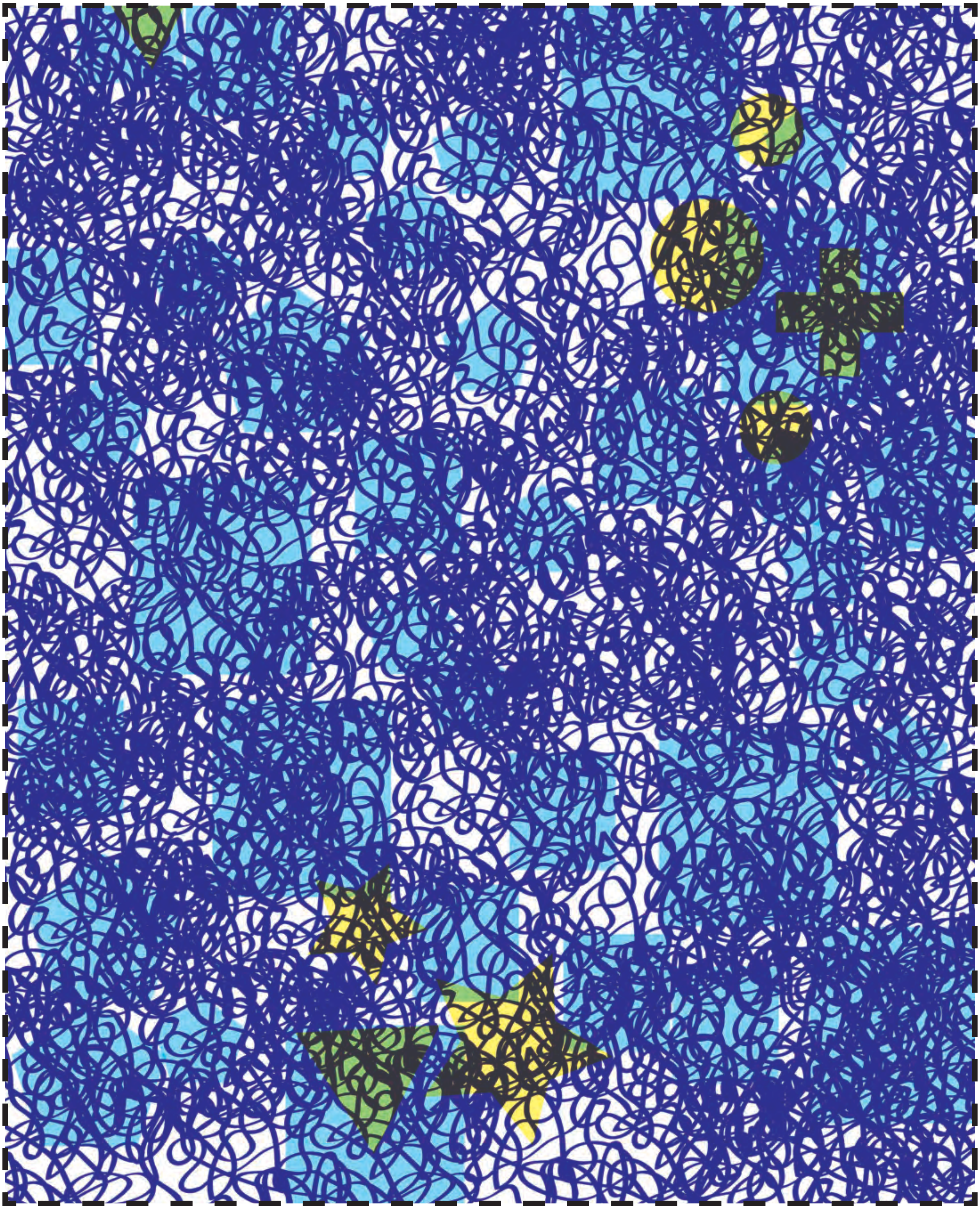
Activity 4

Mineral Paper: Site B, Model 2 (p. 1)

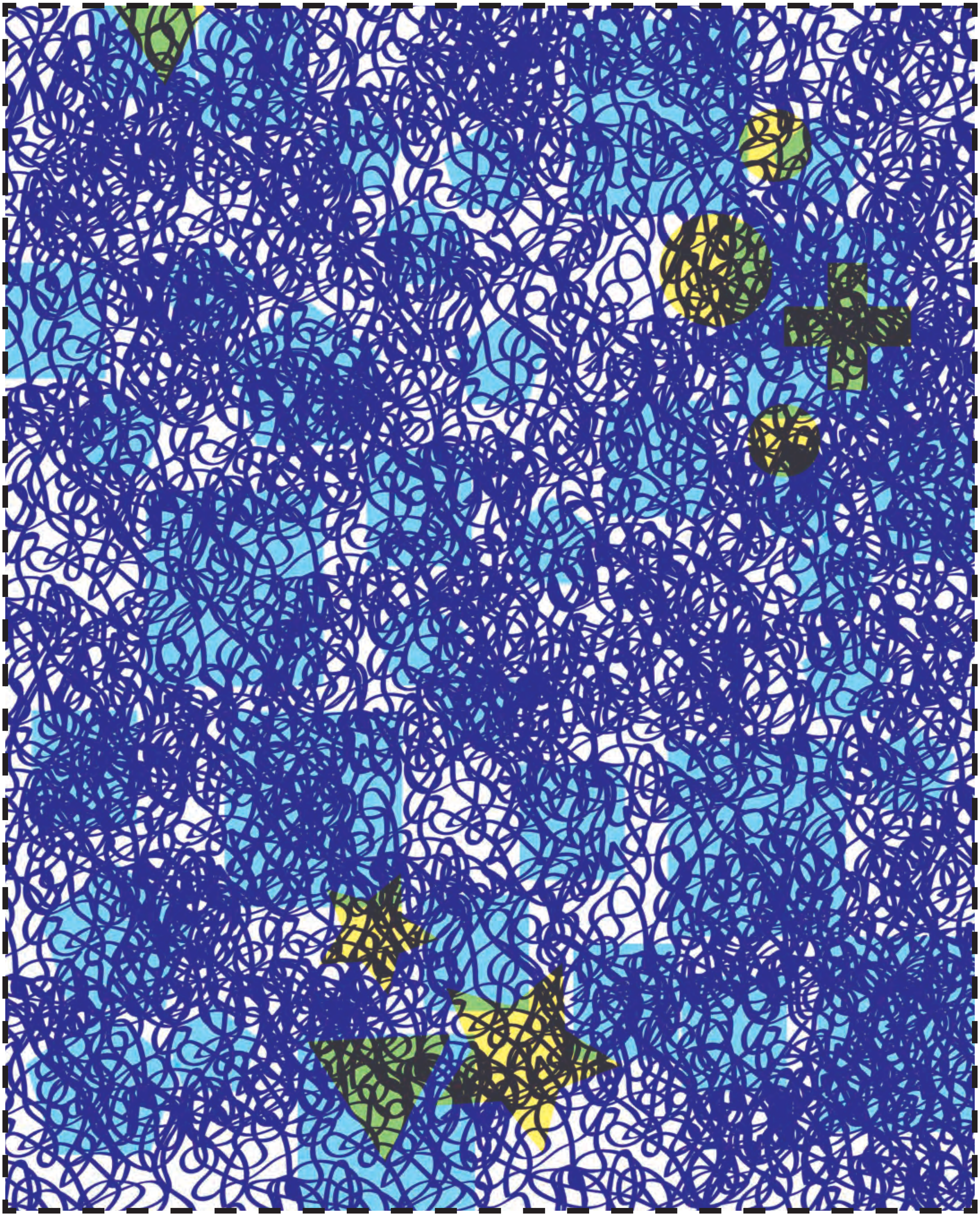


Activity **4**

Mineral Paper: Site B, Model 1 (p. 2)

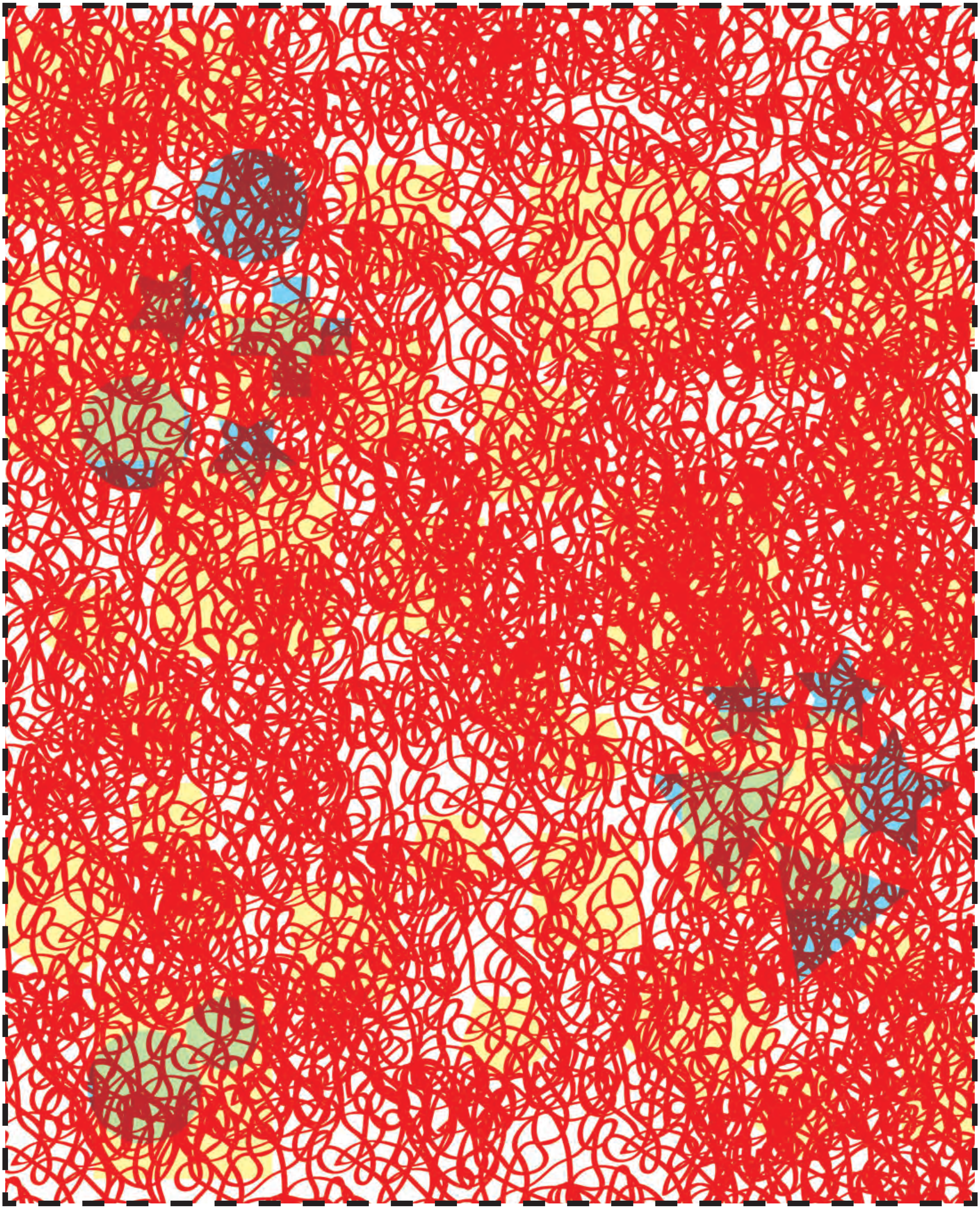


Mineral Paper: Site B, Model 2 (p. 2)



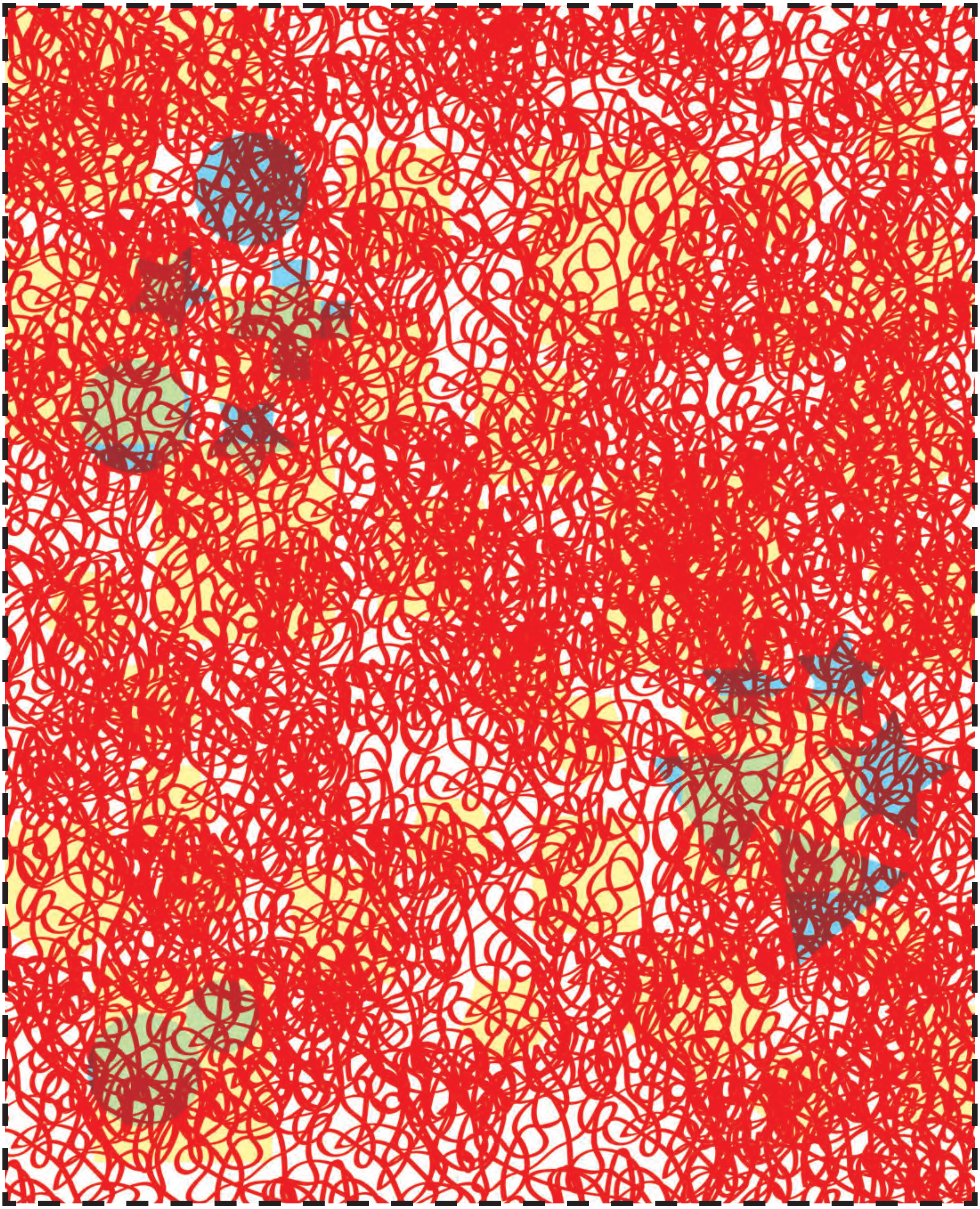
Activity **4**

Mineral Paper: Site B, Model 1 (p. 3)



Activity 4

Mineral Paper: Site B, Model 2 (p. 3)



Activity **5** # Improve

Overview

Youth *improve* their remote sensing devices and start to think about how they will *communicate* the data they collected to the scientists.

Note to Educator:
Designs are successful if youth are able to collect information from the Mystery Moon model landscapes. Groups can *improve* their designs by making them smaller and more compact or changing them to gather more detailed data. **Save each group's design, the Space Screens, and the Mystery Moon Sites for the Engineering Showcase.**

Activity Timing

Introduction:	5 min
Final Launch:	35 min
Presenting the Data:	15 min
Reflect:	5 min
	60 min

21st Century Skill Highlight

Critical Thinking
Creativity
Collaboration

Activity 5 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ *Optical Filter Investigations* chart from Activity 3
- ☐ *Remote Sensing Definition* chart paper
- ☐ crayons and markers
- ☐ Mystery Moon Sites and Space Screens from Activity 4
- ☐ remaining materials from Activity 4
- ☐ 25 sheets of construction paper
- ☐ 25 sheets of copy paper
- ☐ 50 craft sticks
- ☐ 75 pipe cleaners
- ☐ optional: 4 blindfolds

For each group of 3

- ☐ remote sensing devices from Activity 4
- ☐ 1 pair of scissors
- ☐ 1 roll of masking tape
- ☐ 1 ruler

For each youth

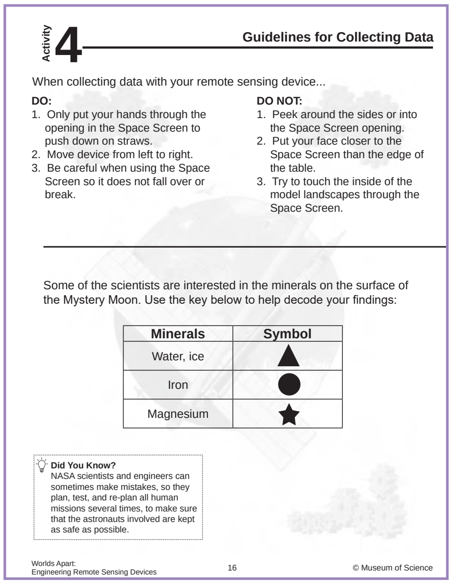
- ☐ Engineering Notebook

Activity 5 Materials Preparation (10 min)

1. Post the *Engineering Design Process* poster.
2. Post the *Remote Sensing Definition* chart paper and *Optical Filter Investigations* chart paper from previous activities.
3. Arrange the Space Screens according to *Space Screen Assembly*, p. 52 of this guide.
4. Create a Materials Table with the remaining materials from Activity 4.
5. Make copies of the *Engineering Showcase* invitation, p. 83 in this guide, for youth to distribute to their family and friends.

Notebook Pages for Activity 5

Guidelines for Collecting Remote Sensing Data, p. 16



Activity 4 — Guidelines for Collecting Data

When collecting data with your remote sensing device...

DO:
1. Only put your hands through the opening in the Space Screen to push down on straws.
2. Move device from left to right.
3. Be careful when using the Space Screen so it does not fall over or break.

DO NOT:
1. Peek around the sides or into the Space Screen opening.
2. Put your face closer to the Space Screen than the edge of the table.
3. Try to touch the inside of the model landscapes through the Space Screen.

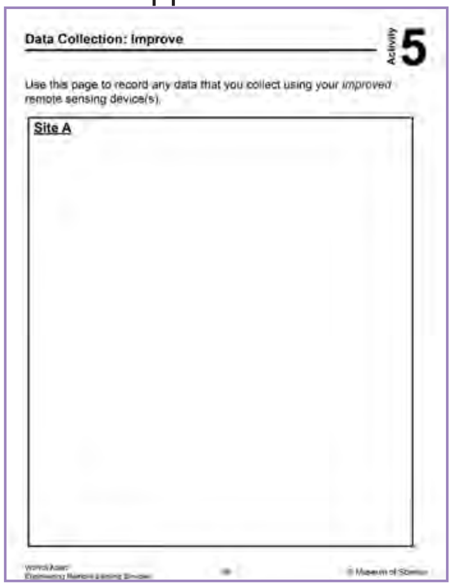
Some of the scientists are interested in the minerals on the surface of the Mystery Moon. Use the key below to help decode your findings:

Minerals	Symbol
Water, ice	▲
Iron	●
Magnesium	★

Did You Know?
NASA scientists and engineers can sometimes make mistakes, so they plan, test, and re-plan all human missions several times, to make sure that the astronauts involved are kept as safe as possible.

Worlds Apart: Engineering Remote Sensing Devices 16 © Museum of Science

Data Collection: Improve, pp. 19–20

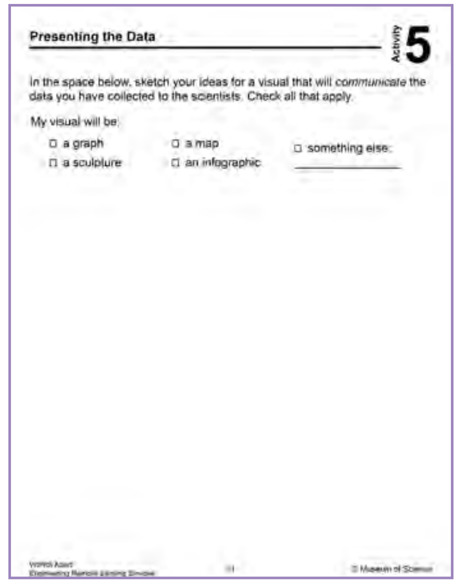


Data Collection: Improve — Activity 5

Use this page to record any data that you collect using your *improved* remote sensing device(s).

Site A

Presenting the Data, p. 21



Presenting the Data — Activity 5

In the space below, sketch your ideas for a visual that will *communicate* the data you have collected to the scientists. Check all that apply.

My visual will be:

☐ a graph ☐ a map ☐ something else: ____
☐ a sculpture ☐ an infographic

Youth will learn:

- The *improve* step allows engineers to reflect upon and alter their designs.

Introduction (5 min)

1. Congratulate youth on their engineering work so far.
2. Have groups volunteer to share their results, discuss problems, or give advice from the last activity. Ask:
   - **Which scientist did you choose to work with and were you able to collect the data they needed?**
   - **What about your design is working well?**
   - **What challenges did you encounter?**
3. Let youth know that today they will *improve* their remote sensing devices to make them even better. They will also start to think about how they will *communicate* the data to the scientists.
4. Remind youth that the *improve* step is an important part of the Engineering Design Process. Let groups know they should *plan* and *test* all the improvements they want to make today, before they share their final design with visitors in the next activity.

Improve (35 min)

1. Let groups know that room on a spacecraft is usually very limited, so one way to improve their remote sensing device is to make it as small and compact as possible.
2. Remind groups that they can refer back to *Remote Sensing Plan*, p. 15 in their Engineering Notebooks, and add notes as they *improve* their designs.
3. Allow groups to collect materials and begin working.
4. As groups are working, ask questions like:
   - **How are you *improving* your design?** *We made it fold up so it can be smaller, tried different straws to change the resolution, focused on one area to get more detailed information.*
   - **Are your improvements working out the way you thought they would?**
   - **What else can you do to *improve* your design?**
5. When groups are ready to launch, have them turn to *Guidelines for Collecting Data*, p. 16 in their Engineering Notebooks, and review the data collection guidelines.
6. Have groups *test* their improved remote sensing devices and

Tip

Have groups check the size of their remote sensing devices by placing them on a folded sheet of construction paper, similar to the way dimensions for carry-on baggage are checked at airports.

> **Tip**
>
> Let youth know that while engineers always strive to *improve* their work, space technologies are much harder to *improve* after they have been launched into space!

> **Tip**
>
> Allow groups to leave their remote sensing devices on their tables. They may realize that they need to collect more data as they make their visuals.

> **Tip**
>
> Data visualizations can take many forms. Encourage youth to be creative in how they display their data; they can use drawings, maps, graphs, or come up with a different way to summarize the data they collected.

record the data they collect about the Mystery Moon on *Data Collection*, pp. 19–20 in their Engineering Notebooks.

7. As groups are working, circulate among them and ask:
    - **What types of data are you collecting?**
    - **What did you learn about the Mystery Moon so far?**
8. Let groups that are still working know when there are 10 and 5 minutes remaining.

Presenting the Data (15 min)

1. Remind groups that the data they collected must be shared with the scientists. Ask:
    - **How do you think you can present your data so the scientists can get the information they need?**
2. Give groups a few minutes to think about how they will make a visual or other representation of the data they collected today. Encourage youth to record their ideas on *Presenting the Data*, p. 21 in their Engineering Notebooks.
3. Allow groups to collect materials and begin working.
4. As groups are working, ask questions like:
    - **What do you want your scientist to know about the Mystery Moon based on the data you collected?**
    - **How will you *communicate* the different types of data you collected?**
5. Let youth know when they have 5 minutes remaining.

Reflect (5 min)

1. Gather the whole group in front of the *Engineering Design Process* poster. Ask:
    - **Which steps of the Engineering Design Process did you use as you were engineering your remote sensing devices?** *We* planned *how we wanted to change our design, then we* created*,* tested *and* improved *them.*
2. Let youth know that in the next activity, they will prepare a presentation to share their designs and the data they collected with an audience. Ask:
    - **What steps of the Engineering Design Process do you think you will use to prepare a presentation?** Communicate.
3. Have groups label their remote sensing devices and visuals and store them in a safe location so they can use them at the Engineering Showcase.
4. At the end of the session, hand out a *Showcase Invitation*, p. 83 in this guide, for youth to share with family and friends.

You're Invited...

ENGINEERING SHOWCASE

WHERE:

WHEN:

WHAT:

Come support your local engineers as they share their remote sensing devices and the data they collected about a Mystery Moon!

Activity 6 Engineering Showcase

Educator Preview

Overview

Youth *communicate* their knowledge of remote sensing devices and the information they gathered about the Mystery Moon at the Engineering Showcase. The Mystery Moon's model landscapes will be revealed.

Note to Educator:
The Showcase and presentation of data is an opportunity for youth to share the engineering work they have completed over the course of the unit. Invite parents, peers, and other staff members to play the roles of the scientists using the Scientist Cards, or ask questions on behalf of the scientists yourself.

Activity Timing

Introduction:	5 min
Presentation Preparation:	15 min
Showcase:	20 min
Reveal:	5 min
Reflect:	10 min
	55 min

21st Century Skill Highlight

Communication
Collaboration

Activity 6 Materials

For the whole group

- ☐ *Engineering Design Process* poster
- ☐ chart paper
- ☐ crayons and markers
- ☐ Mystery Moon Sites and Space Screens from Activity 5
- ☐ 25 sheets of construction paper
- ☐ 25 sheets of copy paper
- ☐ 50 craft sticks
- ☐ 75 pipe cleaners
- ☐ optional: 4 blindfolds

For each group of 3

- ☐ Remote sensing devices from Activity 5

For each youth

- ☐ Engineering Notebook

Activity 6 Materials Preparation (15 min)

1. Post the *Engineering Design Process* poster and have chart paper available.
2. Create a Materials Table with the materials remaining from Activity 5.
3. Arrange the Space Screens according to *Space Screen Assembly*, p. 50 of this guide.
4. Invite people from the community, including families and friends of youth, to the Engineering Showcase.
5. Invite parents, peers, and other staff members to play the roles of the scientists using the Scientist Cards, or ask questions on behalf of the scientists yourself.

Communicate, p. 22

Activity 6 — **Communicate**

During your presentation, you will share information about the Mystery Moon with the scientists, and talk about the engineering challenge. What are some things you might want to *communicate* about engineering remote sensing devices?

Did You Know?
NASA's spacecraft and remote sensing devices record their own notes about the data they collect. This is called "telemetry" and it helps scientists know all the details about how remote sensing data are collected.

Worlds Apart: Engineering Remote Sensing Devices — 22 — © Museum of Science

My Engineering Profile 2, p. 23

My Engineering Profile 2 — Activity 6

Think about how you have changed as an engineer, and update your engineering profile.

- ☐ **Communication**
  - I give valuable feedback to others
  - I like giving presentations
- ☐ **Persistence**
  - I learn from failure
  - I keep trying until I succeed
- ☐ **Creativity**
  - I imagine lots of ideas
  - I come up with new ways of doing something
- ☐ **Teamwork**
  - I work well in teams
  - I like giving and receiving feedback on my work
- ☐ **Critical Thinking**
  - I solve problems
  - I make sense of complicated information
- ☐ **Technical Skills**
  - I make things
  - I like working with different materials
- ☐ **Leadership**
  - I lead teams well
  - I make sure everyone has a voice

Which skills do you want **to use**?	Which skills do you want **to learn**?

Did You Know?
Science and engineering work is almost always done in teams. Each project involves different types of specialized information, from flight systems to biology to communication, so a variety of people with different skills and expertise are needed for it to be successful.

Worlds Apart: Engineering Remote Sensing Devices — 23 — © Museum of Science

Youth will learn:
- *Communicating* with others is an important part of the Engineering Design Process.
- As engineers, they have valuable knowledge to share about the problem they have solved.

Tip

Let groups know that they will have a few minutes to finish their designs and visuals, if needed, before they start preparing for the presentation.

Introduction (5 min)

1. Gather youth in front of the *Engineering Design Process* poster and point out the *communicate* step. Remind youth that today they will *communicate* what they learned about remote sensing technologies and their engineering challenge to others. Ask:
   - **What are the important ideas you think we should present?**
   - **Do you have any ideas about how we might structure the presentation?**

Presentation Preparation (15 min)

1. Explain that the Showcase will be split into three parts.
   - First, there will be a whole-group presentation where volunteers explain what they learned about bouncing light, manipulating color, and measuring topography and why these ideas are important for remote sensing.
   - Then, they will split into groups and explain the remote sensing devices they created for their mission. Volunteers from each group will demonstrate their remote sensing technologies for the scientists and other guests and answer any questions they may have.
   - Finally, guests will have time to explore the designs, speak with groups informally, and ask questions about their remote sensing technologies.
2. The first part of the Showcase will require volunteers to talk about specific things. Write down some possible roles on chart paper for groups to review.
   - Describe and demonstrate the problem
   - Describe how remote sensing technologies can help solve the problem
   - Explain the design challenge and the Engineering Design Process
   - Describe and demonstrate how the group investigated periscopes, optical filters, and model LiDAR technologies
3. Encourage youth to add topics to this list. Have youth decide

Tip

The presentations should be a time for youth who enjoy presenting, or those who would like to work on this skill, to take a lead role. It is not necessary for all youth to present, though everyone should take part in preparing for the presentation.

Tip

If you do not have an opportunity to sufficiently brief the visitors playing the scientists before this activity, have one or more youth provide a summary of the different missions.

who would like to present and assign them roles. Tell youth that they can prepare notes for their group's presentation on *Communicate*, p. 22 in their Engineering Notebooks.

4. While volunteers are practicing their roles, give groups time to put the finishing touches on their remote sensing devices and visuals and prepare for the Showcase.
5. Rotate among the groups to provide support as needed. The process of sharing should be fun and exciting, not stressful!

Engineering Showcase (20 min)

1. When youth are ready, invite guests into the room and explain that they will see a presentation first, then have time to explore the remote sensing technologies and speak with the engineers.
2. Have the volunteers explain the engineering challenge to guests.
3. Give each group a few minutes to share their designs and the data they collected. Have volunteers demonstrate their remote sensing technologies by *testing* them on the Mystery Moon sites. As groups are *testing*, ask questions like:
   - **What are some things you *investigated* to help you solve this problem?**
   - **What did you *test* that worked really well? What did not work so well?**
   - **If you had more time, how would you *improve* your design? Are there any elements of another group's design that you would incorporate?**
   - **How did the Engineering Design Process help you reach this final design?**
4. After all groups have presented, allow guests to walk around and ask the engineers any additional questions they may have about their remote sensing devices or the data they collected.

Mystery Moon Reveal (5 min)

1. Gather youth together and explain that if they were collecting data from a real Mystery Moon and not a model, the data they collected would be extremely important since it would be the only information scientists have to make decisions about their mission. Scientists and engineers very rarely get to see the distant objects they study up close, but because youth are working with models, the Mystery Moon landscapes can now be revealed!
2. Display the model landscapes for Site A and Site B for youth and guests to see.
3. Encourage youth to think about the similarities and

differences between their data and the model landscape and how they might be able to further *improve* their remote sensing devices.

4. At the end of the Showcase, be sure to congratulate your group on doing a great job with the *communicate* step of the Engineering Design Process and on being remote sensing engineers. Have youth thank the audience members before concluding the presentation.

Reflect (10 min)

1. Encourage youth to reflect on the Engineering Design Process. Ask:
   - **Which steps of the Engineering Design Process were most helpful to you?**
   - **Can you *imagine* other problems you might solve using the Engineering Design Process?**
2. Give youth time to complete *My Engineering Profile 2*, p. 23 in their Engineering Notebooks. Giving youth time to record their thoughts will help them reflect on and wrap up the experiences they had throughout the unit.
3. Gather youth together as a group and ask:
   - **What are you most proud of doing as part of this engineering group?**
   - **Why do you consider yourself an engineer?**
4. Congratulate groups on their excellent engineering work.